TURKEY'S ACCESSION TO THE EUROPEAN UNION: IMPLICATIONS FOR AGRICULTURAL SECTORS

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Victory is for those who can say "Victory is mine".

Success is for those who can begin saying "I will succeed" and say "I have succeeded" in the end.

Our true mentor in life is science.

Mustafa Kemal ATATÜRK

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ABSTRACT

In October 2005, the European Council opened accession negotiations with Turkey. This decision has provoked some uncertainties in both sides. Some of these uncertainties are political in nature (e.g., the fulfillment of the political criteria, geographical location, free movement of labour, religion difference etc.) and some are economic, the latter of which forms the basis of this study. More specifically, the aim of this study is to investigate the potential economic impacts to the European Union (EU) of Turkish membership. Since much of the support and tariff protection in EU markets is associated with agriculture and food production, and because agricultural products are not included in the customs union established between Turkey and the EU, the study focuses principally on these sectors in Turkey and the EU.

To derive estimates of Turkey's integration, a multiregional computable general equilibrium (CGE) model framework is employed. The fundamental CGE framework used for this study is based on the Global Trade Analysis Project (GTAP) CGE model of the world economy and the latest GTAP database version 6 (base year 2001). The version of the GTAP model used in this study assumes perfectly competitive markets and involves constant returns to scale technology, a non-homothetic private demand system and a foreign trade structure characterized by the Armington assumption.

The analysis in this study focuses on the long-term economic effects of the Turkish accession. Thus, a status quo (baseline) scenario where Turkey remains outside of the EU in 2025 is analyzed next to two alternative accession scenarios. The baseline scenario includes projections to the year 2025 and some foreseeable policy changes (i.e., Doha Round shocks characterised by reductions in import tariffs and elimination of all export subsidies; elimination of domestic agricultural support in all regions). Both of the accession scenarios include elimination of all tariffs between Turkey and the EU and application of the common external tariff (CET) in Turkey while one of them also includes forecasts of potential migration flows from Turkey to the EU. The results include impacts for production, market prices, trade and economic welfare for Turkey and the EU.

Keywords: Turkey, European Union, Economic Integration, Agriculture and Food, Computable General Equilibrium Models, GTAP

RESUMEN

El pasado octubre de 2005, se abrieron oficialmente las negociaciones de adhesión de Turquía a la Union Europea (UE). Esta decisión ha provocado incertidumbre en ambas partes, de carácter político (por ejemplo, el cumplimiento de los criterios políticos, la situación geográfica, la libre movimiento de las personas, la diferencia religiósa, etc.) y de carácter económico. Estas últimas constituyen la base de este estudio. En concreto, el objetivo de este estudio es investigar las posibles repercusiones económicas de la ampliación de la Unión Europea (UE) a Turquía para amas partes. Dado que gran parte del apoyo y la protección arancelaria en los mercados de la UE está relacionada con la agricultura y la producción de alimentos, y los productos agroalimentarios no están incluidos en la unión aduanera establecida entre Turquía y la UE, el estudio se centra principalmente en estos sectores.

Para derivar las estimaciones de la adhesión de Turquía se recurre a un modelo multiregional de equilibrio general computado (EGC), conocido como Global Trade Analysis Project (GTAP), y se usa la última base de datos de GTAP versión 6 (el año base 2001). La versión del modelo de GTAP utilizado en este estudio asume competencia perfecta y rendimientos constantes a escala, incorpora un sistema no-homotético para las demandas privadas y utiliza el supuesto de Armington para la caracterización del comercio exterior.

El análisis realizado en este estudio se centra en las repercusiones económicas de la adhesión de Turquía en el largo plazo. De este modo, se compara un escenario de referencia (*baseline*) donde Turquía está fuera de la UE en el año 2025, con dos escenarios alternativos en los que Turquía es miembro de la UE. El escenario de referencia (*baseline*) incluye las proyecciones para el año 2025 y algunos cambios previsibles en las políticas económicas: los shocks de la Ronda de Doha; y la eliminación de los apoyos domésticos a la agricultura en todas las regiones incluidas en el modelo. Los dos escenarios alternativos incluyen la eliminación de todos los aranceles entre Turquía y la UE, y la adopción por parte de Turquía del arancel externo común (AEC). Además, uno de ellos incluye también las estimaciones de los posibles flujos migratorios de Turquía a la UE. Los resultados incluyen los impactos en la producción, los precios de mercado, el comercio exterior y el bienestar económico de Turquía y la UE.

Palabras Claves: Turquía, Unión Europea, Integración Económica, Agricultura y Productos Alimentarios, Modelos de Equilibrio General, GTAP

RÉSUMÉ

En octobre 2005, ont été entamées les négociations d'accession de la Turquie à l'Union Européenne. Cette décision a causé quelques incertitudes des deux côtés. Certaines de ces incertitudes sont d'ordre politique (par exemple, l'application des critères politiques, la situation géographique, la libre circulation des personnes, la différence de religion, etc.) et d'autres d'ordre économique. Celles-ci sont à la base de cette étude dont le but plus spécifique est d'examiner les impacts économiques potentiels de cette adhésion, aussi bien pour l'UE que pour la Turquie. Étant donné qu'une grande partie du soutien ou de la protection tarifaire des marchés de l'Union Européenne est associée à l'agriculture et à la production de denrées alimentaires et que les produits agroalimentaires ne sont pas inclus dans l'union douanière établie entre la Turquie et l'UE, l'étude est axée essentiellement vers ces deux secteurs.

Pour dériver les estimations de l'adhésion turque, on a utilisé un modèle multirégional d'équilibre général calculable (EGC), connu sous le nom de Global Trade Analysis Project (GTAP), et également la dernière base de données de GTAP version 6 (année de référence 2001). La version du modèle GTAP utilisée dans cette étude suppose que la concurrence est parfaite et implique des rendements d'échelle constants, un système de demande privé non homothétique et utilise l'hypothèse d'Armington pour caractériser la structure du commerce extérieur.

L'analyse menée à terme dans cette étude est axée sur les répercussions économiques à long terme de l'entrée de la Turquie dans l'UE. C'est ainsi que l'on compare un scénario de base (baseline) où la Turquie se trouverait hors de l'UE en 2005 et deux scénarios alternatifs où la Turquie serait membre de l'UE. Le scénario de référence (baseline) inclut les projections pour 2005, ainsi que certains changements prévisibles de la politique économique : les shocks de la Ronde de Doha ; l'élimination des subventions à l'agriculture dans toutes les régions inclues dans le modèle. Les deux scénarios alternatifs incluent l'élimination de tous les droits douaniers entre la Turquie et l'UE et l'adoption par la Turquie d'un tarif douanier externe commun (TDEC). En outre, un des modèles inclut également une estimation des flux migratoires potentiels de la Turquie vers l'UE. Les résultats comprennent également les impacts sur la production, sur les prix de marché, sur le commerce extérieur et sur le bien-être économique de la Turquie et de l'UE.

Mots-clés : Turquie, Union Européenne, Intégration Économique, Agriculture et Produits Alimentaires, Modèles d'Équilibre Général Calculable, GTAP.

ÖZET

Ekim 2005 tarihinde bir araya gelen Avrupa Birliği (AB) Konseyi, Türkiye ile tam üyelik müzakerelerine başlama kararı aldı. Alınan bu karar iki tarafta da Avrupa Birliği müktesebatına tam uyum, coğrafik konum, kişilerin serbest dolaşımı, dini farklılıklar gibi bazı politik ve ekonomik belirsizliklerin oluşmasına sebep oldu. Oluşan ekonomik belirsizlikler bu çalışmanın temelini oluştururken, ana amaç spesifik olarak Türkıye'nin AB'ye üyeliğinin olası ekonomik etkilerini incelemektir. Bu çalışma, AB pazarlarında kullanılan gümrük vergilerinin ve desteklerinin büyük bir çoğunluğunun tarım ve gıda ürünlerini kapsaması, Türkiye ve AB arasındaki gümrük birliği anlaşmasına bu ürünlerin dahil edilmemiş olmasından dolayı tarım ve gıda sektörleri üzerinde yoğunlaşmıştır.

Bu bağlamda bu çalışma Türkiye'nin üyeliğinin olası etkilerini tahmin etmek için çok-bölgeli bir hesaplanabilir genel denge (HGD) modeli olan Global Trade Alaysis Project (GTAP) modelini ve GTAP'in altıncı sürüm veritabanını (temel yıl 2001) kullanmaktadır. GTAP modelinin bu çalışmada kullanılan sürümü tam rekabet piyasası koşullarının ve ölçeğe göre sabit getiri varolduğunu varsaymakta ve uluslararası ticaret yapısının tanımlamasında Armington varsayımını dahil etmektedir.

Bu çalışmada yapılan analizler Türkiye'nin üyeliğinin uzun vadeli ekonomik etkilerini incelemektedir. Bu nedenle, Türkiye'nin 2025 yılında AB üyesi olduğunun varsayıldığı iki alternatif senaryo Türkiye'in AB üyesı olmadığı bir referans senaryosu (*baseline*) ile karşılaştırılmaktadır. Bu referans senaryosu 2025 yılı için projeksiyonların yanında bir takım öngörülebilir politika değişikliklerini (ithalat vergilerinin düşürülmesini ve ihracat desteklerinin kaldırılmasını içeren Doha turu muzakereleri şokları ve modele dahil edilen bütün bölgelerde üretim desteklerinin kaldırılması şokları) içermektedir. Her iki AB üyeliği senaryosu da Türkiye ve AB arasındaki gümrük vergilerinin kaldırılmasını ve AB'de uygulanan Ortak Gümrük Vergisinin (OGV) (Ortak Dış Tarife) Türkiye tarafından uygulanmasını içermektedir. Bunların yanında bu üyelik senaryolardan biri Türkiye'den AB'ye olabilecek potansiyel göç tahminlerini de dahil etmektedir. Çalışma Türkiye ve AB'de üretim, fiyatlar, ticaret ve ekonomik refah üzerinde meydana gelen etkilerin sonuçlarını da içermektedir.

Anahtar kelimeler: Türkiye, Avrupa Birliği, Ekonomik Entegrasyon, Tarım ve Gıda Ürünleri, Hesaplanabilir Genel Denge Modelleri, GTAP

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

After the Second World War the unification of Europe started with the foundation of the European Coal and Steel Community. The six original members were Belgium, France, Germany, Italy, Luxembourg and the Netherlands. This was followed by the European Economic and the European Atomic Energy Community which was ratified within the Treaty of Rome in 1957. This is considered as the creation of the European Union (EU)[1], which over the course of five enlargements has subsequently grown to 27 member states.

More recently, the EU has launched accession negotiations with Croatia and Turkey and has granted candidate country status to the Former Yugoslav Republic of Macedonia, although in the latter case accession negotiations have yet to begin. Similarly, EU relations with the Western Balkan countries (Albania, Bosnia and Herzegovina, Montenegro and Serbia) have been moved from the 'external relations' to the 'enlargement' policy segment, where these countries currently hold the status of 'potential candidates'. (European Commission, 2007a)

The relationship between the European Economic Community – later the EU – and Turkey started in July 1959 when Turkey made its first formal application to join the community. The negotiations resulted in the signature of the Ankara Agreement on September 12, 1963, an association agreement covering the liberalisation of markets for goods and financial aid. Turkey submitted its application for full membership into the European Community on April 14, 1987 and in January 1996 Turkey and the EU established a Customs Union (CU). This CU is limited to industrial products, whilst a significant part of agricultural trade takes place under preferential agreements.

[1] The EU formally established when the Maatricht Treaty came into force on November 1, 1993.

At the European Council meeting, held in Helsinki in December 1999, Turkey gained candidate status for full membership. The European Council decided to start accession negotiations with Turkey on October 3, 2005. This decision has provoked some uncertainties on both sides. Some of these uncertainties are political in nature and some are economic, the latter of which form the basis of this study. More specifically, the main objective is to investigate the potential economic impacts of Turkish accession to the EU while providing an overview of Turkey's relations with the EU, the Turkish economy and, in particular its agriculture. Since much of the support and tariff protection in EU markets (also in Turkey) is associated with agriculture and food production, and because agricultural products are not included in the CU agreement, the study focuses principally on these sectors in Turkey and the EU.

In this context, the study investigates the following questions.

- How much will the accession of Turkey benefit or cost Turkish and European producers and consumers?
- Which agricultural sectors will expand and which will contract?
- What are the possible opportunities and threats of integrating Turkey into the EU – Could migration from Turkey have a positive effect on the EU?

To derive estimates of Turkey's integration into the EU, a multiregional computable general equilibrium (CGE) model framework is employed in this study. More specifically, our study uses the Global Trade Analysis Project (GTAP) model with its associated version 6 database is use. The GTAP database, with its detailed input – output tables, final demand accounts, detailed support and protection data across numerous regions and sectors, is the most up to date and comprehensive global trade database of its type. Benchmarked to the year 2001, the GTAP data covers 57 sectors and 87 regions. To focus on issues of interest the data is aggregated into 13 regions/countries and 21 sectors including 18 agricultural sectors. The agriculture and food sectors are fully disaggregated to examine the impacts of Turkish accession in greater depth from the perspective of agro-food producers.

Several long run scenarios are developed for the simulation design. Firstly, a status quo (baseline) scenario is employed where Turkey remains outside of the EU in 2025. The baseline scenario includes projections to the year 2025, elimination of all intra-EU trade protection to characterise the formation of the EU-27 single market, Doha Round trade policy shocks and an assumed long run elimination of domestic agricultural support in all regions (i.e, direct market support)[2]. In comparison with the baseline, two integration scenarios between Turkey and the EU are implemented. In addition to the baseline shocks, both of the scenarios include shocks to eliminate all trade tariffs between Turkey and the EU-27 and the application of the EU-27 common external tariff (CET) for Turkey. In scenario-2[3] we also include forecasts of potential migration flows from Turkey to the EU.

The structure of this study is as follows:

Following the introductory chapter, Chapter II provides a brief history of the EU-Turkish relationship accompanied with some arguments on Turkish membership found in the literature. A general description of the Turkish economy and the main developments in the recent past with comparisons to the EU and accession countries is also provided in this chapter. Special attention is given to the agricultural situation in Turkey with comparisons to the situation in the EU. Information on land usage, agricultural holdings, production, trade and agricultural support policies (a subsection is dedicated to the Common Agricultural Policies (CAP) of the EU). The final section of the chapter is the literature review of recent CGE studies on EU enlargement. The review is focused on the relevant works that investigate the impacts of Turkish accession. These studies are evaluated with special reference to model characteristics, policy concerns, policy experiments and their resulting implications.

Chapter III discusses the principles of CGE theory, its practice and also briefly evaluates this methodology based on its strengths and weaknesses. A detailed discussion of the most popular types of functional forms used in CGE models and the concepts of model representation and solution

[2] The possibility of non-market good support payments which are not captured within this framework is not ruled out.
[3] This scenario is divided into two simulations according to the assumptions used on the composition of the migrants.

methodology is provided. This chapter also includes a simple linearised CGE model example to illustrate the basic steps involved in CGE analysis.

Chapter IV then continues by providing information on the theory behind the GTAP model and its database. Accounting relationships within the database and the model are explained in this chapter by tracking value flows from production and sales to intermediate and final demands. The chapter also provides behavioural equations to describe the behavioural patterns of producers and consumers within the economy. The construction of the GTAP database (version 6) is also discussed in this chapter.

Chapter V presents the experimental design and results obtained after their implementation. The chosen sectoral and regional aggregation and a quantitative description of the scenarios are also included in this chapter. Detailed analyses of the results are done by examining sectoral and welfare effects for various regions of the model.

The final chapter concludes with a discussion on the major results and implications of the study for the accession and offers suggestions for future research. In addition, the study contains six appendices. Appendix I describes the techniques that are used to solve CGE models, such as Johansen approach, multi-step solution methods and extrapolation, in more detail. Appendix II and III include theoretical restrictions for the choice of the functional forms in CGE models. Appendix IV provides codes (for the GEMPACK software) for the stylised model used in the chapter. Appendices V and VI provide some simulation results for all 10 chosen regions (except Turkey) related with the changes in production and welfare.

CHAPTER II

TURKEY AND ITS RELATIONS WITH THE EUROPEAN UNION

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2.1. INTRODUCTION

In December 2004, the European Council began negotiations with Turkey on the issue of membership with the European Union (EU). This decision has provoked some uncertainties on both sides. Some of these uncertainties are political in nature and some are economic, the latter of which form the basis of this study. More specifically, the aim of this chapter is to give some background to the possible accession of Turkey and the studies which investigate the economic impacts from such a scenario.

The chapter is structured as follows. Section 2.2 gives a brief history of the EU-Turkish relationship and continues with section 2.3 giving some arguments on Turkish Membership. Section 2.4 provides general information on the Turkish economy by giving information on GDP, economic growth, inflation, trade and income distribution. Section 2.4 also reviews the agricultural situation in Turkey by providing information on land usage, agricultural holdings, production, trade and agricultural support policies. Section 2.4 intends to compare the Turkish economy and agriculture with that of the European Union. Then the chapter continues with section 2.5 which reviews recent (Computable General Equilibrium (CGE) modelling) studies on European Union enlargement to include Turkey. Finally, the section 2.6 concludes the chapter.

2.2. TURKEY – EUROPEAN UNION RELATIONS

In July 1959, shortly after the creation of the European Economic Community (EEC), Turkey made its first formal application to join the community. The negotiations resulted in the signature of the Ankara Agreement on September 12, 1963 which created an association between Turkey and the EEC. This agreement, which came into effect on December 1, 1964, set out to integrate Turkey into a customs union with the EEC with the final objective of full membership. Although the Ankara Agreement conceived the free circulation of goods, persons, services and capital between Turkey and the EEC, it excluded Turkey from the decision-making mechanisms of the EEC and prevented Turkey from recourse to the European Court of Justice (ECJ) for dispute settlement (Turkish Embassy, 2006). To achieve these goals an additional protocol signed on November 13, 1970 between the two parties, established a timetable (between 12 and 22 years) for the abolition of tariffs and quotas on goods traded between Turkey and the EEC. Moreover, this protocol proposed the free circulation of persons in the next 12 to 22 years.

Relations froze after the military intervention of September 12, 1980 following a period of political and economic instability in Turkey, although diplomatic contacts were resumed after the multiparty elections, held in 1983. Turkey submitted its application for full membership into the European Community on April 14, 1987; three years before Cyprus and Malta and between seven and nine years before applications were lodged by ten Central and Eastern European (or accession) countries (CEECs or AC-10). Due to internal political change in the EU, which was further complicated by developments in Eastern Europe and Soviet Union, The European Commission did not respond to this until 1990, rejecting the option of immediate accession negotiations. However, the EU wanted to extend economic relations without explicitly rejecting the possibility of full membership at a future date. Accordingly, the two parties concentrated on reviving the plans for a customs union agreement.

On March 6, 1995, it was agreed that a customs union (CU) would be created between Turkey and the EU as of January 1, 1996 to be fully phased in by 2001 (Hoekman and Togan, 2005). As a result of this agreement, Turkey and the EU have subsequently abolished all quotas and tariffs on imports of industrial goods from each other. The most important exception to free trade was for agricultural commodities where neither party liberalised completely. Turkey imposes an average tariff rate of 21.4 percent tariff rate on imports of agricultural commodities from the EU (Hoekman and Togan, 2005). Agricultural trade is also subject to tariff quotas and price regulation, which have produced a high degree of protection in both the EU and Turkey. Therefore, in terms of further liberalisation of merchandise trade, accession probably will primarily have an effect on agriculture (Hoekman and Togan, 2005). Another important result of the customs union was that Turkey began to use the European Union's Common Customs Tariff on imports of industrial goods from third countries. Turkey also adopted most of the preferential trade agreements of the EU, as well as other measures covered by the EU's commercial policy (such as antidumping), EU competition policies and EU rules on protection of intellectual and industrial property rights. Turkey also launched a process of harmonizing technical standards for industrial products and strengthening internal conformity assessment and market surveillance structures (Hoekman and Togan, 2005).

On December 10-11, 1999, the European Council meeting, held in Helsinki, proved a milestone in Turkey-EU relations as the EU recognised Turkey officially as a candidate for accession on an equal footing with other potential candidates. But, in contrast to other candidate countries, Turkey did not receive a timetable for accession. This decision motivated the creation of an Accession Partnership which means that the EU is working together with Turkey to enable it to adopt the legal framework of the EU, the *acquis communautaire*[4].

The next breakthrough in Turkey-EU relations produced in December 2002, the Copenhagen European Council concluded that "if the European Council in December 2004, on the basis of a report and a recommendation from the Commission, decides that Turkey fulfils the Copenhagen political criteria, the EU will open accession negotiations with Turkey without delay" (European Commission,

[4] The Turkish government announced on March 19, 2001, its own National Program for the adoption of the *acquis communautaire*, after the approval of the Accession Partnership by the Council and the adoption of the Framework Regulation on February 26, 2001(Hoekman and Togan, 2005).

2004a, pp. 2). Following this, the European Commission recommended that the negotiations should begin and the EU's leaders agreed on December 16, 2004 to start accession negotiations with Turkey on 3 October 2005.

2.3. ARGUMENTS ON THE TURKISH MEMBERSHIP

Although Turkey made its application for full membership to the European Community earlier than the new members of the European Union (Central and Eastern European or Accession Countries) Turkey only could begin accession negotiations on October, 2005. At the current time, the EU and Turkey have closed the first chapter in the negotiations on June, 2006.

This section intends to point out some arguments on political issues of Turkish membership to the EU within the framework of the studies which are made by Hoekman and Togan (2005), Hughes (2004), Hughes (2006), Littoz-Monnet and Penas (2005), European Commission (2004b) and Nugent (2005)[5]. In the following section (2.4) of this chapter, taking into account the objectives of this study, the arguments on economic issues will be discussed mainly focusing on agriculture.

2.3.1 The fulfilment of the political criteria

During 2001-2004 Turkey made two major constitutional reforms and adopted eight legislative packages to fulfil the Copenhagen political criteria including measures to eliminate practices of torture and ill-treatment. The death penalty has been abolished, laws on forming associations and the right to assemble have been liberalised and more legal rights have been given to religious and ethnic minorities (Littoz-Monnet and Penas, 2004). Moreover, in its November 2005 report the European Commission considers that Turkey continues to sufficiently fulfil the Copenhagen political criteria. However, in the same report Turkey is criticised in that the implementation of these reforms, although they have entered into force, remain uneven and it is also indicated that the pace of structural reform slowed in 2005. The

[5] It is possible to find many studies about this subject but from the author it is believed that the studies cited above should be sufficient.

report suggests that more efforts are needed concerning fundamental freedom and human rights, especially freedom of expression and religious belief, better rights for woman, trade unions, recognition of different cultures and the further strengthening of the fight against torture and ill-treatment.

Another important issue on fulfilment of political criteria is that the Turkish armed forces have so far been seen as the guarantor of the secular system of Turkey. Although its influence has been reduced, the 2005 progress report of the European Commission on Turkey indicates that the military still has a significant influence on political development and government policies by making public statements.

2.3.2. Geographical Location: Is Turkey European?

Another argument which is made on Turkish membership is its geographical location. Turkey is located at a regional crossroads between the Balkans, Caucasus, Central Asia, Middle East and Eastern Mediterranean. The accession of Turkey would extend EU borders to the Caucasus (Azerbaijan, Georgia, Armenia), Middle East (Iraq, Iran, Syria) and the Black Sea. This will increase the Union's interests in these difficult regions and will have an impact on foreign policy of the EU. With the accession of Romania and Bulgaria the EU already have borders with Black Sea countries and the accession of Turkey will increase the EU's involvement in this region, which will also have an impact on relations with Russia as long as Turkey control the Bosphorus route from the Black Sea to the Mediterranean.

On the other hand, some are concerned that Turkey can be a transit country to the EU for problem areas like human trafficking, drugs, illegal immigration and other aspects of organised crime. Indeed, the eastern borders of Turkey have, historically, been difficult to control especially in mountainous regions (Hughes, 2004).

To sum up, according to the EU, Turkey could be an opportunity to increase stability and the role of the EU in the region, whilst also serving important trans-national issues like energy, water

sources etc. But it is also believed that this membership would present some challenges for foreign affairs (European Commission, 2004b).

There are also some critics who are questioning whether Turkey is European or not. These critics propose that Turkey is not in Europe and is not European historically and culturally, although according to Hughes (2004), Turkey is geographically on the edge of Europe. Moreover, the accession of the Republic of Cyprus, which is located nearly on the coast of Syria, weakens this argument. And historically, the history of Turkey, specifically the Ottoman Empire period, has always interweaved with the history of the rest of Europe where it was tagged as the "sick man of Europe" (Hughes, 2004).

2.3.3. The Cyprus Conflict

The Cyprus conflict has a large history to be mentioned in this study but basically the Turkish government's refusal of officially recognising the Republic of Cyprus is an important obstacle to Turkey's accession.

Actually the most recent problem in Turkey-EU relations comes from the Cyprus conflict. On December 17, 2004 in the Brussels European Council, when the EU decided to open accession negotiations with Turkey, Turkey confirmed that they were ready to sign an Additional Protocol to the Ankara Agreement extending it to all actual members of the EU. Turkey signed the protocol on July 29, 2005, although a declaration was included to the effect that the signature of the Protocol would not in any form constitute recognition of the Republic of Cyprus (Turkish Embassy, 2006). Moreover, Turkey recently rejected EU demands to open its borders to Greek-Cypriot shipping. In this case, Turkey is insisting that they will only open their ports if and when the isolation of the Turkish Cypriots is lifted as promised by the EU by April 2004. As a result on November 29, 2006, the European Commission recommended the partial suspension of talks and on December 11, 2006, EU foreign ministers agreed to follow the Commission's recommendation to sanction Turkey and suspend talks on eight of the 35 areas (Euractiv, 2007).

2.3.4. Migration and population

Within the EU, there are fears that with Turkey in the EU, freedom of movement could cause huge migration flows to the EU. These fears also applied to the 2004 enlargement and for this reason a flexible transition period of up to seven years was implemented. In the case of Turkish membership, it is believed that a transition period would also be used. On the other hand, according to Littoz-Monnet and Penas (2004) and Hughes (2004), Turkish migration could have a positive economic impact, since the EU has an aging demographic profile and limiting the freedom of labour movement would therefore constitute a lost opportunity. Hughes (2004) also postulates, that by 2015 (or 2025), countries and companies will be trying to encourage more migration rather than limit it since tight EU labour markets and skill constraints will exist.

Turkey is a large country in terms of population and it is economically small compared to other member states. These two points can cause several political and economic implications for Turkish membership. Turkey now has a population of 70 million and by 2025 this is expected to grow to 90 million (UN World population division, 2007). In population terms, Turkey would be the largest member of the EU ahead of Germany.

Using the forecast of the United Nations (UN) it can be calculated that Turkey would constitute 15.5 % of the EU's population in 2025 while in today's EU of 25 members Germany constitutes 18.1 % of the EU's total population. In these circumstances it can be concluded that Turkish accession does not present a new or unusual problem in terms of size as Turkey's relative share would differ very little from that of Germany's relative share of today's EU. (Hughes, 2004)

Moreover, in terms of population, Turkey is nearly the same size as the new ten members of the EU (see Table 2.1). Yet, the fact that Turkey is one country, not ten, its accession should be easier to manage for EU (Hughes, 2004).

2.3.5. Institutional Impact

Turkish accession will inevitably impact on EU institutions and decision-making processes[6]. Although the EU's institutions already adapted for the 2004 enlargement, some advise further reforms for Turkish accession.

With its high population, Turkey will have a large impact on the European Parliament, especially on the allocation of seats; the medium and large sized states in particular will have to lose seats which implies losing their voting strengths too (European Commission, 2004b).

The constitution introduces, as from November 1, 2009 a "double-majority" voting system for European Council (European Commission, 2004b). Then, "the majority shall be defined as at least 55% of the members of the Council comprising at least fifteen of them and representing Member States comprising at least 65% of the population of the European Union" (European Commission, 2004b, pp. 45). According to Hughes (2004), in an EU-28 both Turkey and Germany will have nearly 14,5% of the voting power for each which indicates that they will be important players but will be unable to block proposals even together. When the five largest countries come together in an EU-28 (i.e., Germany, France, Italy, the United Kingdom (UK) and Turkey), it is estimated that they will have 60,5 % of the vote by population which will be only 3,4% higher than the share of Germany, France, Italy and UK in EU-25, so Turkey will be an important state and will complicate the balance of power set of alliances and blocking combinations inside the EU (Hughes, 2004).

As an institution, The European Commission, will be perhaps less affected[7], since Turkey like all other member states will sometimes have a Commissioner and sometimes not.

[6] In particular, it will have direct impact on the three main institutions of the EU; Council, Commission and Parliament.
[7] Under the Constitution the Commission to be appointed as from the term starting in 2014 shall consist of a number of Members, including its President and the Union Minister for Foreign Affairs, corresponding to two thirds of the number of Member States, unless the European Council, acting unanimously, decides to alter this figure. The members shall be selected on the basis of a system of equal rotation between the Member States.

Hughes (2004), concludes his discussion about this issue indicating that Turkey will have a considerable institutional impact, but the accession of Turkey does not necessarily requires a major institutional reform.

2.3.6. Is the EU ready to integrate a Muslim state?

Perhaps, the biggest argument on Turkish membership is whether EU governments and societies are ready and willing to accept a large secular Muslim state[8] as part of the EU or not (Hoekman and Togan, 2005). On the other hand, the accession of Turkey is also perceived to be an opportunity for the EU to play a role in the reconciliation of Islam, democracy and the West (Littoz-Monnet and Penas, 2004).

2.4. TURKEY'S ECONOMY AND TURKISH AGRICULTURE

After discussing some political arguments on Turkish membership to the EU, this section gives an overview on Turkey's economy and the importance of agriculture in the Turkish economy. Moreover, a discussion on Turkish accession concerning agriculture provides a useful background to the reader before the impacts of the accession on the Turkish agro-food industry is analysed later in this study.

2.4.1 General overview of the Turkish economy

Turkey with its area of 769604 km^2 is the largest country among the thirteen Accession Countries (AC-13)[9] representing 15% of the EU-28 and 41% of the AC-13. Moreover, as pointed out in subsection 2.3.5 Turkey would be the largest member of the EU-28 in terms of population.

[8] Turkish accession would increase the EU's Islamic population from 3% to 20% (Nugent, 2005)
[9] AC-13: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, Slovenia and Turkey.

Figure 2.1 provides key indicators of Turkey's economy. Further discussion can be found in the following sections with comparisons to the EU values for some of them. Turkish GDP in 2005 was nearly 2,6 per cent of the EU-25 level and 51.7 per cent of the Accession-10[10] level which shows that Turkey is a significantly poorer country. Table 2.1 gives economic indicators for Turkey, Bulgaria, Romania, AC-10, EU-15 and EU-25. For a better comparison, in Table 2.1 GDP is also provided in purchasing power standards (PPS)[11]. Turkey's share in GDP at PPS of the EU-28 would be 4,1%. Turkey's income per capita of 6500 EUR (PPS) is considerably lower than the average EU-25 level (reaching only 28% of the EU-25), but is comparable to Bulgaria and Romania. As it can be observed in Table 2.1, Turkey's official unemployment rate is only slightly higher than the EU-25.

Indicator	Turkey	Bulgaria	Romania	AC-10	EU-15	EU-25
GDP at market prices (EUR billion)	290,5	21,4	79,3	561	10286	10847
Population	71,1	7,7	21,6	74,1	386,2	460,3
GDP per capita (EUR, current prices)	4000	2800	3700	7600	26500	23500
GDP per capita (EU-25=100)	17	12	16	32	113	100
GDP in PPS (EUR Billion)	466,1	59,8	173,1	989,3	9858	10847
GDP per capita (PPS)	6500	7700	8000	13350	25400	23500
GDP per capita (PPS) (EU-25=100)	28	33	34	57	108	100
Unemployment	10,3	10,1	7,2	n/a	7,9	8,8

Table 2.1 Indicators of the General Economy for Turkey, Bulgaria, Romania, AC-10, EU-15 and EU-25, 2005 (EUROSTAT, 2007)

[10] AC-10: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic and Slovenia

[11] The purchasing power standards (PPS), is an artificial currency that equalises the purchasing power between different currencies. Thus, expressing GDP in PPS eliminates differences in price levels between countries, and calculations on a per head basis allows for the comparison of economies significantly different in absolute size.

NATIONAL ACCOUNTS			
	2005[1]	**% average annual growth 1995-2005[2]**	
GDP EUR billion	290,5	3,2	
GDP per capita (EUR)	4000	1,5	
GDP per capita (PPS)	6500		
STRUCTURE OF THE ECONOMY			
Share of sectors in GDP (2005)[2]	**%**	**% average of annual growth 1995-2005[2]**	
Agriculture	11,9	1.0	
Industry	23,7	2.4	
Services	64.5	3.4	
EMPLOYMENT (2005)			
Employment by sector[3]	**%**		**%**
Agriculture	29,5	Labour force participation rate[3]	48,3
Industry	19,4	Unemployment rate[3]	10,3
Construction	5,3	Labour force growth 1999-2005[2]	1,6
Services	45,8		
EXTERNAL TRADE (2005)[1]			
Exports (EUR billion)	58,8	Imports (EUR billion)	93,4
Exports (% GDP)	19,7	Imports (% GDP)	32,1
Export to EU-25 (% of total)	53,6	Imports from EU-25 (% of total)	47,9
Share of sectors in exports[4]	**%**	**Share of sectors in imports[4]**	**%**
Agricultural products	11,3	Agricultural products	5,5
Food	10,5	Mining Products	24
Agricultural raw material	0,8	Manufactures	66,8
Mining Products	6,2	Other products	3,7
Manufactures	81,8		
Other products	0,7		

Figure 2.1 Key indicators of Turkish economy ([1] EUROSTAT, 2007, [2] World Bank, 2006, [3] Undersecretariat of Treasury, 2006, [4] Undersecretariat of Foreign Trade of Turkey, 2007) (Adapted from Oskam et al, 2004)

Turkey's economic growth shows high instability due to the economic crises which took place in 1994, 1999 and 2001. The growing fiscal imbalances following the capital account liberalisation, the appreciated exchange rate, together with extensive short term borrowing of commercial banks caused a currency crisis in 1994 which led to a decline in real GDP by approximately 6 per cent (Celasun, 1998). The Turkish economy went into another recession in 1999, when real GDP fell by 5%. The main reasons for this were a combination of the Russian crisis, political uncertainty and the earthquakes in August 1999. At the end of 1999, Turkey launched a stabilisation programme to achieve single digit inflation by 2002. Although significant progress was achieved during 2000, a severe banking crisis occurred in late November, accompanied by a currency crisis. The crisis resulted in a 7,5 per cent decline in GDP (OECD, 2002). Such instability inevitably represents a concern for the EU. However, after the crisis of 2001, the economy returned to a growth path (in 2002 recorded GDP growth rate was 7,8 per cent), inflation reduced and the currency stabilised. In Figure 2.2 Turkish real GDP (in national currency) and GDP growth are given for the period 1990-2005. As it can be observed from the figure, the real GDP nearly doubled between 1990 and 2005, where the growth rates are irregular especially between 1990 and 2000.

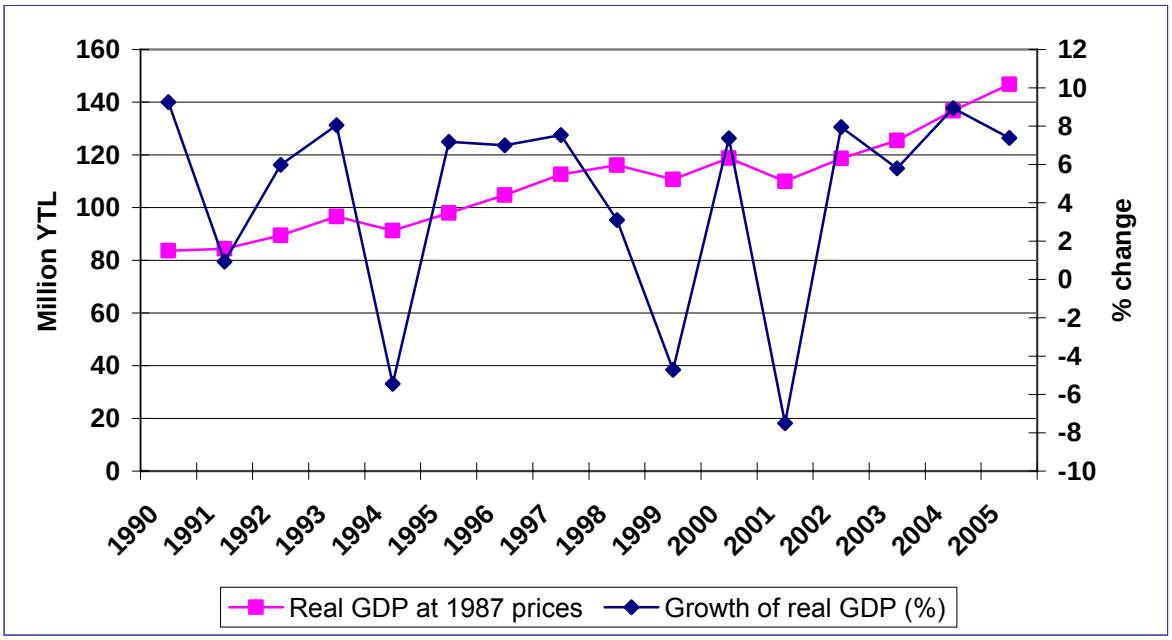


Figure 2.2 Real GDP and Real GDP growth rate in Turkey, 1990-2005 (Undersecretariat of Treasury, 2006)

In Figure 2.3 the economic growth path of Turkey, Bulgaria, Romania, EU-15 and EU-25 is shown for comparison. Turkey registers higher growth rates in more recent years than Bulgaria, Romania, EU-15 and EU-25 but also records instability in its economic growth, which is not observed for the other countries.

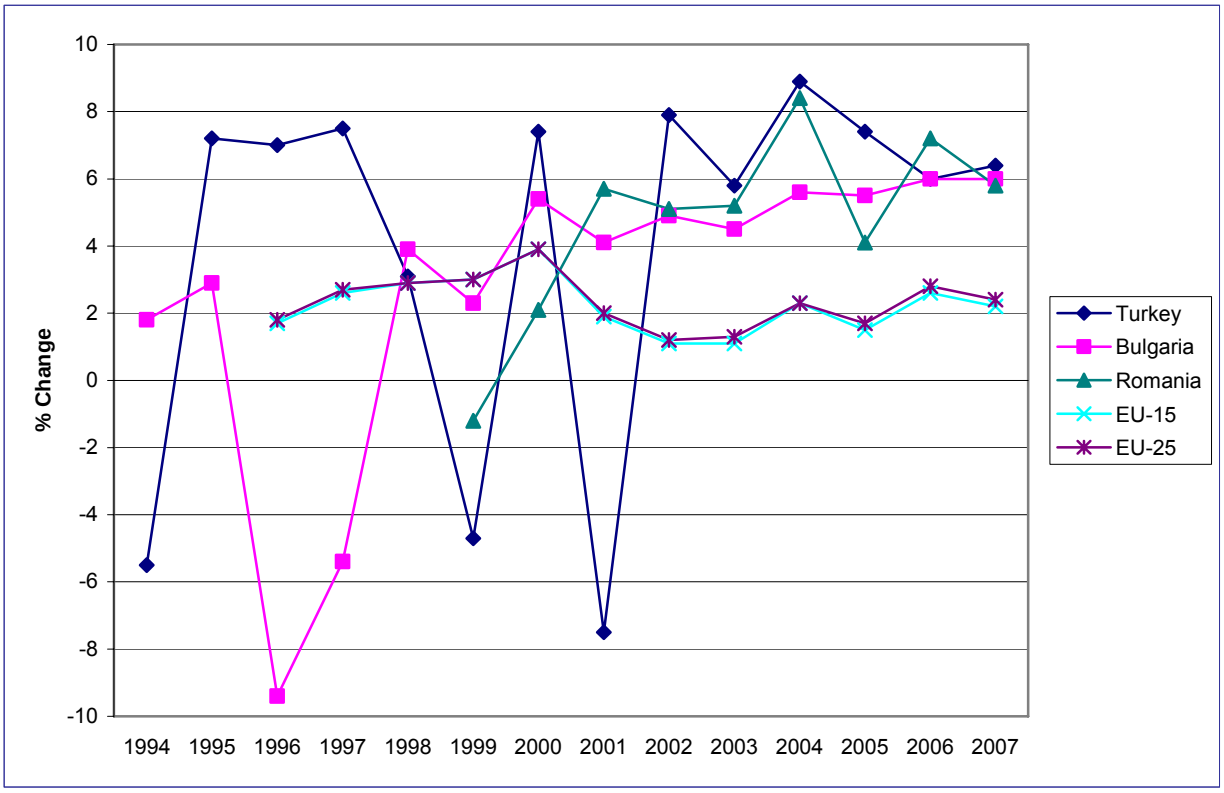


Figure 2.3 Real GDP growth rate Turkey, Bulgaria, Romania, EU-15 and EU-25 (IMF, 2006)

Price inflation in Turkey has historically been higher than EU-25 although it is decreasing since 1994. Turkish inflation fell to single digits in 2004 for the first time in 30 years and in 2005 average inflation in Turkey recorded 8,2 per cent per year whilst it was 2,2 in EU-25 (see Figure 2.4).

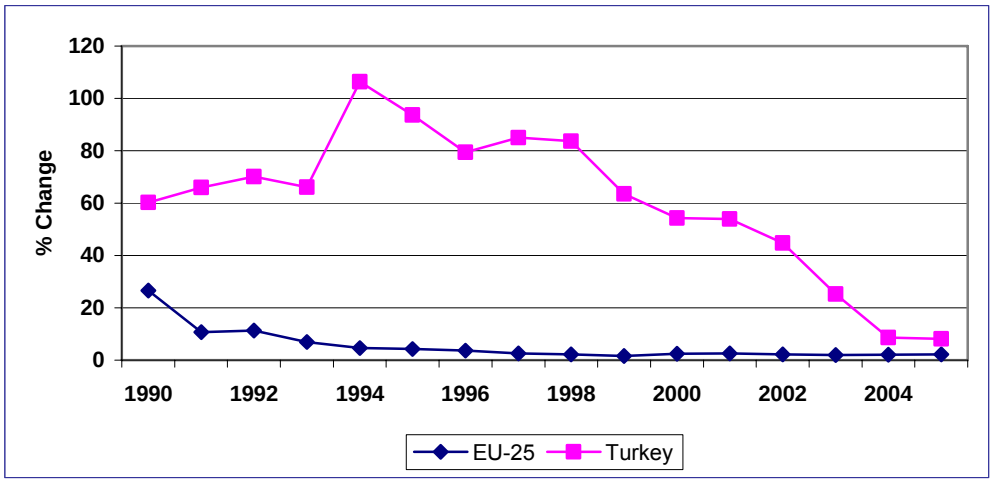


Figure 2.4 Inflation in Turkey and EU-25, annual percentage change in CPI (Consumer Price Index) (IMF, 2006)

In 2005, Turkey had a trade deficit of EUR 34,6 billion, with a total export value of EUR 58,8 billion and total import value of EUR 93.4 billion. In Figure 2.5 it can be seen that total export value is increasing in a stable manner since 1995, whilst total imports show a less regular pattern. Indeed, the crises in 1999 and 2001 and their concomitant impacts on incomes resulted in import reductions in Turkey. This result reflects the common observation that the propensity to import is particularly sensitive to changes in growth. Interestingly, the manufacturing sector accounts for 81,8 per cent of the total exports and 66,8 per cent of imports (see Figure 2.1).

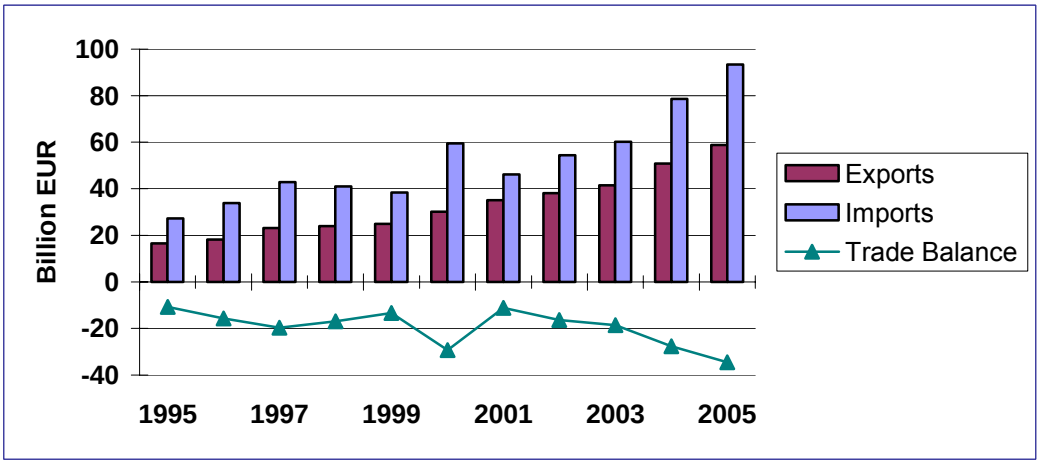


Figure 2.5 Total exports, imports and trade balance for Turkey, EUR billion (EUROSTAT, 2007)

The main Turkish export market in 2005 was the EU-25 with 53,6 per cent of exports, followed by the USA (6,9 per cent) and Iraq (3,5 percent). Textiles dominate EU imports from Turkey with 30,3 per cent of the total. Other important imports are transport equipment (20,1%), agricultural products (8,7%) and office and telecommunications equipment (7,1%). As in the case of exports the main Turkish import market was the EU-25 in 2005 accounting for 47,9 per cent of total imports. Other important import markets were Russia with 10,6 per cent and China with 4,5 per cent. The main EU exports to Turkey were transport equipment (22,2%), chemicals (17,4%), and machinery (17,4%). Moreover, Turkey is the EU's 7th most important trade partner in terms of EU imports and ranks 6th in exports. (European Commission, 2006c)

Household income distribution in Turkey shows inequalities. Although Turkey's income distribution improved in the past decade, still the richest 20 per cent of households receive 44,4 per cent of total disposable income (see Table 2.2). On the other hand, as shown in Table 2.2, income inequalities increased significantly between 1987 and 1994 especially in urban areas. This situation may be explained by economic crisis and immigration from rural areas to urban areas. Examining the time series data, Turkey recorded its best Gini coefficient[12] value in 2005 with 0,38.

Percentage of Households	Turkey				Urban				Rural			
	1987[1]	1994[2]	2002[2]	2005[3]	1987[1]	1994[2]	2002[2]	2005[3]	1987[1]	1994[2]	2002[2]	2005[3]
1st %20	5,2	4,9	5,3	6,1	5,5	4,8	5,5	6,4	5,2	5,6	5,2	6,1
2nd %20	9,6	8,6	9,8	11,1	9,3	8,2	9,7	11,5	10,0	10,1	10,3	11,3
3rd %20	14,1	12,6	14,0	15,8	13,6	11,9	13,9	16,0	15,0	14,8	14,7	15,9
4th %20	21,2	19,0	20,8	22,6	20,8	17,9	20,5	22,6	22,0	21,8	21,7	22,6
5th %20	49,9	54,9	50,1	44,4	50,9	57,2	50,4	43,5	47,9	47,7	48,0	44,2
Gini Coeff,	0,43	0,49	0,44	0,38	0,44	0,51	0,44	0,37	0,42	0,41	0,42	0,38

Table 2.2 Household income distribution in Turkey ([1] Oskam et al., 2004, [2] TURKSTAT, 2007a, [3] TURKSTAT, 2006a)

[12] The Gini coefficient is often used to measure income inequality. Here, 0 corresponds to perfect income equality (i.e. everyone has the same income) and 1 corresponds to perfect income inequality (i.e. one person has all the income, while everyone else has zero income).

According to Gini coefficient comparisons Turkey's income inequality is higher than Bulgaria, Romania, AC-10, EU-15 and EU-25 (see Table 2.3). Importantly, compared to other OECD countries, Turkey is the country with the second highest Gini coefficient after Mexico, where the OECD average is 0.31 (OECD, 2006).

	Gini Coefficient	
Countries	2001	2003
EU-25	0,29	0,29
EU-15	0,29	0,30
AC-10	0,29	0,29
Bulgaria	0,26	0,24
Romania	0,30	0,30
Turkey	0,44*	0,42

Table 2.3 Gini coefficients for Turkey, Bulgaria, Romania, AC-10, EU-15 and EU-25 (EUROSTAT, 2007) * 2002 figures

Turkey also shows high regional income disparities when compared to EU-15, AC-10, Bulgaria and Romania. The average ratio of GDP per capita between the richest and the poorest NUTS[13] II regions averages 2,4 in these countries whereas in Turkey it is 5,62 (Oskam et al., 2004). Thus, dealing with widespread poverty and especially with regional inequality will probably be Turkey's biggest economic challenge in the accession process.

2.4.2. Agricultural situation in Turkey

Agriculture is an important part of the Turkish economy, with its high shares in GDP and employment. Table 2.4 shows some indicators of the agricultural economy such as share of agriculture in GDP, employment, utilised land, agricultural output and foreign trade for Turkey, Bulgaria, Romania, AC-10, EU-15 and EU-25. The main trends from the data are that the share of agriculture in GDP has steadily declined over the last three decades from 37,3 per cent in 1970 to 10,3 per cent in 2005 and the

[13] The Nomenclature of Territorial Units for Statistics (NUTS) is a geocode standard which is developed by the European Union for referencing the administrative division of member states for statistical purposes.

share of agriculture in total employment has declined from 60 per cent in 1970 to 29,5 in 2005. Notwithstanding, these figures remain much higher than in the EU-25. (TURKSTAT, 2006b)

Agricultural Economic Indicators (2005)	Turkey	Bulgaria	Romania	AC-10	EU-15	EU-25
Share of agriculture in GDP (%)	11,1	8,2	12,2	n/a	1,6	1,6
Employment in agriculture (million)	7,4	0,3	3	3,4	6,2	9,6
Share of agriculture in civilian employed	34,0	10,7	32,6	11,9	3,8	5
Utilized agricultural area (1000 ha)	26578	5331	14324	33404	128989	162393
Output of the agricultural industry (Mio EUR)	n/a	3464	13654	30757	299688	330445
Agricultural imports in total imports (%)	4,8	6,2	6,8	n/a	6,1	6
Agricultural exports in total exports (%)	9,5	11,0	3,3	n/a	6	6

Table 2.4 Indicators of the agricultural economy for Turkey, Bulgaria, Romania, AC-10, EU-15 and EU-25 (European Commission, 2006a)

The share of agricultural imports to total imports in Turkey is relatively similar to the EU-25, whilst agricultural exports have a larger share of total exports. As a result, with the exception Romania, in no other EU state, does agriculture have such an important role.

2.4.2.1. Land in agriculture

As it is pointed out by Oskam et al. (2004) estimates of agricultural land in Turkey vary significantly according to the statistical source. An overview of land estimates which are obtained from Food and Agricultural Organization (FAO) and Turkish Statistical Institute (TURKSTAT) are given in Table 2.5 and 2.6.

	1985	1995	2004
Area Cultivated	23933	23588	23066
Area sown	17908	18464	18110
Fallow land	6025	5124	4956
Other agricultural land (Vegetable gardens, vineyards, orchards, olive trees)	3597	3246	3527
Total agricultural land	27530	26834	26593

Table 2.5 Agricultural land in Turkey according to TURKSTAT, 2006b, 1000 ha

	1985	1995	2004
Arable land	24595	24654	23358
Permanent crops	2935	2461	2655
Permanent pasture	10600	12378	13167
Total agricultural land	38130	39180	39180

Table 2.6 Agricultural land in Turkey according to FAO, 2007a, 1000 ha

Agricultural area in Turkey has declined according to TURKSTAT, whilst according to FAOSTAT it has increased. As a result of differences in estimates, it is difficult to comment on trends in agricultural land in Turkey. However, using the estimates of TURKSTAT it can be concluded that area cultivated and fallow land have declined slightly, the area of olive trees and vineyards has declined, the area of vegetable gardens has increased and the area of orchards has remained constant[14]. As a final point, 8,5 million hectares of the arable land in Turkey are economically irrigable where the total irrigated area now is about 4,9 million hectares (DSI, 2007).

2.4.2.2. Agricultural Holdings

The family owned farm, where family members provide most of the farm labour, is the basic unit of agricultural production (Hoekman and Togan, 2005). According to the results of the general

[14] This data is aggregated under the title of other agricultural land in Table 2.5 but disaggregated data can be found in TURKSTAT, (2006b).

agricultural census 2001 there are around 3 million agricultural holdings in Turkey in comparison with nearly 9,9 million in the EU-25, 6,3 million in the EU-15, approximately 0,7 million in Bulgaria and 4,5 million in Romania (European Commission, 2006a). The average holding size is 6 ha in Turkey as compared to 15,8 ha in the EU-25, 20,2 ha in the EU-15, 4,4 in Bulgaria and 3,1 in Romania. Thus, although the average size of agricultural holdings is far below the average of the EU-15 and the EU-25 it is above the accession members, Bulgaria and Romania. Around 66 per cent of the holdings in Turkey have less than 5 ha and 84 per cent less than 10 ha (see Table 2.7). By comparing the results of the 1991 and 2001 censuses it can be said that the total number of agricultural holdings in Turkey decreased by 25 per cent which can be related to the decrease in agricultural employment. The Gini coefficient is also provided in Table 2.7 which shows the high inequality in the distribution of the land between agricultural holdings in Turkey. According to these Gini coefficients it can also be said that inequality in the distribution of the land has not improved significantly over the last ten years (has declined from 0,60 to 0,59).

	Holdings				Average size of holdings (ha)	
	1991		2001			
Size of holdings (ha)	Number (1000 holdings)	%	Number (1000 holdings)	%	1991	2001
Without land	102	3	55	2	-	-
0-2	1386	34	1008	33	0,9	0,9
2-5	1275	31	951	31	3	3,1
5-10	713	18	560	18	6,5	6,8
10-20	383	9	327	11	12,8	13,4
20-50	174	4	154	5	26,8	27,4
50 +	37	1	22	1	108,6	95,5
Total	**4070**	**100**	**3077**	**100**	**5,8**	**6**
Gini*					0,60	0,59

Table 2.7 Number of agricultural holdings and average size of agricultural holdings in Turkey (TURKSTAT, 1994 and 2004a, *TUSIAD, 2005)

2.4.2.3. Agricultural Production

Turkey has a great range of climatic and topographical conditions and as a result Turkish agricultural production is highly diversified, offering a wide range of crops. Using the calculations of the total value of commodity quantities of FAO, Turkey's most widely grown crop in 2005 was wheat, followed by the activities of cow milk, tomatoes, grapes and chicken meat. Turkey also ranks in the world's top three producers for apricots, cherries, figs, hazelnuts, melon, cucumber, vetches, watermelon, apples, green beans, chickpeas, chillies and pepper, lentils, pistachios, sheep milk, sour cherries and tomatoes (FAO, 2007b).

	Turkey		Bulgaria		Romania		EU-25	
	Million €	%	Million €	%	Million €	%	Million €	%
Field Crops	12087	35,1						
Cereals	6608	19,2	635	20,8	3612	27,9	44615	13,8
Wheat	4208	12,2	341	11,2	1014	7,8	21430	6,6
Pulses	919	2,7						
Industrial Crops	2430	7,1	299	9,8	488	3,8	16601	5,1
Sugar Beet	796	2,3	1	0,03	14	0,1	5646	1,7
Oil Seeds	545	1,6	170	5,6	379	2,9	5876	1,8
Tuber Crops	1585	4,6						
Potatoes	986	2,9	89	2,9	1092	8,4	6997	2,2
Vegetables	6463	18,8	406	13,3	1694	13,1	24553	7,6
Fruits	7079	20,6	155	5,1	856	6,6	20511	6,3
Total crops	25629	74,5	1961	64,3	9501	723,3	191556	59,2
Milk	3711	10,8	326	10,7	951	7,3	42904	13,3
Meat	2308	6,7						
Eggs and poultry	2192	6,4	269	8,8	1029	7,9	18627	5,8
Total Livestock	8764	25,5	1088	35,7	3465	26,7	132091	40,8
Total agricultural output	34393	100	3049	100	12966	100	323647	100

Table 2.8 Value of agricultural output in Turkey, Bulgaria, Romania and EU-25, 2004 (TURKSTAT, 2007b and European Commission, 2006a)

The value of agriculture recorded in Turkey in 2004 was 34393 million euro which was 10,6 per cent of the output of the EU-25, 10 and 3 times bigger than the outputs of Bulgaria and Romania respectively. Table 2.8 provides agricultural output values for the main agricultural product categories for Turkey, Bulgaria, Romania and EU-25. In Table 2.8, some values are missing for the EU countries because data for Turkey is taken from the Turkish Statistical Institute and data in a similar format for the EU does not exists. Thus, all of the categories could not be matched with those for Turkish data.

Table 2.8 also shows that crop production is the most important agricultural activity, accounting for 74,5 percent of the total value of production. This is much higher than in the EU-25 and Bulgaria but is similar to Romania. Within crop production, field crops have the largest share with 35,1 per cent of the total agricultural production (see Table 2.9).

	Cereals	Pulses	Industrial Crops	Oil Seeds	Tube Crops	Fallow Land	Total
1975	13668	568	1185	1197	251	8177	25049
1980	13291	732	1226	1362	268	8188	25067
1985	13845	1433	1258	1489	304	6025	24354
1990	13711	2283	1392	1557	286	5324	24553
1995	13816	1867	1401	1537	355	5124	24100
2000	13963	1538	1388	1319	319	4826	23353
2004	13893	1547	1230	1306	272	4956	23204

Table 2.9 Area in field crop production in Turkey 1000 ha., 1975-2004 (TURSTAT, 2006b)

Figure 2.6 shows changes in cereal production[15] and area during the period 1990-2005. Over the past decade sown cereals area has been declining whilst the output has been increasing due to higher yields obtained.

[15] In Figure 2.6 cereal production and area only includes wheat, barley and maize as Turkish Statistic Institute provides production quantities only for wheat, barley and maize.

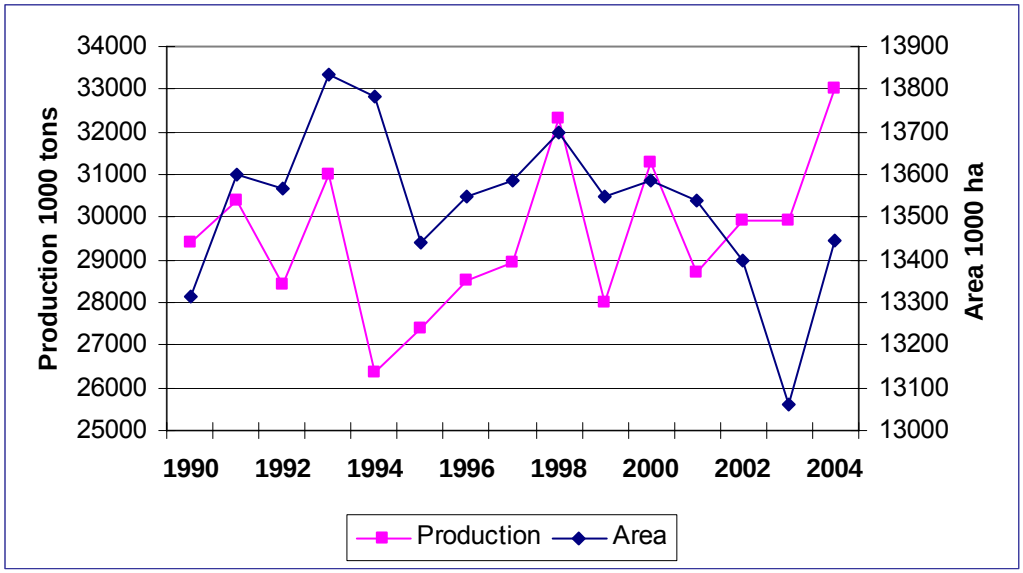


Figure 2.6 Cereal production and area in Turkey, 1990-2004 (TURKSTAT, 2006b)

Some selected cereal yields in Turkey are given in Figure 2.7 over the period 1990-2005. Both wheat and barley yields show a small improvement for this period, whilst maize yields have increased by nearly 25 per cent.

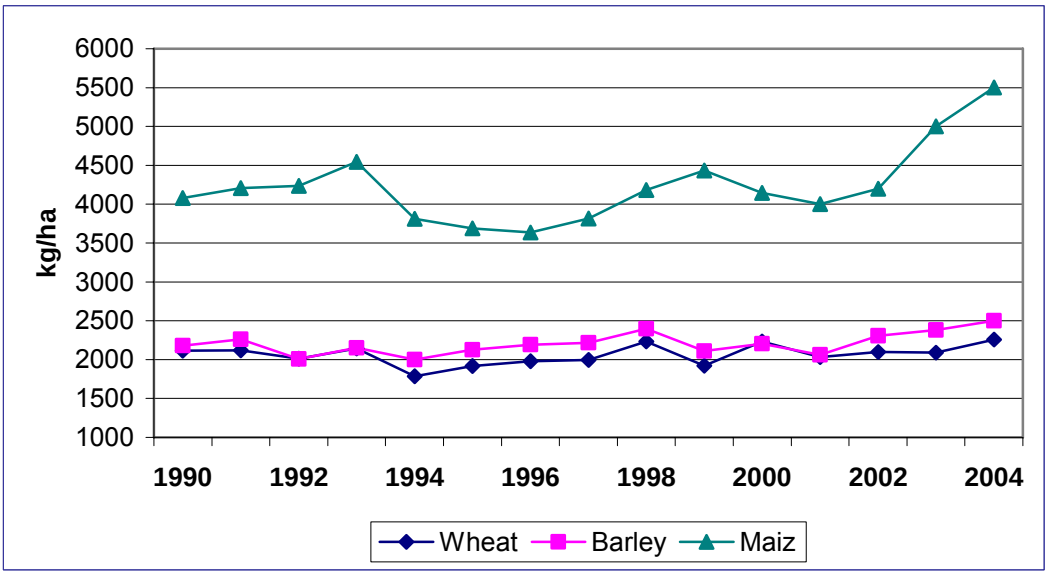


Figure 2.7 Wheat, barley and maize yields in Turkey, 1990-2004 (TURKSTAT, 2006b)

Although cereal yields improved in Turkey, they are still far below the average EU-25 yields. In 2004, the yield for wheat in Turkey was only 38 per cent of the EU-25, 52 per cent for barley and 65 per cent for maize (European Commission, 2006a) (see Figure 2.8 for cereal yields in the EU-25). However, according to Oskam et al. (2004), the average yield of EU-25 is heavily influenced by yields in the United Kingdom, France, Denmark, Belgium, Germany and the Netherlands, which are exceptionally high from world standards. On the other hand, average yields in Turkey for these products are more similar to those in Romania, where Turkey recorded higher yields for maize in 2004 (TURKSTAT, 2006b and European Commission, 2006a).

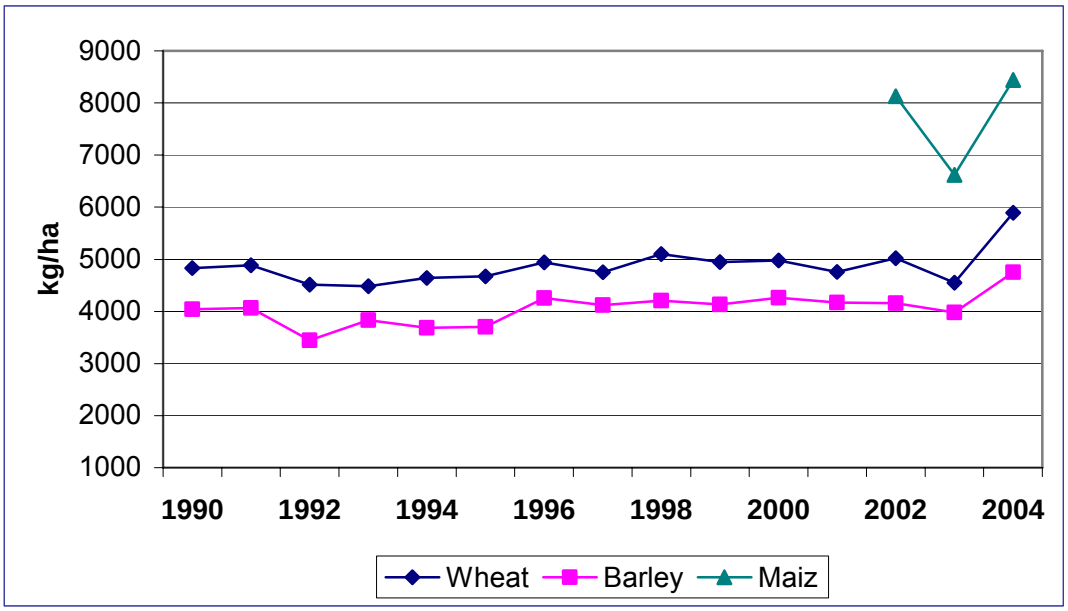


Figure 2.8 Wheat, barley and maize yields in EU-25, 1990-2004 (EUROSTAT, 2007 and USDA-FAS, 2007)

In contrast to the EU-25 and the AC-2, Turkey has a high production share in fruits (20,6 per cent) and vegetables (18,8 per cent) (see Table 2.8). In Table 2.10, the value of the key components of fruit and vegetable production is given. The most important products are grapes and tomatoes, which together account for nearly 30 per cent of the total.

	Million euro[16]	%
Vegetables	6463	47,7
Leafy or stem edible[1]	581	4,3
Leguminous	441	3,3
Fruit bearing[2]	5069	37,4
Root, bulb, tuberous[3]	299	2,2
Other[4]	73	0,5
Fruits	7079	52,3
Pome fruits[5]	1067	7,9
Stone fruits[6]	2263	16,7
Citrus	816	6,0
Nuts[7]	1007	7,4
Grape like[8]	1599	11,8
Green tea	327	2,4
Total fruits and vegetables	13542	100

Table 2.10 Fruit and vegetable output value in Turkey, 2004 (TURKSTAT, 2007a)

[1] Cabbages, artichokes, cress, celery, mint, lettuces, spinach, parsley etc.

[2] Tomato, watermelon, melon, cucumber, pepper, eggplant, squash, pumpkin

[3] Onion (green), carrot, radish, garlic (green), turnip

[4] Asparagus, cauliflower

[5] Apples, medlar, loquats, quinces, pears

[6] Apricots, cherries, sour cherries, nectarines, peaches, olives plums, cornel

[7] Almonds, chestnuts, hazelnuts, pistachios, walnuts

[8] Bananas, avocado, carobs, figs, grapes, mulberry, kiwi, strawberries, pomengranates, persimmons

As shown in Table 2.11, the total vegetable production in Turkey has more than doubled over the period 1980-2004 due to high increases in the production of fruit bearing and tuberous vegetables.

[16] Data provided by Turkish Statistic Institute have been converted from Turkish Lira to euros by using the annual exchange rate for the year 2004 from the European Central Bank (European Central Bank, 2007).

	Leafy	Fruit Bearing	Leguminous	Tuberous	Other	Total
1980	1094	10111	443	277	65	11990
1985	1289	12989	542	380	58	15258
1990	1420	13958	560	451	68	16457
1995	1492	16101	602	670	80	18945
2000	1671	19284	660	653	90	22358
2004	1686	19769	756	863	142	23216

Table 2.11 Trends in vegetable production in Turkey (1000 tons), 1980-2004 (TURKSTAT, 2004b and 2007)

Total fruit production increased by 61 per cent over the period 1980-2004 (see Table 2.12). This increase in production is largely attributed due to large increases in citrus production, which tripled over this period.

	Pome Fruits	Stone Fruits	Citrus	Nuts	Grape like	Total
1980	1819	738	875	470	4010	7912
1985	2352	806	983	422	3851	8414
1990	2407	1094	1474	630	4042	9647
1995	2599	1106	1782	715	4107	10309
2000	2901	1557	2222	758	4182	11620
2004	2513	2931	2707	592	4220	12963

Table 2.12 Trends in fruit production in Turkey (100 tons), 1980-2004 (TURKSTAT, 2004b and 2007)

Total livestock numbers in Turkey declined due to the degradation of pastures, increasing input costs and low competitiveness levels compared to imports (European Commission, 2003a) (see Table 2.13). On the other hand, the number of poultry increased by five times over the period 1980-2004.

	Cattle	Sheep	Goats	Poultry
1980	15894	48630	19043	58584
1985	12466	42500	13336	61046
1990	11377	40553	10977	96676
1995	11789	33791	9111	129015
2000	10761	28492	7201	258168
2004	10069	25201	6610	296876
Total % Change 1980-2004	-36,6	-48,1	-65,2	506,7

Table 2.13 Distribution of livestock (1000 head), 1980-2004 (TURKSTAT, 2004b and 2006c)

As can be seen in Figure 2.9 chicken meat production has more than doubled over the period 1990-2004 whilst sheep meat and beef has declined since 1998 and goat meat has stayed unchanged. Finally, milk is another important livestock which has a share of 10,8 per cent in total agricultural output. Cow milk production, which is the most produced, was 9,6 million tons in 2004.

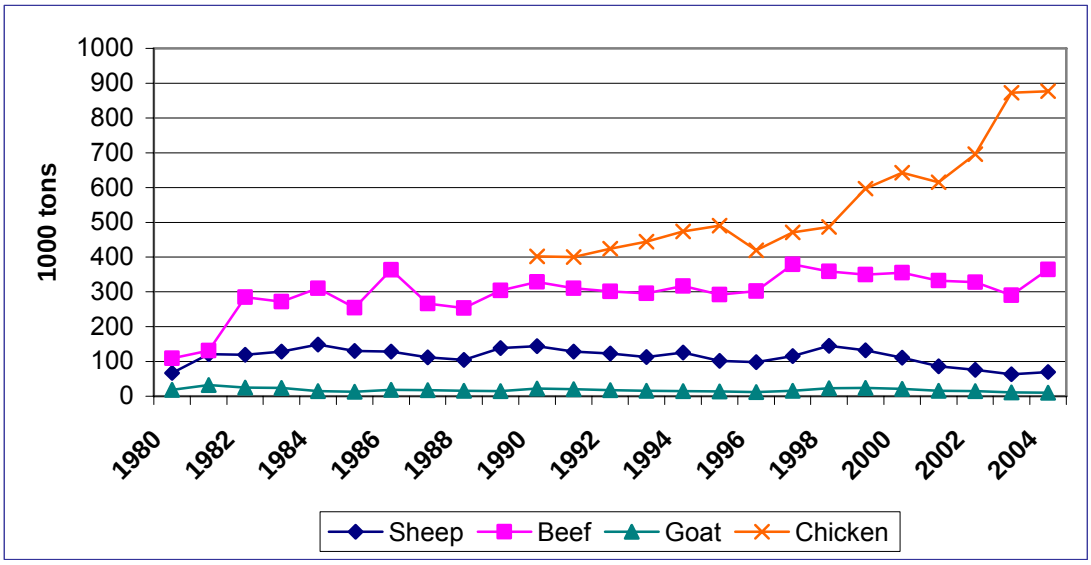


Figure 2.9 Meat production in Turkey, 1980-2004 (TURKSTAT, 2006b and FAO, 2007a)

2.4.2.4 Trade in agricultural products

Turkey exported about 4,8 billion EUR of agricultural and food products and imported 3,5 billion EUR in 2004 (see Figure 2.10). As shown in Figure 2.10, Turkey typically has a positive trade balance in agricultural products. Total agricultural exports contributed 9,5 per cent of total Turkish exports while the share of agricultural imports to total imports was 4,5 per cent[17]. In 2005, fruits contributed nearly 33 per cent of the total agricultural exports followed by preparations of vegetables and fruits with 17 per cent and vegetables with 7 per cent. As for agricultural imports, oilseeds with 20 per cent and animal or vegetable oils with 21 per cent have the highest shares in total agricultural imports.

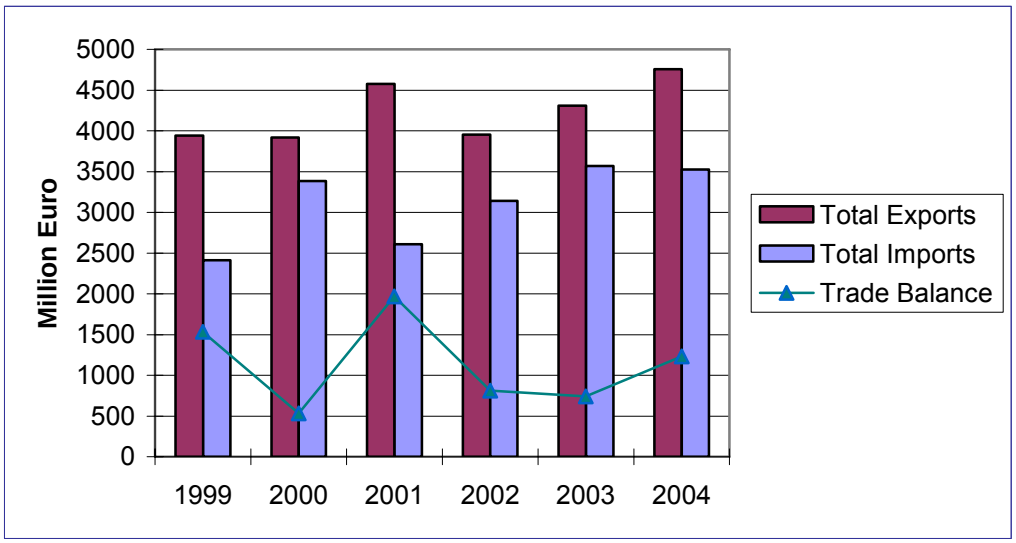


Figure 2.10 Agricultural and food products trade (TUSIAD, 2005)

[17] These shares vary according to the source of the data because, the definition of agricultural and food products also varies according to data source. In Figure 2.10 and Table 2.14 chapters 01-24 (excluding chapter 03 which is fish and seafood) of the Combined Nomenclature (CN), which is the usual definition adopted by European Community for trade statistics, is referred to as agricultural and food products. Data have been converted from US dollars to euros by using the annual exchange rate obtained for the years 1999, 2000, 2001, 2002, 2003 and 2004 from the European Central Bank (European Central Bank, 2007).

As mentioned earlier in this chapter, Turkey formed a customs union (CU) with the European Union in January 1996. As a result, Turkey adopted the EU's common external tariff for industrial goods and also eliminated quotas for industrial goods from EU and EFTA countries (Oskam et al., 2004). On the other hand, although agricultural products are excluded from the customs union, the EU granted some trade preferences to Turkey. According to Grethe (2003), more than 60 per cent of Turkey's agricultural exports to the EU entered the EU market without import barriers whilst another 36 per cent were subject to reduced tariff rates in 2001. In the same year, high import tariffs used for most important products of the CAP, such as meat, cereals, dairy products, olive oil and the minimum entry price system for some fruits and vegetables in certain periods were also used by the EU (Grethe, 2003). On the other hand, Turkey also granted preferential market access to many EU agricultural products. For this, in 1998 Turkey created 39 TRQs (Tariff rate quota) across abroad for a high variety of agricultural imports from the EU, where many products can be imported with its zero-tariff TRQ (Grethe, 2003). Grethe, (2003) also points out that although processed agricultural products seem to be included in the CU after its formation, the expected increase in trade did not occur. However, Grethe (2003) notes that most processed agricultural products are covered by Annex II of the Treaty of Rome as agricultural products (CN-chapters 16-20) and consequently these products are not included in the CU.

The EU-25 accounts for approximately 52 per cent of Turkey's total agricultural exports, which makes the EU-25 Turkey's major trade partner both in agricultural products and overall. The main exported products are fruits and nuts. Turkey's agricultural imports from the EU-25 account for about 30,5 per cent of total agricultural imports and are more diverse than exports. Table 2.14 shows agricultural trade flows between Turkey and the EU-25 for 2003 and 2004. As can be seen from the Table, Turkey has a trade surplus with the EU-25 in agriculture, in the sample period (approximately 1 billion € and 1,4 billion €).

		EU-25 Imports from Turkey		EU-25 Exports to Turkey	
CN code	Products	2003	2004	2003	2004
01	Live animals	2,4	2,1	5,6	6,2
02	Meat and edible meat offal	1,2	1,9	0,6	1,4
04	Dairy produce; eggs; natural honey	33,3	12,9	28,8	28,0
ex,05	Other products of animal origin	42,3	34,4	2,1	2,6
06	Live plants and floricultural products	23,6	22,7	11,6	16,2
07	Edible vegetables, plants, roots and tubers	188,7	203,8	6,3	8,0
08	Edible fruit and nuts; peel of citrus fruit or melons	790,1	974,5	5,7	7,8
09	Coffee, tea, maté and spices	16,6	19,0	3,7	4,7
10	Cereals	22,6	13,8	70,0	34,9
11	Products of the milling industry; malt; starches	8,5	10,4	4,7	7,8
12	Oilseeds and oleaginous fruits	40,0	39,9	34,1	40,2
13	Lac; gums, resins, other vegetable saps and extracts	0,4	0,5	17,6	21,5
14	Vegetable plaiting materials etc	6,6	7,3	0,2	0,2
15	Animal or vegetable fats and oils	92,8	47,7	55,0	46,1
ex,16	Meat preparations	0,0	0,2	2,6	3,6
17	Sugars and sugar confectionery	28,4	40,1	12,1	18,7
18	Cocoa and cocoa preparations	21,3	19,1	45,8	55,4
ex,19	Preparations of cereals, flour or starch	27,0	37,7	31,8	41,4
20	Preparations of vegetables, fruit or nuts	412,0	657,9	9,3	13,5
21	Miscellaneous edible preparations	28,8	38,0	51,2	64,1
22	Beverages, spirits and vinegar	34,8	41,9	58,1	79,7
ex,23	Residues and waste from the food industries	1,9	1,6	29,7	35,9
24	Tobacco and manufactured tobacco substitutes	115,6	124,4	81,1	109,4
01-24	TOTAL agricultural products - Chapters 01 to 24	1939,1	2351,9	567,7	647,1
Other	Other agricultural products included in the Uruguay Round	109,5	119,6	461,4	429,5
Total	**TOTAL - AGRICULTURAL PRODUCTS**	2048,6	2471,6	1029,2	1076,7
01-99	**TOTAL – ALL PRODUCTS**	24015,7	30282,1	28219,4	37453,1

Table 2.14 EU agricultural trade with Turkey, EUR million (European Commission, 2006a)

2.4.2.5. Agricultural policies and support in Turkey

According to a European Commission report (2003), the competitiveness of Turkish agriculture and food industries represents one of the major political and economic challenges from the point of view of agricultural policies.

Market price support, input subsidies and supply control measures for crops were three important channels of support to Turkish agriculture. Market price supports for important crops (cereals, oilseeds, cotton, tobacco and sugar beet) have been the most important part of the agricultural support structure in Turkey, but this is changing with the implementation of the reform program (see below). State-owned enterprises (SOEs) and agricultural sales cooperative unions (ASCUs) were commissioned to buy commodities from farmers at the announced floor prices while independent buyers could also buy these commodities (Oskam et al., 2004). Input subsidies were the second most important pillar of agricultural support. Various subsidies were used to reduce input prices of fertilizer, seed, pesticide and irrigation. Farmers were also permitted to take loans subsidised by government at low interest rates from the Turkish Bank of Agriculture. Supply control measures were also used to control the output of tobacco, hazelnuts, tea and sugar beet (Hoekman and Togan, 2005).

Until the late 1990s these agricultural support policies were so expensive and unsustainable that they were causing macroeconomic problems to Turkey (World Bank, 2001). As a result, Turkey decided to reform its agricultural policies with support from the World Bank and the International Monetary Foundation (IMF) and developed the Agricultural Reform Implementation Project (ARIP). The objective of the ARIP is to phase out price support and input subsidies, to privatize state enterprises in agriculture and introduce direct income support (DIS) payments in order to compensate farmers. This project began in 2000 with a pilot program which covered four regions selected and then was employed nationwide in 2001-2002 (Hoekman and Togan, 2005).

	1998		1999		2000		2001		2002		2003		2004	
	Mln €	%	Mln €	%	Mln €	%	Mln €	%	Mln €	%	Mln €	%	Mln €	%
Market Price Support	7714	82	5339	74	6255	83	-52	-7	4457	73	7883	80	6996	77
Payments based on output	40	0	251	3	387	5	507	67	172	3	208	2	287	3
Payments based on historical claims	0	0	0	0	0	0	76	10	1317	21	1614	16	1597	18
DIS	0	0	0	0	0	0	76	10	1317	21	1372	14	1400	15
Diesel payment	0	0	0	0	0	0	0	0	0	0	186	2	198	2
Payments based on input use	1643	18	1601	23	887	12	232	30	179	3	157	2	174	2
Based on use of variable inputs	1571		1539		785		134		66		58		50	
Concessional loans	973		1142		502		0		0		0		6	
Fertilizer subsidy	442		230		172		51		0		0		0	
Seed loans	51		67		23		0		0		0		28	
Based on use of on-farm services	9		7		9		9		9		9		10	
Based on on-farm investment	63		56		93		88		104		90		114	
Total	9397	100	7192	100	7528	100	763	100	6125	100	9862	100	9055	100

Table 2.15 Agricultural support in Turkey, 1998-2004 (OECD, 2007a)

After this reform, payments based on input use were phased out, including fertilizer and loan subsidies (see Table 2.15). Although government tried to reduce market support prices, this level increased in 2002 and 2003 due to falls in world prices (TUSIAD, 2005). In Table 2.15 it can also be seen how the Turkish government has tried to compensate farmers for the drop in input subsidies with increases in direct income support payments. All farmers who are cultivating between 0,5 ha and 20 ha now receive a DIS payment and they are all registered under the Farmer Registration System (FRS) (European Commission, 2003).

2.4.2.6. Agricultural Policies in the EU: The Common Agricultural Policy – A Brief Overview

The Common Agricultural Policy (CAP) of the EU was initially conceived as a response to the food shortage problems in the wake of World War II. Based on the principles of a common market of farm products with common prices, and the free movement of goods within the community, the CAP had five initial objectives: (1) to increase productivity, (2) to ensure a fair standard of living for farmers, (3) to stabilize markets, (4) to secure availability of supplies and (5) reasonable prices for consumers. The CAP is funded by the European Agricultural Guidance and Guarantee Fund (EAGGF). Up until the 1980s, the main mechanisms of the CAP were artificially high support prices above world prices and the use of import tariffs, non-tariff barriers and export subsidies to guarantee higher internal CAP prices. High internal prices penalized consumers while encouraging farmers to increase their production, leading to surpluses. As a result, in the EU, like in Turkey, domestic agricultural policies were creating excessive budgetary burdens and conflicts in international trade relations.

The first serious attempts to reform the CAP started in the 1980s, with the introduction of production quotas in the dairy sector and support price reductions in the cereals and livestock sectors. In 1992, the MacSharry reforms were created to limit rising agricultural production, by introducing further reductions in EU intervention prices, balanced by direct payments. In addition to this, the principle of cross-compliance was introduced to limit production which was based on rewarding farmers for less intensive usage of production inputs (i.e. extensification premium, compulsory land set-aside). One of the main catalysts of this reform was the need then the position of the EU at the Uruguay round of the General Agreement on Tariffs and Trade (GATT) negotiations. (Philippidis, 2004)

In March 1999, the Agenda 2000 reform package was approved at the Berlin Council. The aims of the reform were the same as that of ARIP: to minimize the government's role in setting prices and make further reductions in support prices with increases in area-based and headage-based direct payments (Hoekman and Togan, 2005). In addition, second pillar support was introduced to shift resources from market support (first pillar support) into rural development (Philippidis, 2004). Notwithstanding, further reform of the CAP was always inevitable given the internal pressure of the

possible budgetary consequences of EU enlargement and the external pressure of the ongoing World Trade Organization (WTO) trade talks (Hoekman and Togan, 2005). On June 26, 2003, EU farm ministers adopted a fundamental reform of the CAP that had been proposed in the Mid-term Review of the CAP in January. The key elements of this reform were as follows: (1) most support will be in the form of a decoupled 'single farm payment' (SFP) (i.e. independent of production level) linked to environmental, food safety, animal and plant health and animal welfare standards, as well as the requirement to keep all farmland in good agricultural and environmental condition ('cross-compliance'), (2) rural development policy will be strengthened with new measures and more money, (3) direct payments will be reduced in order to finance the new rural development policy ('modulation'), (4) a mechanism will be introduced for financial discipline to ensure that the farm budget fixed until 2013 is not overshot, (5) some specific revisions to the market policy of the CAP (including asymmetric price cuts in the milk sector, reduction of the monthly increments in the intervention price for the cereal sector and reforms in the rice, durum wheat, nuts, starch potatoes and dried fodder sectors) (European Commission, 2003b).

Although the Mid-term reforms decoupled payments from production in cereals and oilseed and partially in beef sectors, a large proportion of sugar, tobacco and fruits and vegetables were untouched (Hoekman and Togan, 2005). On February 20, 2006, EU agriculture ministers decided to adopt a radical reform of the EU sugar sector reducing the guaranteed price for white sugar, whilst farmers are compensated within the SFP. The reform also includes a reduction in sugar production quotas (European Commission, 2006b). Further reforms for the sugar sector are proposed on May 7, 2007 in order to reduce sugar output as the changes done in 2006 did not result in expected quota renouncements (European Commission, 2007d). The European Commission on January 24, 2007 also proposed wide-ranging reforms to the Common Market Organization for fruit and vegetables to bring this sector closer into line with the rest of the reformed Common Agricultural Policy (European Commission, 2007b). The reforms, which are agreed by EU agriculture ministers on June 12, 2007, the fruit and vegetables sector will be integrated into the SFP, export subsidies for these sectors will be abolished and Producer Organisations (POs) will be offered a wider range of tools for crisis management (European Commission, 2007c). Furthermore, on July 4, 2007, the European Commission is currently debating a reform package for the EU wine sector to regain the lost market share like the

case of the fruits and vegetable sector by incorporating this sector to the SFP (European Commission, 2007e). Taking into account WTO trade talks it seems that further reforms for the CAP are under way.

2.5 RECENT STUDIES ON EUROPEAN UNION ENLARGEMENT

As discussed in the following chapter, computable general equilibrium modelling represents a powerful analytical tool for assessing the impact of bilateral, regional and multilateral reform scenarios, as well as market integration scenarios (i.e., EU enlargement). Accordingly, the modelling approach dominates the relevant literature on EU enlargement and CAP integration. Thus, in the first subsection studies on twelve accession countries (AC-12[18]) are briefly reviewed. Subsequently, it is continued with studies on Turkish accession.

2.5.1 AC-12 integration into the EU

Earlier studies dealing with the integration of AC-12 to the EU by employing CGE techniques include Baldwin and Francois (1996), Brockmeier et. al. (1996), Frandsen et. al. (1996), Baldwin et. al. (1997), Hertel et. al. (1997), Swaminathan (1997), Liapis and Tsigas (1998), Jensen et. al. (1998), Banse (2000), Herok and Lotze (2000), Fuller et. al. (2002), Brockmeier et. al. (2003), Jensen and Frandsen (2003), Scrieciu (2004) and Scrieciu and Blake (2005). Table 2.16 provides an overview and comparison of these studies.

[18] AC-12: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic and Slovenia.

Selected Studies	Model Characteristics	Notes
Jensen et. al. (1998)	• Multiregional and static CGE model under perfect competition • Projections for 2005 • GTAP v4 database • 16 regions and 19 commodities including 16 agricultural commodities	• Captures the effects of important features of the CAP and the Uruguay Round agreement (includes import-export policies, compensatory payments with set-aside premium, milk and sugar quotas and EU budget) • AC-10 is treated as a single entity
Herok and Lotze (2000)	• Multiregional and static CGE model under perfect competition • Projections for 2005 • GTAP v3 database for 1992 • 10 regions and 10 sectors including 7 agricultural sectors	• Captures 1992 CAP reform and implementation of Uruguay round • AC-7 (Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia) is treated as a single entity
Jensen and Frandsen (2003)	• Multiregional and static CGE model under perfect competition • Projections for 2013 • GTAP v5 database for 1997 • 40 regions and 24 commodities of which 12 are primary agricultural commodities and 8 are secondary	• Captures features of the CAP and Agenda 2000 reform (includes direct payments with set-aside requirements, milk and sugar quotas and EU budget) • All members of AC-10 are explicitly represented
Brockmeier et. al. (2003)	• Multiregional and static CGE model under perfect competition • GTAP v5 database for 1997 • 14 regions and 14 sectors	• Includes specific instruments of the CAP and the EU budget (quotas, direct payments, set-aside regulation and a budget module) • All members of AC-12 are explicitly represented
Scrieciu and Blake (2005)	• Single country static CGE model under perfect competition • 1997 data is used (A modified GTAP database format) • 5 regions and 23 sectors of which 11 are agricultural and 7 are food-processing activities	• AC-10 is treated as a single entity whilst Romania and Bulgaria are explicitly represented.

Table 2.16 Overview of selected studies on EU enlargement of AC-12

2.5.2 Studies on Turkish Membership

In this subsection a number of studies that explore the economic implications of the agricultural market integration between Turkey and the EU are reviewed. The analytical studies on this subject can be grouped into two; firstly, studies that investigate the economic implications of the possible Turkish membership and second, studies that assess the effects of a possible extension of the customs union to cover all agricultural products (as discussed in section 2.2 that agricultural products are excluded from customs union agreement). The first group includes Acar (1999), Bayar et. al. (2000), Bekmez (2002), Çakmak and Kasnakoğlu (2002), Lejour et. al. (2004), Hoekman and Togan (2005) and Sulamaa and Widgrén (2007). The second group includes Harrison et. al. (1996), Köse (1996), Santis (1996), McClatchy (1997), Grethe (1999 and 2003) and Zahariadis (2005).

Of the studies found, seven of them are discussed given their focus on the agriculture sector. Bayar et al. (2000) studied issues on agricultural trade liberalization, growth and capital accumulation in the context of a world economy using an intertemporal, multi-region general equilibrium model with 9 regions (Asia, EU, EFTA and economies in transition, Former Soviet Union, Turkey, Morocco, rest of Middle East, rest of North Africa and rest of world) and 9 sectors including 5 agriculture sectors (grain crop agriculture, vegetables-fruits-oil, sugar, animal products and other agriculture) and an agribusiness sector. The authors focused on Turkey, the EU, the Middle East and the economies in transition. Data used in this study comes from the GTAP v3 database. This study implements two policy experiments for Turkey. In the first experiment the customs union agreement between Turkey and the EU is expanded to cover all sectors by eliminating all bilateral tariffs between two parties whilst Turkey implements the EU's common external tariff on third countries. In the second experiment a Middle East and North Africa (MENA) customs union between Turkey, Morocco, the rest of the Middle East and North Africa is established. In an additional scenario, the MENA is extended to include the economies in transition and the Former Soviet Union. The model results suggest that the size of the expected positive effects of the current CU agreement between Turkey and the EU depend on whether non-tariff barriers could be eliminated and a move towards a more competitive environment could be achieved. On the other hand, the customs union which is established in both simulations in the second experiment yields more gains to Turkey in comparison to the CU with the EU.

Bekmez (2002) analyse the sectoral impact of Turkish accession to the EU. In order to achieve the objectives of the study, a CGE model for the Turkish economy (TRCGE) is developed. The model consists of 22 different sectors (imperfect competition in the Turkish manufacturing sector) including a basic agriculture and an agribusiness sector and three regions including Turkey, European Union and rest of the world (ROW). In the study, four policy experiments are implemented. The first experiment assumes that Turkey eliminates tariff rates on EU imports for the manufacturing sector (tariff rates on the agricultural and services sectors are not eliminated according to the customs union agreement). In the second experiment, Turkey becomes a member state of the EU eliminating its tariff rates for EU imports (whilst the EU does the same for Turkish imports) and continues to impose higher tariff rates on 'third' countries. In this scenario the EU compensates a proportion of the losses of the Turkish government caused from the reduction of the tariff rates. In the third experiment Turkey also accedes to the EU but the tariff reduction is compensated by increases in the domestic tax rate in Turkey. The fourth experiment analyses a case of free trade where Turkey reduces tariff rates for all countries. According to the results of the study; the full membership (second experiment) seems to be most beneficial scenario for the Turkish economy where domestic production, domestic sales, trade volume and profit rates increase.

Çakmak and Kasnakoğlu (2002) conducted an analysis that utilizes a regional, partial equilibrium static optimisation model (TASM-EU) of Turkish agricultural sector. The study focuses on the impacts of the customs union and EU membership. The base period used is the average of the years 1997, 1998 and 1999 and projections are made for the year 2005. A status quo scenario where Turkey remains outside of the EU in 2005 is analyzed next to various EU membership scenarios. The first simulation conducted under the EU membership scenario includes EU prices except compensatory area payments, while the second simulation includes these payments. The difference of the third simulation from the first one is a technological improvement in Turkey's livestock production. The welfare results indicate that after membership, producers' surplus decreases whilst that of consumers increases. High proportion of consumers' surplus causes an increase in total welfare under all scenarios. The overall results also are similar to the welfare impacts which indicate that the membership will be beneficial to the consumers and will upset the producers.

Grethe (2003) presents another study to investigate the effects of expanding a customs union between Turkey and the EU to all agricultural products. In this study a comparative static regional partial equilibrium model (TURKSIM) of Turkey's agricultural sector (supply side of the model includes 12 crops, 17 vegetables and fruits, and 5 animal products with processing activities in sunflower, cotton and soybean). 1997-1999 averages are used for the based period of the model, whilst the model is projected to 2006. A status quo scenario is developed as a baseline, characterised by no changes agricultural policies and compared with two scenarios. In the first scenario Turkey eliminates all tariffs and export subsidies. The second scenario expands the CU agreement to include all agricultural products. The model's estimates indicate that consumers gain whilst producers lose under both scenarios compared to the status quo. Results reveal that the net gain (consumers' welfare minus producers' surplus) in trade liberalisation is 0,7 billion EUR while this number is 0,5 billion EUR for the CU expansion scenario. Total welfare gains are higher under the first scenario than the second one. These results are consistent with those of Çakmak and Kasnakoğlu (2002). In his study Grethe also points out that Turkey will become a net importer of agricultural products, whilst it is a net exporter in the status quo.

Zahariadis (2005) also studies the economic implications of a deep integration in the customs union between Turkey and the EU. However his study differs from the studies of Çakmak and Kasnakoğlu (2002) and Grethe (2003) by employing a CGE model. The standard GTAP model (based on perfect competition) is extended to capture the effects of non-conventional regulatory barriers (includes internal-external standardisation and certification costs). The author employs data from the GTAP v5 dataset for 1997, aggregated into 9 regions (NAFTA, EU, EFTA, CEEC, Former Soviet Union, North Africa, Middle East, Turkey and rest of world) and 20 sectors including 4 agricultural sectors. In the study, six policy experiments are employed on different issues on traditional integration (e.g., includes only the extension of the CU to cover all agricultural products) and deep integration in the CU (e.g., extending it to cover all agricultural products including the adoption of the EU technical regulations or harmonisation with the EU standards or abolition of certification costs). According to his findings, traditional integration can have a strong positive effect on Turkey's welfare, but a small negative effect on EU's total welfare. Under these traditional integration scenarios Turkey gains between US$ 480 m to US$ 1,4 billion in terms of equivalent variation (EV) (a measure for welfare, for

further discussion on EV see chapter IV - 4.4.7.2). On the other hand, results of the deep integration scenarios reveal that deep integration can have positive impact on Turkey's welfare whilst this positive effect will be smaller for the EU. The author notes that the benefits of deep integration will be realised in full only when all relevant restrictions (including both standardisation and certification) are accounted for (under this scenario Turkey records a welfare gain of US$ 1 billion while in the EU the welfare only increases by US$ 63 m.

Lejour et al. (2004) analyse three main issues linked with Turkish membership; accession to the internal European Market, institutional reform in Turkey initiated by the EU-membership; and migration in response to the free movement of workers. The authors utilized a CGE model for the world economy called 'Worldscan' which is calibrated on the basis of the GTAP v6 database. The data is aggregated into 16 regions (including Germany, France, United Kingdom, Italy, Netherlands, rest of the EU-15, AC-10, Bulgaria, Romania, Croatia, Turkey, Former Soviet Union, rest of OECD, Middle East-North Africa and rest of world) and 20 sectors including 1 agriculture and 1 food processing sector. The authors developed a status quo baseline to 2025. More specifically, the baseline scenario incorporates developments inside and outside Turkey that can be foreseen like demographic projections, economic growth, the accession of AC-10, Romania and Bulgaria, and the completion of the textiles and clothing agreement. Subsequently, the authors implemented three scenarios to appraise the implications of EU accession. In the first scenario the accession of Turkey to the EU is investigated by focusing on the trade effect of the internal market. To simulate this they used gravity estimations for determining the potential trade increase per sector and then these estimations are translated into a Samuelsonian iceberg trade-cost equivalent which is referred as a non-tariff barrier (NTB), where these barriers are removed in the model. The second scenario implements Turkish institutional reform (less corruption and more transparency) triggered by EU membership. This is done by deriving the trade potential between Turkey and other countries under institutional reform conditions (again via gravity estimation). The third scenario imposes migration flows from Turkey to the EU following the accession. Under the all scenarios it is assumed that Turkey enters the EU in 2010. The main findings of this study indicate that the accession to the internal market benefits Turkey: welfare (in terms of EV) increases by US$ 4.4 billion while GDP rises by about 0.8 per cent in the long term. The accession also has a small positive effect on the EU-15 and AC-10. Under the second scenario (improvements in institutions),

welfare increases by US$ 28.2 billion whilst Turkish GDP expands by 5,6 per cent. The results of the third scenario show that Turkish GDP declines by between 1,8 per cent and 2,2 per cent while in the EU-15 GDP increases by between 0,5 per cent and 0,7 per cent. Per capita income in Turkey rises whilst declines slightly in the EU. If migrants are primarily unskilled, also wage inequality rises in the EU-15. Of the three different scenarios the improvements in institutions bring the greatest gains to Turkey.

In a recent study Sulamaa and Widgrén (2007) analysed the effects of elimination of trade barriers between EU-25 and Turkey and application of the common external tariff in Turkey under Turkish membership. In this study like Acar (1999), Bayar et al. (2000), Lejour et al. (2004) and Zahariadis (2005), the GTAP model is used. The authors modified the standard GTAP model to introduce imperfect competition by existence of scale economies on non-agricultural sectors. The version 6 GTAP database is aggregated into 8 regions (Turkey, Germany-Austria, North EU, South EU, Balkan countries, NAFTA, ASIA and rest of world) and 15 sectors including only one agricultural sector. The authors implemented three scenarios to assess economic effects of market structure on the costs of Turkish membership. In the first scenario, EU membership employs the standard assumption of perfect competition. In the second scenario, EU membership incorporates imperfect competition with no entry (assuming existence of scale economies and profit) and in the third scenario, EU membership includes imperfect competition with free entry and exit (zero profit assumption). The results indicate that Turkish membership is beneficial for Turkey and it does not have significant negative effect for the rest of world. Under the imperfect competition with no entry scenario, Turkey's welfare gain (US$ 700 million) is higher than under perfect competition (US$ 300 million).

Studies on the financial consequences of Turkish membership to the EU budget also are reviewed. According to these studies if the current rules still applied on Turkish entry, Turkey would be eligible for substantial net transfers from the EU budget given that Turkey is a relatively poor country (i.e., smaller budgetary contributions) with a large agricultural sector (i.e., larger budgetary receipts). Large positive net transfers are estimated in various studies including; Dervis et al. (2004), European Commission (2004b), Hughes (2004), Lejour et al. (2004), Quaisser and Wood (2004) and Grethe (2005). The estimated net costs (including CAP first pillar, CAP second pillar, structural policy funding,

other items and Turkey's contribution to the EU budget) vary between 8 billion EUR to 26 billion EUR. The variance in these estimates is due to the degree of comprehensiveness (Dervis et al. (2004), Lejour et al. (2004) and Quaisser and Wood (2004) provides estimations on all budgetary costs), timing of accession and methodology used[19] (Oskam et al., 2004). The European Commission (2004b) points out that all estimations would be speculative as timing of accession and the configuration of EU policies at that time are unknown.

2.5.3 Overall Evaluation of Literature Revision

Computable general equilibrium modelling approach has been used by many studies to evaluate different policy issues especially to assess the impacts of EU enlargement with different countries. The usage of multi-regional CGE model of GTAP in the literature is also worthy of note. Although there are many studies that employed general equilibrium modelling to assess impacts of the Turkish accession to the EU, none of these studies solely focused on Turkish agricultural sectors at a disaggregated level within a multi-regional general equilibrium framework (there are two studies that intended to do that by using partial equilibrium framework). Thus, this study intends to fill in a gap in the literature dealing with accession of Turkey to the EU.

2.6. CONCLUSIONS

This chapter opened with a background about the accession of Turkey and reviewed the studies which investigate the economic consequences of this accession. After a brief introduction to the chapter, the following section offered a brief history of European Union - Turkish relations.

The chapter then examined some of the important arguments on political issues of Turkish membership to the EU (section 2.3). The arguments are given in seven titles; the fulfilment of the political criteria, geographical location, the Cyprus conflict, free movement of persons, population,

[19] Methodology used in studies range from regressions to partial equilibrium modelling.

institutional impact and the religion difference. Turkey is a large country and strategically important but complex and politically sensitive geographical location. It is a secular state with a large Muslim population. The main arguments on Turkey come from these characteristics. Also Turkish accession would have a considerable impact on the EU because of its size. Indeed, it would be the largest member state in terms of population by 2025.

Subsequently, employing up to date statistics, the next section (2.4) reviewed the Turkish economy, both from a macroeconomic view point and from the perspective of the agriculture sectors. The section is divided into two. The first subsection (2.4.1) gave an overview of Turkish economy and compared it with the EU-15, EU-25, Bulgaria and Romania. The Turkish economy is around the half size of the Accession-10, although the Turkish population is only slightly smaller. Thus, GDP per capita is lower in Turkey than the accession-10 and at a similar level to Bulgaria and Romania. The second subsection (2.4.2) summarised Turkish agriculture in relation to land usage, production, agricultural holdings, trade and policies. Turkish agriculture plays a important role in the country's economy with higher shares in GDP and employment and differs Turkey from the other accession-12 countries except Romania. This section also offered a summary of the evolution of the agricultural policies in the EU and Turkey.

The chapter continued with a literature revision of the recent studies on European Union enlargement to include Turkey (studies focused on AC-12 also reviewed) (Section 2.5). Of the studies reviewed, McClatchy (1997), Çakmak and Kasnakoğlu (2002), Grethe (1999 and 2003) and Hoekman and Togan (2005) analysed the integration between Turkey and the EU in a partial equilibrium modelling framework. While partial equilibrium models are usually quite detailed in the commodity disaggregation, they do not consider inter-linkages to other sectors and economic agents of an economy through factor markets and intermediate input use. CGE models contain detailed support and protection data on both agricultural products and industrial trade which enables a better assessment of the budgetary implications of EU enlargement. Moreover, with a CGE framework it is possible to generate a comprehensive welfare measure for the EU and the accession countries (Hertel et. al. 1997). These characteristics of CGE models make this approach the best suited tool for investigating integration issues.

The studies that explore the economic implications of market integration between Turkey and the EU can be grouped into two. The first group includes studies that investigate the economic effects of the possible Turkish membership and the second group includes studies that assess the effects of a possible extension of the customs union to cover all agricultural products. The estimates in the literature range between US$ 300 million to € 28200 million of welfare gain for Turkey after the membership. The differences in welfare estimates can be explained with the variation in model (i.e., perfect or imperfect competition, static or dynamic model use) and implemented scenario assumptions, the employed database source and the inclusion of non-tariff barriers into the protection data etc. These estimates suggest that the greatest gains to Turkey would be possible with an institutional reform after the accession.

Finally, a review of the literature reveals that there is a paucity of literature which focuses on the impacts of Turkish membership on the agricultural sectors. Those studies that incorporate primary agriculture do so at a more aggregated level. Thus, the main objective of this study is to combine GTAP's strength's as a trade policy evaluation tool and the broad sectoral coverage of the database, to assess the economic implications of EU enlargement with Turkey on a fully disaggregated set of agro-food sectors.

CHAPTER III

COMPUTABLE GENERAL EQUILIBRIUM THEORY AND PRACTICE

CHAPTER III

Computable General Equilibrium Theory and Practice

3.1 INTRODUCTION

Computable General Equilibrium (CGE) models use neo-classical behavioural concepts of economic theory such as utility maximisation and cost minimisation, to characterise the workings of the economy. A CGE model which is carefully designed will have a transparent and theoretically consistent structure and will offer a tool for policy appraisal. Indeed, with the availability of appropriate software CGE has become a productive research area over two decades.

A simple model identifies a single 'representative' consumer, who is assumed to own an initial endowment of a number of commodities and factors, and a set of preferences. By maximising utility subject to a budget constraint market demand functions for each commodity can be derived. Market demands must satisfy Walras's Law; that at any set of prices, the total expenditure of consumers equals consumer income. On the production side, technology is typically described by constant returns to scale production functions and producers maximise profits (or minimise costs). A general equilibrium can therefore be characterised by a set of prices and levels of production in each industry which equals market demand across all commodities. And this simple model can be extended to include many other elements like a government sector or an external sector. However, regardless of the level of additional complexity which the market clearing condition is what characterises a general equilibrium. (Greenaway et al., 1993)

Once the model structure is formalised by specifying dimensions of the model and choosing functional forms for production and utility functions the next step is to specify a benchmark data set and calibrate functional forms to this initial equilibrium benchmark data set (see Figure 3.1). A benchmark data set can be constructed from input-output tables (I-O tables), national income statistics and other major data sources for both a single or representative year and, where necessary, average data over a time period. Calibration can be defined as fitting the model to the benchmark data set and

typically involves choosing and adjusting the parameters of the model. After the calibration stage the model can be used to see the results of specific macroeconomic and trade policy scenarios.

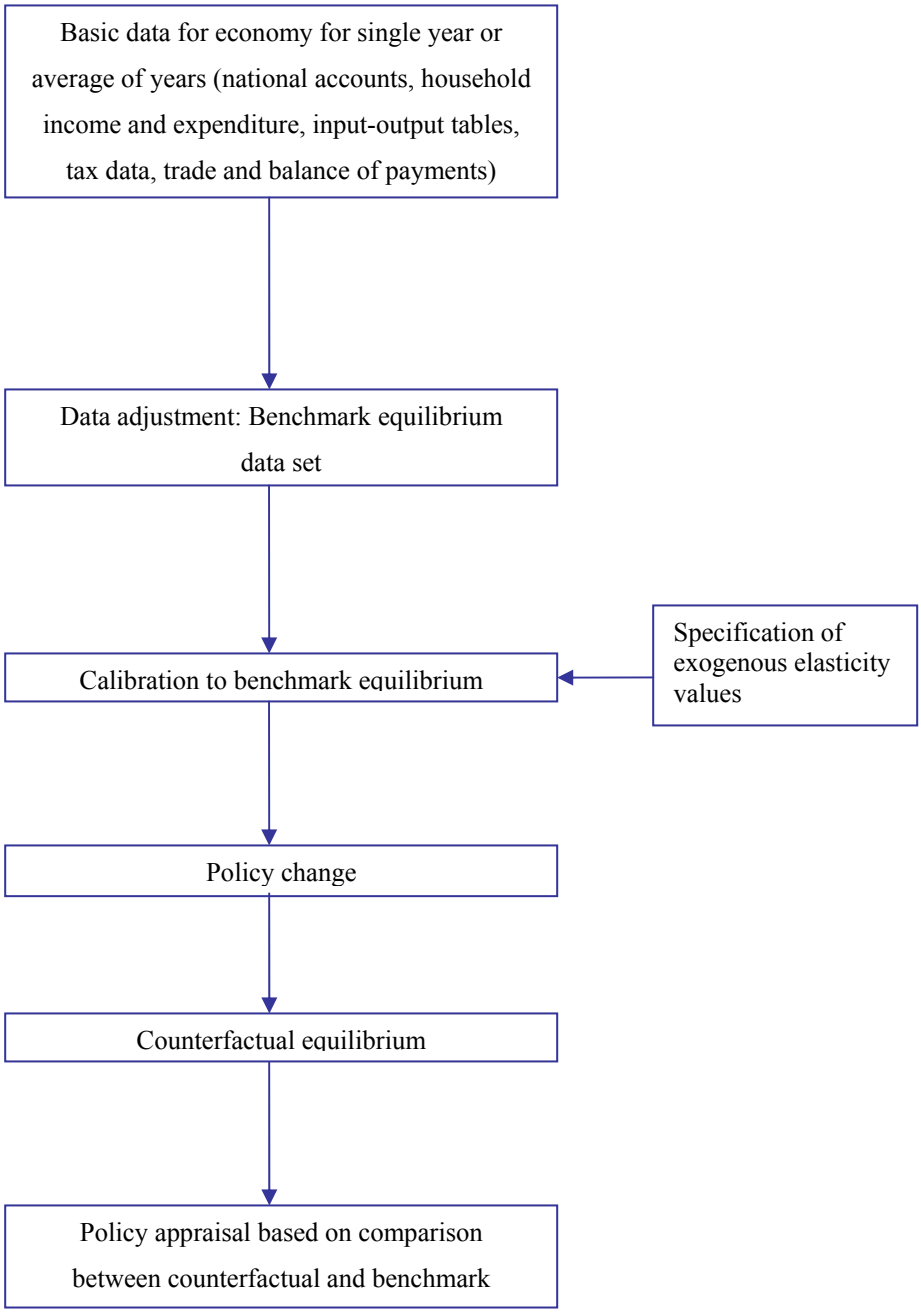


Figure 3.1 Steps in CGE Modelling (Adapted from Greenaway et al., 1993)

This chapter intends to discuss the principles of CGE theory, its practice and also evaluate the methodology. Section 3.2 gives a detailed discussion of the most popular types of functional forms used in CGE analysis and continues in section 3.3 with a discussion of the concepts of model representation and solution methodology in CGE modeling including two important issues in CGE modeling; nesting and calibration. Section 3.4 offers a simple linearised CGE model example to illustrate the basic steps involved in CGE analysis. The chapter continues with an explanation of closure (Section 3.5). The chapter continues with section 3.6, which evaluates the usefulness of CGE modelling for policy appraisal, outlining its strengths and weaknesses. Finally, section 3.7 concludes the chapter.

3.2 FUNCTIONAL FORMS IN CGE MODELS

There are many factors which affect the choice of functional forms in CGE models. In general, the function chosen should be continuous and homogeneous of degree zero and result in a system of demand in conformity with the Walras's Law (Shoven and Whalley, 1984). These conditions make a function 'convenient' because they ensure equilibrium and ease the analysis of variations in the price resulting from economic policiesIn the following section, the most popular functional forms are reviewed.

3.2.1. Leontief Function

The Leontief function specifies that there is zero substitution between inputs such that there is only one combination of inputs for any given level of output. For this reason the isoquant is 'L' shaped. The implied L-shaped isoquants of such a production function are shown in Figure 3.2. In the figure, at any particular output level Q, there is a specified level of X_1 and X_2 at the corner of the isoquants, Q and Q', which shows the best point for the firm to operate at the specified output because it represents the lowest level of input cost. An increase in the usage of one input (e.g., $X_1' \rightarrow X_1''$), holding the other

input fixed ($\overline{X}_2$), will not result in an increase in production, since we remain on the same isoquant Q), although it would increase the cost of production.

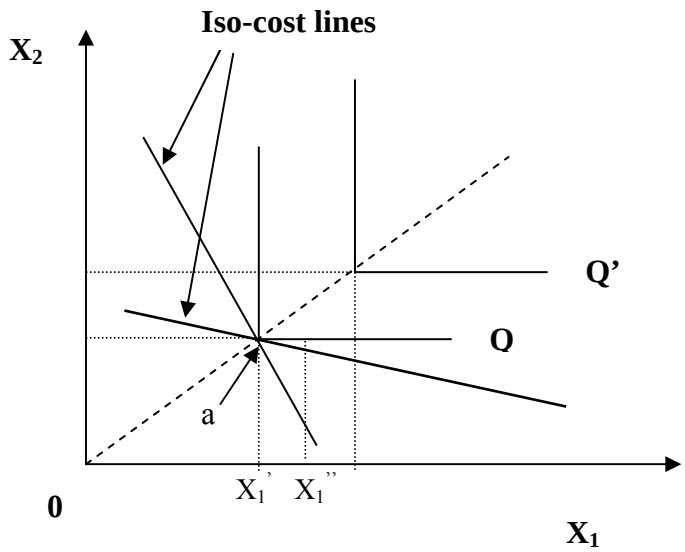


Figure 3.2 Leontief Isoquant

In the case of 'n' inputs, the Leontief function is algebraically expressed as:

$$Q_j = \min\left[\frac{X_{1,j}}{A_{1,j}}, \frac{X_{2,j}}{A_{2,j}}, \ldots\ldots, \frac{X_{n,j}}{A_{n,j}}\right] \qquad \text{(LF.1)}$$

where it is supposed that the *minimum* number of units of *all* (intermediate) inputs $X_{i,j}$ required to produce an extra unit of output (Q_j), is given by the parameter $A_{i,j}$. This fixed relationship between output and each input implies constant returns to scale.

The nature of the function implies that to increase output, rational cost minimising producers will only employ the minimum number of input units, giving demand functions:

$$X_{i,j} = A_{i,j} Q_j \qquad \text{(LF.2)}$$

where demand for each input 'i' is a function of the fixed input-output parameter $A_{i,j}$. Observe that, Leontief demands remain unaffected by changes in relative prices. This can be illustrated in Figure 3.2 above, where changes in the slope of the iso-cost line running through optimal production point 'a' (along the ray), does not affect input intensity.

The composite output price over all 'i' inputs (i=1…n), P_j, can be derived by assuming zero profits in industry 'j':

$$P_j Q_j = \sum_{i=1}^{n} R_{i,j} X_{i,j} \qquad \text{(LF.3)}$$

where

Q_j - Output in industry 'j'.

P_j - Output price in industry 'j'.

$X_{i,j}$ - Demand for input 'i' in industry 'j'.

$R_{i,j}$ - Price of input 'i' in industry 'j'.

Substituting expression (LF.2) and dividing by Q_j gives:

$$P_j = \sum_{i=1}^{n} A_{i,j} R_{i,j} \qquad \text{(LF.4)}$$

The Leontief function is a common specification in many CGE models. In the GTAP (Global Trade Analysis Project) model which is used later in this study, Leontief functions are chosen to characterise (zero) substitution possibilities between composite value added and composite intermediate inputs. In an agricultural context, it may be argued that such a treatment of producer

behaviour is not realistic, where for example a farmer may use a different fertiliser application in response to a relative price change with respect to land. However, with a general lack of data on substitution possibilities between composites of this nature, most CGE applications like GTAP model utilise the Leontief functions.

3.2.2. More advanced functions

The Cobb-Douglas (CD - Cobb and Douglas, 1928), Constant Elasticity of Substitution (CES - Arrow et al., 1961) and Constant Elasticity of Transformation (CET) are more advanced functions which explain producer/consumer behaviour as they allow for substitution between inputs although they still have restrictions which will be explained in following parts. The nature of these functions implies the shape of the isoquant to be smooth and convex with respect to the origin as shown in Figure 3.3. Thus, changes in relative input prices, imply substitution between factors (inputs).

In the next two sub-sections, CD and CES production functions are assessed on three criteria:

1. The response of short run output to variation in a single output, all inputs held constant (marginal product and average product)
2. The substitution possibilities of one input for another (applies equivalently to consumer theory)
3. The response of long run output to an equiproportional change in all inputs (returns to scale)

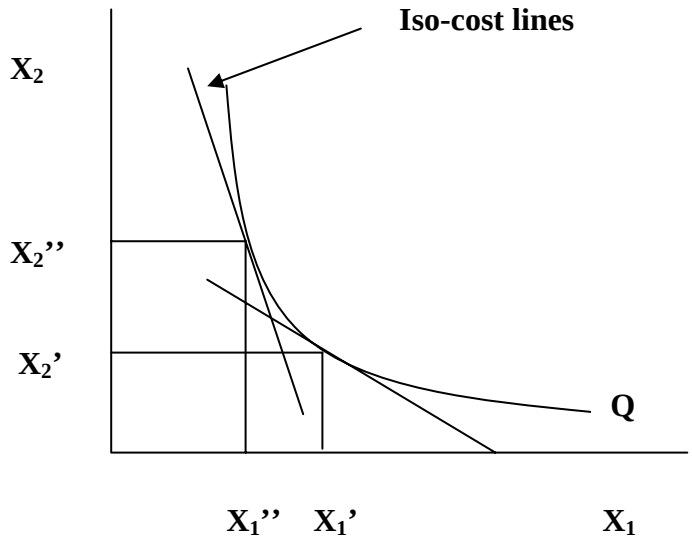


Figure 3.3 A smooth Convex Isoquant

3.2.2.1. Cobb-Douglas Function

The standard Cobb Douglas (CD) production function may be expressed as follows:

$$Q = AX_1^{\alpha} X_2^{\beta} \qquad \text{(CD.1)}$$

where demands for input 1 and 2 are X_1 and X_2 respectively, Q is output, A is an efficiency parameter and α and β are elasticities. First order *partial* derivatives give short run marginal products:

$$\frac{\partial Q}{\partial X_1} \Rightarrow MP_1 = \alpha A X_1^{\alpha-1} X_2^{\beta} \qquad \text{(CD.2)}$$

$$\frac{\partial Q}{\partial X_2} \Rightarrow MP_2 = \beta A X_1^{\alpha} X_2^{\beta-1} \qquad \text{(CD.3)}$$

The average product (for input 1) is given as:

$$\frac{Q}{X_1} = AP_1 = AX_1^{\alpha-1}X_2^{\beta} \qquad \text{(CD.4)}$$

Substituting (CD.4) into (CD.2) gives the relationship between marginal and average products:

$$MP_1 = \alpha AP_1 \qquad \text{(CD.5)}$$

In CGE models the production function chosen must obey either concavity or strict concavity (see appendix II) to be consistent with the theory, which limits the range of values that the parameters may assume in the chosen function (see appendix II)[20]. Resulting from these short- and long-run theoretical restrictions, Beattie and Taylor (1985) demonstrate that production functions present three stages of production (see appendix III). Given equation (CD.5) and appendix II, CD functions which are restricted to strict concavity only show stage II of production (i.e., MP<AP) either with respect to each factor (short-run) or with respect to scale (i.e., proportional changes in all inputs, long-run). In a similar way, strict quasi-concavity in CD functions implies stages I or II with respect to either each factor or scale (see Beattie and Taylor, 1985, pp68-69).

The elasticity of substitution measures the curvature of an isoquant. More specifically, the elasticity of substitution measures the percentage change in the factor ratio divided by the percentage change in the marginal rate of substitution (MRS), with output being held fixed (Varian, 1992, pp13). For a two input production function:

$$\sigma = \frac{MRS_{12}}{X_2 / X_1} \cdot \frac{d(X_2 / X_1)}{d(MRS_{12})} \qquad \text{(CD.6)}$$

[20] In theoretical terms, 'Short-Run' production functions must show Diminishing Marginal Returns; 'Long-Run' production functions must show some form of returns to scale.

The marginal rate of substitution (MRS) is the ratio of the marginal products, or the slope of the isoquant (Koutsoyiannis, 1979, pp73). Dividing (CD.2) by (CD.3) gives:

$$MRS_{12} = \left(\frac{\alpha}{\beta}\right).\left(\frac{X_2}{X_1}\right) \qquad \text{(CD.7)}$$

Substituting into equation (CD.6) it is derived:

$$\sigma = \frac{\left(\frac{\alpha}{\beta}\right).\left(\frac{X_2}{X_1}\right)}{\left(\frac{X_2}{X_1}\right)}.\frac{d\left(\frac{X_2}{X_1}\right)}{\left(\frac{\alpha}{\beta}\right)d\left(\frac{X_2}{X_1}\right)} = 1 \qquad \text{(CD.8)}$$

Hence, for the Cobb-Douglas function, the elasticity of substitution is always equal to one. Thus, if the MRS_{12} between input 1 and 2 changes by 1%, then the input usage ratio changes by 1% also. In equilibrium, the marginal rate of substitution (slope of the isoquant) is equal to the ratio of input prices (slope of the iso-cost line), so that expression (CD.6) can be rewritten as:

$$\sigma = \frac{(R_1 / R_2)}{(X_2 / X_1)} \times \frac{d(X_2 / X_1)}{d(R_1 / R_2)} = 1 \qquad \text{(CD.9)}$$

Thus, a 10% increase in the factor (commodity) price ratio (R_1/R_2), leads to a 10% increase in factor (commodity) intensity (X_2/X_1). This implies that in CD functions, the cost (expenditure) shares are fixed.

It is also possible to measure the change in long run output (Q) with changes in scale (i.e. equiproportional change in *all* inputs) by defining the elasticity of scale 'ε' which is the sum of the elasticity of output with respect to proportional changes in all inputs in the function. Then for a two input production function:

$$\varepsilon = \frac{\partial Q}{\partial X_1}\frac{X_1}{Q} + \frac{\partial Q}{\partial X_2}\frac{X_2}{Q} \qquad \text{(CD.10)}$$

$$\varepsilon = \alpha A X_1^{\alpha-1} X_2^{\beta} X_1 Q^{-1} + \beta A X_1^{\alpha} X_2^{\beta-1} X_2 Q^{-1} \qquad \text{(CD.11)}$$

$$Q = A X_1^{\alpha} X_2^{\beta}$$
$$\varepsilon = \alpha Q X_1^{-1} X_1 Q^{-1} + \beta Q X_2^{-1} X_2 Q^{-1} = \alpha + \beta \qquad \text{(CD.12)}$$

According to whether the elasticity of scale for the CD production function is greater than, less than or equal to 1, this implies increasing, decreasing and constant returns to scale as summarised below.

$\alpha + \beta < 1$ – decreasing returns to scale

$\alpha + \beta = 1$ – constant returns to scale (CRS)

$\alpha + \beta > 1$ – increasing returns to scale

As α and β are constant, the elasticity of scale for the CD function is also a constant, so it is invariant to changes in the level of output.

Standard CGE applications employ perfectly competitive structures and also constant returns to scale (CRS) is assumed, implying that long run average cost (TC/Q) is equal to long run marginal cost ($\partial TC/\partial Q$). Given the assumption of long run zero profits, output price equals average unit cost, as well as long run marginal cost (due to CRS), which is a key characteristic of perfectly competitive market structures (Koutsoyiannis, 1979).

When a production function does exhibit constant returns to scale then it is said to be 'linearly homogeneous'. This relationship between homogeneity and returns to scale can be proven mathematically. Considering Q_0 as an initial period, multiplying each of the inputs by a scalar 'c' gives output in period Q_1:

$$Q_1 = A(cX_1)^{\alpha}(cX_2)^{\beta}$$
$$Q_1 = c^{\alpha+\beta}Q_0 \qquad \text{(CD.13)}$$

where the new output level Q_1 can be expressed as a function of c (to a power $\alpha + \beta$) multiplied by the initial output, Q_0. The power of c is the *degree* of homogeneity of the function where linear homogeneity *in inputs* is established by restricting $\alpha + \beta$ equal to 1.

To derive Hicksian demands, minimise cost subject to the Cobb-Douglas function to give the first order conditions:

$$\frac{\partial L}{\partial X_1} = R_1 - \Lambda\alpha A X_1^{\alpha-1} X_2^{\beta} = 0 \qquad \text{(CD.14)}$$

$$\frac{\partial L}{\partial X_2} = R_2 - \Lambda\beta A X_1^{\alpha} X_2^{\beta-1} = 0 \qquad \text{(CD.15)}$$

$$\frac{\partial L}{\partial \Lambda} = Q - A X_1^{\alpha} X_2^{\beta} \qquad \text{(CD.16)}$$

where R_i (i=1,2) are input prices, and Λ is the Lagrangian multiplier. Divide (CD.14) by (CD.15), rearrange in terms of X_2 (X_1), and substitute into (CD.16). Rearranging the resulting expression in terms of X_1 (X_2) gives CD Hicksian demands:

$$X_1 = \left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} \left(\frac{R_2}{R_1}\right)^{\frac{\beta}{\alpha+\beta}} \qquad \text{(CD.17)}$$

$$X_2 = \left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{R_1}{R_2}\right)^{\frac{\alpha}{\alpha+\beta}} \qquad \text{(CD.18)}$$

Note that in consumer theory, there is no income effect in compensated demand functions[21]. Also uniform increases in *all* input prices by x% has no effect on the level of demand (i.e. no money illusion)[22]. This can be shown that the underlying demands of a linearly homogeneous function are zero degree homogeneous in prices. Thus, for (CD.17) increasing the input prices by a scalar 'c' and factorising for 'c' gives the expression:

$$X_1^{t+1} = c^{\left(\frac{\beta}{\alpha+\beta}\right)-\left(\frac{\beta}{\alpha+\beta}\right)} X_1 \Rightarrow c^0 X_1 \qquad \text{(CD.19)}$$

Given the assumption of zero profits:

$$PQ = R_1 X_1 + R_2 X_2 \qquad \text{(CD.20)}$$

from the equation (CD.20) it is possible to derive the composite output price, P. Substituting Hicksian demands (CD.17) and (CD.18) into (CD.20), simplifying and factorising for prices R_i gives:

$$P = Q^{\frac{1-(\alpha+\beta)}{\alpha+\beta}} A^{-\frac{1}{\alpha+\beta}} \left\{ \left[\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} + \left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \right] R_1^{\frac{\alpha}{\alpha+\beta}} R_2^{\frac{\beta}{\alpha+\beta}} \right\} \qquad \text{(CD.21)}$$

Assuming CRS (i.e. $\alpha + \beta = 1$), the composite output price, P, is linear homogeneous in R_i and zero degree homogeneous in output Q.

[21] Hicksian final demands are a function of utility and prices only.
[22] Homogeneity proofs can also be shown in the case of other 'convenient' functions (i.e. CES, CET), but this is not done in the text.

The restrictions on the demand elasticities can also be examined: As an example, the input elasticity of demand for input 1 is:

$$\frac{\partial X_1}{\partial R_1}.\frac{R_1}{X_1} = -\left(\frac{\beta}{\alpha+\beta}\right)\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}}\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}}\left(\frac{R_2}{R_1}\right)^{\left(\frac{\beta}{\alpha+\beta}\right)} X_1^{-1} \qquad \text{(CD.22)}$$

cancelling terms gives:

$$\frac{\partial X_1}{\partial R_1}.\frac{R_1}{X_1} = -\left(\frac{\beta}{\alpha+\beta}\right) = -(1-\alpha) \qquad \text{(CD.23)}$$

provided $\alpha + \beta = 1$. In a similar manner, the Hicksian compensated own-price elasticity for input 2 is:

$$\frac{\partial X_2}{\partial R_2}.\frac{R_2}{X_2} = -\left(\frac{\alpha}{\alpha+\beta}\right) = -(1-\beta) \qquad (\alpha+\beta=1) \qquad \text{(CD.24)}$$

Compensated cross-price elasticities are given as:

$$\frac{\partial X_1}{\partial R_2}.\frac{R_2}{X_1} = \left(\frac{\beta}{\alpha+\beta}\right) = (1-\alpha) \qquad (\alpha+\beta=1) \qquad \text{(CD.25)}$$

$$\frac{\partial X_2}{\partial R_1}.\frac{R_1}{X_2} = \left(\frac{\alpha}{\alpha+\beta}\right) = (1-\beta) \qquad (\alpha+\beta=1) \qquad \text{(CD.26)}$$

A similar experiment can be conducted for the Marshallian CD demand functions. Thus,

$$\frac{\partial L}{\partial X_1} = \alpha X_1^{\alpha-1} X_2^{\beta} - \Lambda R_1 = 0 \qquad \text{(CD.27)}$$

$$\frac{\partial L}{\partial X_2} = \beta X_1^{\alpha} X_2^{\beta-1} - \Lambda R_2 = 0 \qquad \text{(CD.28)}$$

$$\frac{\partial L}{\partial \Lambda} = Y - R_1 X_1 - R_2 X_2 \qquad \text{(CD.29)}$$

where 'Y' is consumer (household) income. Dividing (CD.27) by (CD.28), rearranging in terms of X_1 and substitute into (CD.29). Rearranging the resulting expression in terms of X_2 gives:

$$X_2 = \frac{P_1}{P_2}\frac{\beta}{\alpha} X_1 \qquad \text{(CD.30)}$$

Substituting (CD.30) into (CD.29) and rearranging in terms of X_1 gives:

$$X_1 = \frac{Y}{P_1}\frac{1}{((\beta/\alpha)+1)} \qquad \text{(CD.31)}$$

Substituting β with $(1-\alpha)$, where $\alpha + \beta = 1$, and simplifying gives the Marshallian Cobb-Douglas household demand function for final commodity 1:

$$X_1 = \frac{Y}{P_1}\alpha \qquad \text{(CD.32)}$$

Using a similar procedure, it is possible to derive the household demand function for commodity 2 as:

$$X_2 = \frac{Y}{P_2}\beta \qquad \text{(CD.33)}$$

With a simple procedure own-price, cross-price and income elasticities can be derived to show that they are -1, 0 and 1 respectively. The income elasticity of demand is restricted to one, which is highly restrictive in light of empirical evidence showing food products to have income elasticities

considerably less than one. Finally, it is obvious from (CD.32) and (CD.33) that the underlying Marshallian demands are zero homogeneous in prices and income.

3.2.2.2. Constant Elasticity of Substitution (CES) Function

The equation for the CES production function is:

$$Q = A\left[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}\right]^{-\frac{v}{\rho}} \qquad \text{(CES.1)}$$

where A is an efficiency parameter, δ_1 is a distribution parameter, ρ is an elasticity parameter and v is a scale parameter (discussed further below). First order *partial* derivatives give short run marginal products (assuming v=1 – the significance of v is discussed below):

$$\frac{\partial Q}{\partial X_1} = MP_1 = A\left[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}\right]^{-\left(\frac{v+\rho}{\rho}\right)} . \delta_1 X_1^{-(1+\rho)} \qquad \text{(CES.2)}$$

after simplifying the expression (CES.2):

$$MP_1 = A^{-\rho} Q^{1+\rho} \delta_1 X_1^{-(1+\rho)} \qquad \text{(CES.3)}$$

and similarly for input 2:

$$MP_2 = A^{-\rho} Q^{1+\rho} (1-\delta_1) X_2^{-(1+\rho)} \qquad \text{(CES.4)}$$

Therefore, marginal product is unambiguously positive with positive inputs, outputs, scale and distribution parameters. The average product (Q/X_i) can be related to the marginal product via expressions (CES.3) and (CES.4) as:

$$MP_1 = A^{-\rho} Q^{\rho} \delta_1 X_1^{-\rho} AP_1 \qquad \text{(CES.5)}$$

$$MP_2 = A^{-\rho} Q^{\rho} (1-\delta_1) X_2^{-\rho} AP_2 \qquad \text{(CES.6)}$$

Like the Cobb-Douglas function, strict concavity in CES functions implies stage II of production either with respect to each factor (short-run) or with respect to scale (long-run). Similarly, strict quasi-concavity in CES functions implies stages I or II only with respect to each factor and scale (Beattie and Taylor, 1985, pp68-69).

The CES marginal rate of substitution between inputs 1 and 2 is given as:

$$MRS_{12} = \left[\frac{\delta_1}{(1-\delta_1)}\right].\left[\frac{X_2}{X_1}\right]^{1+\rho} \qquad \text{(CES.7)}$$

To derive the elasticity of substitution, it is necessary to differentiate MRS_{12} with respect to input ratio:

$$\frac{dMRS_{12}}{d\left(X_2 / X_1\right)} = (1+\rho)\left[\frac{\delta_1}{(1-\delta_1)}\right].\left[\frac{X_2}{X_1}\right]^{\rho} \qquad \text{(CES.8)}$$

Furthermore, since:

$$\frac{MRS_{12}}{\left(X_2 / X_1\right)} = \left[\frac{\delta_1}{(1-\delta_1)}\right].\left[\frac{X_2}{X_1}\right]^{\rho} \qquad \text{(CES.9)}$$

substitute (CES.9) into (CES.8) to give:

$$\frac{dMRS_{12}}{d\left(X_2 / X_1\right)} = (1+\rho)\frac{MRS_{12}}{\left(X_2 / X_1\right)} \qquad \text{(CES.10)}$$

Given the formula for the elasticity of substitution in (CD.6), (CES.10) can be rearranged to give the CES elasticity of substitution as:

$$\sigma = \frac{1}{1+\rho} \qquad \text{(CES.11)}$$

Therefore, the elasticity of substitution of the CES function is constant and depends on the elasticity parameter, ρ, which is constrained to be greater than -1. Thus, with CES production functions the elasticity of substitution can vary, with the consequence that changes in the factor (commodity) price ratio can lead to factor-intensity reversals and which gives more flexibility to CES functions than CD functions (Dinwiddly and Teal, 1988).

As it has been demonstrated with the CD function, it is also possible to measure the change in long run output (Q) with changes in scale. Referring to the two factor CES function (CES.1), assume that $X_2 = \vartheta X_1$ such that the ratio X_2/X_1 is constant with increases in scale. Thus, the CES production function may be rewritten as:

$$Q = X_1^{v} A\left[\delta_1 + (1-\delta_1)\vartheta^{-\rho}\right]^{-\frac{v}{\rho}} \qquad \text{(CES.12)}$$

where the elasticity of scale with respect to proportional changes in inputs is given as:

$$\frac{dQ}{dX_1}\frac{X_1}{Q} = v \qquad \text{(CES.13)}$$

As it is shown the elasticity of scale is a function of the scale parameter 'v'. Then, according to whether v is greater than, less than or equal to 1, implies increasing, decreasing and constant returns to scale respectively. From the discussion of CD returns to scale above, CES functions are restricted to CRS, so v=1[23]. Given the relationship between homogeneity and returns to scale (see (CD.12)), CES

[23] In subsequent parts, the value of 'v' in CES (and CET) will be assumed the value of 1.

production functions are homogeneous of degree 'v' in inputs. In addition, it can be proven (this is not done here) that the composite output price function is also homogeneous of degree 'v' in input prices, and compensated demands are homogeneous of degree v-1 in prices. [24]

Minimising cost subject to the CES function gives first order conditions:

$$\frac{\partial Z}{\partial X_1} = R_1 - \left[-\frac{1}{\rho} \Lambda A[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}]^{-\frac{1}{\rho}-1} - \rho \delta_1 X_1^{-(1+\rho)} \right] = 0 \qquad \text{(CES.14)}$$

$$\frac{\partial Z}{\partial X_2} = R_2 - \left[-\frac{1}{\rho} \Lambda A[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}]^{-\frac{1}{\rho}-1} - \rho (1-\delta_1) X_2^{-(1+\rho)} \right] = 0 \qquad \text{(CES.15)}$$

$$\frac{\partial Z}{\partial \lambda} = Q - A[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}]^{-\frac{1}{\rho}} = 0 \qquad \text{(CES.16)}$$

Dividing (CES.14) by (CES.15) and rearranging in terms of X_1 gives:

$$X_1 = \left[\frac{R_1 (1-\delta_1)}{R_2 \delta_1} \right]^{-\frac{1}{1+\rho}} X_2 \qquad \text{(CES.17)}$$

Substituting (CES.17) into (CES.16) and simplifying gives:

$$Q = A X_2 \left[\delta_1 \left[\frac{R_1 (1-\delta_1)}{R_2 \delta_2} \right]^{\sigma\rho} + (1-\delta_1) \right]^{-\frac{1}{\rho}} \qquad \text{(CES.18)}$$

where σ is defined in equation (CES.11). Rearranging the equation (CES.18) in terms of X_2 gives the CES Hicksian demand function for input (commodity) 2:

[24] Marshallian (uncompensated) commodity demands are homogeneous of degree v-1 in prices and income.

$$X_2 = \frac{Q}{A}\left[\delta_1\left[\frac{R_1(1-\delta_1)}{R_2\delta_1}\right]^{\sigma\rho} + (1-\delta_1)\right]^{\frac{1}{\rho}} \qquad \text{(CES.19)}$$

With a similar procedure, it is possible to derive the CES Hicksian demand function for input (commodity) 1:

$$X_1 = \frac{Q}{A}\left[\delta_1 + (1-\delta_1)\left[\frac{R_2\delta_1}{R_1(1-\delta_1)}\right]^{\sigma\rho}\right]^{\frac{1}{\rho}} \qquad \text{(CES.20)}$$

Differentiating (CES.19) with respect to R_2:

$$\frac{\partial X_2}{\partial R_2} = \frac{1}{\rho}\frac{Q}{A}\left[\delta_1\left[\frac{R_1(1-\delta_1)}{R_2\delta_1}\right]^{\sigma\rho} + (1-\delta_1)\right]^{\frac{1}{\rho}-1} .-\sigma\rho\delta_1\left[\frac{R_1(1-\delta_1)}{\delta_1}\right]^{\sigma\rho} R_2^{-\sigma\rho-1} \qquad \text{(CES.21)}$$

Multiplying (CES.21) by R_2/X_2 and substituting X_2, Q and A gives the Hicksian (compensated) own-price elasticity of demand for input 2:

$$\frac{\partial X_2}{\partial R_2}.\frac{R_2}{X_2} = -\sigma\left[\frac{X_2 A}{Q}\right]^{-\rho}\delta_1\left[\frac{R_1(1-\delta_1)}{R_2\delta_1}\right]^{\sigma\rho} \qquad \text{(CES.22)}$$

Similarly for input 1:

$$\frac{\partial X_1}{\partial R_1}.\frac{R_1}{X_1} = -\sigma\left[\frac{X_1 A}{Q}\right]^{-\rho}(1-\delta_1)\left[\frac{R_2\delta_1}{R_1(1-\delta_1)}\right]^{\sigma\rho} \qquad \text{(CES.23)}$$

Compensated cross price elasticities of demand are given as:

$$\frac{\partial X_2}{\partial R_1}.\frac{R_1}{X_2} = \sigma\left[\frac{X_2 A}{Q}\right]^{-\rho} \delta_1 \left[\frac{R_1(1-\delta_1)}{R_2\delta_1}\right]^{\sigma\rho} \qquad \text{(CES.24)}$$

$$\frac{\partial X_1}{\partial R_2}.\frac{R_2}{X_1} = \sigma\left[\frac{X_1 A}{Q}\right]^{-\rho} (1-\delta_1)\left[\frac{R_2\delta_1}{R_1(1-\delta_1)}\right]^{\sigma\rho} \qquad \text{(CES.25)}$$

3.2.2.3. Constant Elasticity of Transformation (CET) Function

The algebraic representation of the CET function is:

$$Z = B\left[\sum_{i=1}^{n} \gamma_i Q_i^{-\rho}\right]^{-\frac{1}{\rho}} \qquad \text{(CET.1)}$$

where B and γ's are positive parameters with $\sum_{i=1}^{n} \gamma_i = 1$ and ρ is a transformation elasticity. Z is a measure of the firm's overall capacity which depends on the quantities of inputs and Q_i is a measure of the output level of each supply activity 'i'. The CET function is identical to the CES function apart from the restriction on ρ. In CES ρ is greater than or equal to -1 where in CET ρ is less than or equal to -1. Therefore, CES is convex with respect to the origin and CET is concave with respect to the origin. As with CES, the CET function is also linearly homogeneous, where a doubling of output from each supply activity (Q) doubles the firms overall capacity (Z).

The derivation of activity supplies is a revenue maximisation process subject to a production possibilities frontier. The mathematical derivations are analogous to the CES function, in which the elasticity of transformation between supply activities is equivalent to the elasticity of substitution in inputs.

3.3. MODEL REPRESENTATION AND SOLUTION METHODS

In section 3.2 above, some of the most common functional forms in CGE models are examined. In this section an examination is made of how these functions may be represented within a CGE framework and how solutions may be gained from a large system of equations.

The exposition begins with a discussion of equation 'linearisation' – this format will be the basis of the model application later in this dissertation. Multistage optimisation is then discussed using a technique known as 'nesting'. This process improves the flexibility of CGE models without rendering the model unmanageable. In the latter part of this section various linearised solution algorithms are examined whilst their accuracy vis-á-vis the levels algorithms is briefly commented. The section concludes with a brief discussion of calibration and its reduced role in the case of a linearised model representation.

3.3.1. Linearisation

This section shows how to derive a linear representation of a levels[25] function, which will be employed in the final model structure in later chapters. A more complex linearisation example can be found in section 3.4 which provides the derivations of a nested linearised stylised model.

Linearised representation besides being able to get accurate results, has some advantages too. First of all, it offers a more straightforward representation of behavioural relationships and a model which is much simpler to interpret because of being able to obtain results in percentage change forms or in elasticities. (Hertel et al.1992)

[25] Reference is made to "levels" forms of equations which were presented in section 3.2 of the discussion of functional forms

With multivariate functions, the total differential calculates the change in the dependent variable dz at a point brought about by an infinitesimal change in each of the independent variables denoted as dx and dy. Thus, if a multivariate function is given as:

$$z = z(x, y) \qquad \text{(LIN.1)}$$

then the total differential is:

$$dz = \left(\frac{\partial z}{\partial x}\right)dx + \left(\frac{\partial z}{\partial y}\right)dy \qquad \text{(LIN.2)}$$

Equation (LIN.2) measures the change of z with respect to infinitesimal changes in x and y.

More specifically, there are three rules of differentials for obtaining the total differential of each of the equations in levels form. These rules are:

The product rule	$R = PQ \Rightarrow r = p + q$	
The power rule	$R = P^{\alpha} \Rightarrow r = \alpha p$	(LIN.3)
The sum rule	$R = P + Q \Rightarrow r = pS_p + qS_q$	

where r, p and q are percentage changes (or they may be interpreted as changes in logarithms) in R, P and Q, α and β are parameters and Sp and Sq are the shares of P and Q in P+Q.

Using the product rule above, the linearisation error which occurs when Johansen single-step solution (explained in subsection 3.3.3) method is used can be shown. For example, if the levels variables P and Q are originally valued at 10 and 5, their product is 50. Changing both variables by +10%, gives P and Q values of 11 and 5.5 respectively which is a product increase of 21%, compared to the rule result of 20%. This result occurs because the total differential only looks at infinitesimal

changes along the curve. But as explained in section 3.3.3 below, this kind of linearisation error can be reduced by using different solution methods like Euler's and Gragg's method.

Finally, to illustrate how the total differential can be done, as an example the total differential of the Marshallian Cobb-Douglas demand (CD.32) in the stylised model is given as:

$$dX_i = dY(P_i^{-1}\alpha) - dP(YP_i^{-2}\alpha) \qquad \text{(LIN.4)}$$

To convert from differential changes to linearised percentage changes it is multiplied and divided by respective variables and simplified, which gives:

$$\frac{dX_1}{X_1}X_1 = \frac{dY}{Y}YP_1^{-1}\alpha - \frac{dP_1}{P_1}YP_1^{-1}\alpha \qquad \text{(LIN.5)}$$

Multiplying both sides by 100, dividing by X_i and simplifying gives:

$$x_1 = y - p_1 \qquad \text{(LIN.6)}$$

$$x_1 = \frac{dX_1}{X_1}100 \quad y = \frac{dY}{Y}100 \quad p_1 = \frac{dP_1}{P_1}100 \qquad \text{(LIN.7)}$$

Equations (LIN.6) and (LIN.7) are in percentage form, where the lower case letters are the percentage changes in their respective upper case variables. Because of using the Cobb-Douglas functional form, the linearised Marshallian CD function has an income elasticity of one, and own- and cross-price elasticities of minus one and zero respectively.

3.3.2 Nesting

As mentioned in the subsection 3.3.4 when flexible functional forms are chosen, it is necessary to calibrate a larger number of parameters. Therefore, these kinds of requirements lead modellers to use more convenient functional forms like Cobb-Douglas (CD) and Constant Elasticity of Substitution (CES). Using convenient functional forms greatly reduces the number of parameters which limits the degree of flexibility when specifying producer or consumer behaviour within the model. Thus, to build more complicated or realistic models using these simple functions a technique which is known as nesting (or hierarchical functions) is used.

The basic idea behind nesting is very simple; instead of letting goods or inputs enter the utility or production function directly, one uses functions of a subset (or different groups, aggregations) of the original goods or inputs (Petersen, 1997). This assumption of separability allows for subsequent optimisation at several stages, which leads a greater number of elasticity parameters in each stage of the production/utility function. The result is that this increases the flexibility of the model, without increasing the burden of calibration.

3.3.2.1. Separability and Aggregation

The relationship between separability and multi-stage optimisation can be illustrated with the following theoretical example. Assuming a three factor (x_i i = 1,2,3) production function which is of the form:

$$Y = f(X, x_3) \qquad \text{(N.1)}$$

where input X is represented as an aggregator function consisting of inputs x_1 and x_2:

$$X = g(x_1, x_2) \qquad \text{(N.2)}$$

A schematic representation of this two-level nested structure is shown in Figure 3.4.

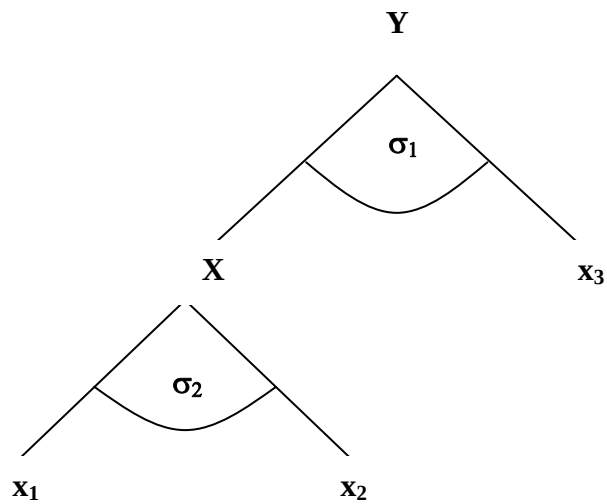


Figure 3.4 A two level nested production structure

Employing cost minimisation techniques, the producer decides how inputs x_1 and x_2 should be combined into a single 'composite' input X, using the function (N.2). Secondly, the producer decides how this composite input should be combined with input x_3 by using function (N.1). This is called a two stage optimisation procedure.

There are two conditions to meet in order to use a two-stage optimisation procedure (Koschel, 2001). The first condition is that the production function must be weakly separable to permit a partitioning of the inputs. The production function (N.1) is said to be weakly separable if the marginal rate of substitution (MRS) between any two inputs x_i and x_j (in the example x_1 and x_2) from any subset (nest) N_s where s = 1,…,r is independent of the input usage outside of N_s, i.e (Berndt and Christensen, 1973). This can be shown with the following expression:

$$\frac{\partial}{\partial x_3}\left(\frac{\partial X / \partial x_1}{\partial X / \partial x_2}\right) = 0 \qquad \text{(N.3)}$$

The convenient functions like CD and CES show weak separability. For example, in the case of a two-level nested CD production function:

$$Y = AX_1^{\alpha} X_2^{\beta} \qquad and \qquad X_1 = Ax_{11}^{\gamma} x_{21}^{\delta} \tag{N.4}$$

The $MRS_{11,21}$ can be shown to be:

$$MRTS_{11,21} = \frac{MP_{11}}{MP_{21}} = \frac{\gamma}{\delta}\frac{x_{21}}{x_{11}} \tag{N.5}$$

Obviously, changes in the level of X_2 in the upper CD nest, has no effect on the MRS between inputs x_{11} and x_{21} in the lower nest. Mathematically:

$$\frac{\partial}{\partial X_2}\left(\frac{\gamma}{\delta}\frac{x_{21}}{x_{11}}\right) = 0 \tag{N.6}$$

The second condition is that aggregator function (N.2) must be linear homogenous with respect to each of inputs. In section 3.2.2.1, it was demonstrated that the output price composite of a linearly homogeneous function is linearly homogeneous in input prices. Hence, the sum of the prices and quantities of the inputs derived in each nest will be equal to the aggregate quantity and price indices:

$$RX = \sum_{i=1}^{n} r_i x_i \tag{N.7}$$

As shown in the subsection 3.2.2.1 a basic property of linear homogenous functions is that first order derivatives (i.e. marginal products/utilities) are homogeneous of degree zero. Taking the case of a linearly homogenous Cobb-Douglas production function this property can be shown. Since MP_1 for a two input production function is given as:

$$MP_1 = \frac{\partial Y}{\partial x_1} = \alpha A x_1^{\alpha-1} x_2^{\beta} \tag{N.8}$$

Multiplying each of the inputs by a scalar, λ, gives:

$$MP_1 = \frac{\partial Y}{\partial x_1} = \alpha A(\lambda x_1)^{\alpha-1}(\lambda x_2)^{\beta}$$
$$MP_1 = \frac{\partial Y}{\partial x_1} = \lambda^{\alpha-1+\beta}\alpha A x_1^{\alpha-1} x_2^{\beta} \qquad \text{(N.9)}$$
$$MP_1 = \frac{\partial Y}{\partial x_1} = \lambda^{0}[\alpha A x_1^{\alpha-1} x_2^{\beta}]$$

Thus, multiplying both inputs by λ, does not affect the marginal product of x_1. In other words the marginal products are zero degree homogenous in inputs. Since the MRS is the ratio of MPs, then proportional increases in both inputs by the scalar value λ implies higher isoquant levels have no effect on the MRS. Therefore, a ray from the origin must cut all isoquants or indifference curves at points of equal slope. According to Green (1971), the isoquants or indifference curves are therefore 'homothetic with respect to the origin' (pp141). In other words, increases in the level of composite (aggregate) output or utility with relative input price ratios fixed has no effect on factor intensity. Thus, increase in the level of composite output means movements onto higher isoquants or indifference curves.

Thus, if the function (N.1) satisfies both weak separability and linear homogeneity, then this function is said to be *weakly homothetically separable* and ensures consistent aggregation. Since the assumption of weak separability assure that the increase in other inputs outside the aggregator nest has no effect on factor usage ratios, and of linear homogeneity assures that increases in the level of composite (aggregate) output or utility with relative input price ratios fixed has no effect on factor intensity, then a weakly homothetically separable function implies that changes in input intensities can only be a function of the relative prices of various types of inputs in the nest. Weak homothetic separability gives the possibility of a two-stage optimisation procedure which implies that the mix of inputs within each aggregate is optimised in the first step, and then the level of each aggregate in the second step (Koschel, 2001).

Finally, Allanson (1989) also notes that relative price changes in one nest can have *indirect* effects on input (commodity) allocations elsewhere in the nest. Using the nested structure in Figure 3.4, if the price of input x_2 increases, this will affect the optimal combination of x_1 and x_2 in the aggregate nest, but due to the separability restriction, it will not directly affect the optimal use of x_3. But there will be an *indirect* effect on the use of x_3 due to a rise in the composite price of *aggregate* input X. This implies that the firm will substitute x_3 for aggregate X, in the top nest. Moreover, if x_3 was an aggregate input, then as a consequence of linear homogeneity, its increased use would be translated proportionally to all inputs in that nest. An example of the usage of nesting in CGE models can be found in section 3.4.

3.3.3 Solution Methods For Linearised Representations

For many years modellers preferred using a levels non-linear algorithm to the linearised algorithm method first employed by Johansen (1960), due to the greater accuracy of the former. However, as Hertel et al. (1992) note and demonstrate, there are ways to improve the accuracy of the results obtained by the early Johansen approach such that the choice between levels and linear solution algorithms is no longer an issue.

To explain the basis of a linear algorithm, consider a simple function, g(X,Y), where X is exogenous and Y is endogenous (see Figure 3.5). Supposing that the initial (or benchmark) solution of the model is point (X,Y), an exogenous shock from X to X_1 gives a true solution of Y to Y_1 (or A to B). Johansen's method involves calculating the derivative (dY/dX) at A, and then in a "single step" passing from X to X_1, by moving along the tangent to the function at A. This brings us to the point B_1 in Figure 3.5 which gives the estimate Y_2. This represents the linearised approximation to the non-linear solution at B. Therefore with the Johansen method, the bigger the shock on X the poorer is the quality of the estimation as the tangent gets further from the 'true' solution.

To reduce this "single step" linearisation error, or to obtain more accurate solutions different solution methods can be used like Euler's method, Gragg's method or midpoint method. The main idea behind these methods is to follow the function g(X,Y) more closely. To do this, Euler's method divides

the shock (X,X_1) into a number of equal steps. A 2-step Euler solution is shown in Figure 3.5 where the path is from A to C to B^* which gives the solution Y^*. At point C, an update procedure of the endogenous variable Y occurs to verify the position of this variable. Therefore with this method the solution obtained by using higher step solution procedure can be much closer to the true solution Y_1.

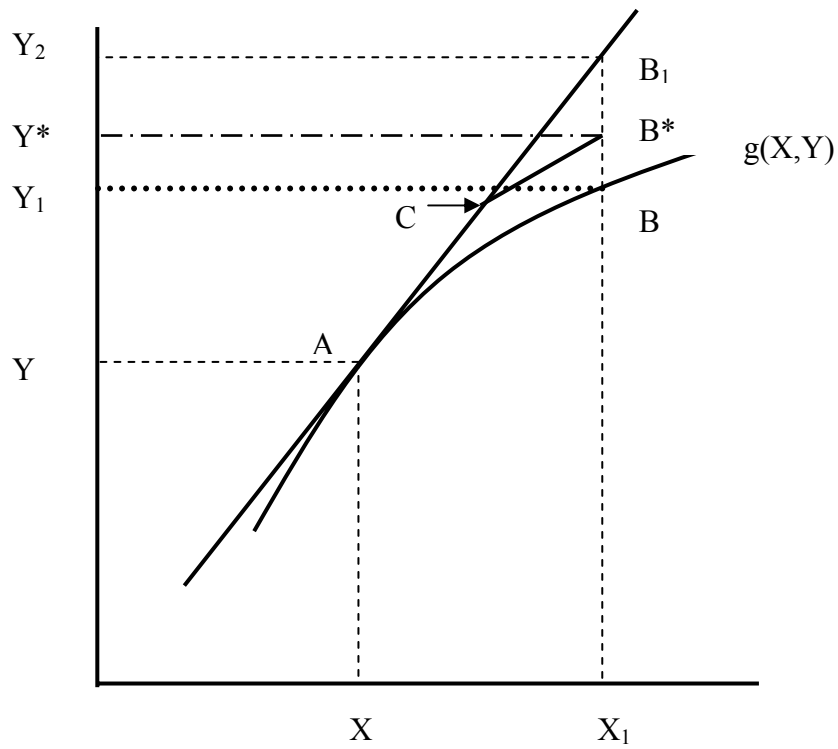


Figure 3.5 Illustration of Euler's method (Hertel et al., 1992)

Gragg and midpoint methods are identical to Euler's method in step one, following a tangent along the curve from the initial solution. The difference is that Euler's method follows this tangent from the current point (point C in Figure 3.5) while Gragg's method and the midpoint method follow this direction but from the n-1th point in this simple two step example, point A. This difference can be shown in Figure 3.6 with a little modification on Figure 3.5. Each method comes to point C after step-1. At step-2 as shown before Euler's method follows the line CB_1 which gives the solution Y_2, while Gragg and midpoint methods follow line AB_2 which gives the solution Y_3. It can be seen that the solution obtained by using Gragg and midpoint methods is much closer to the true solution Y_1.

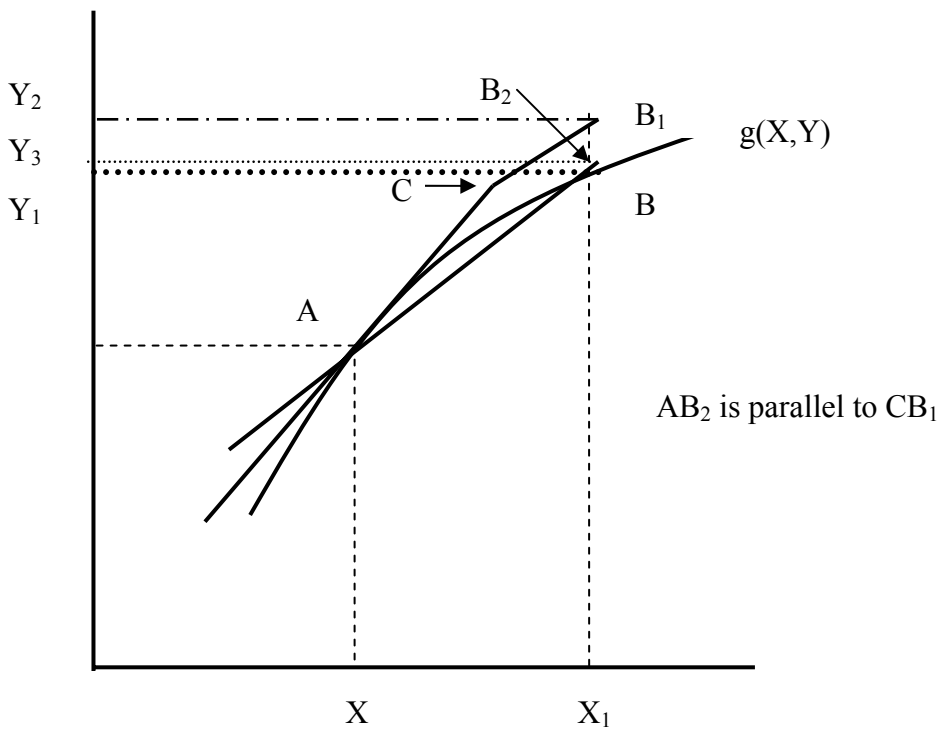


Figure 3.6 Midpoint and Gragg's method compared to Euler's method

Whilst increasing steps will improve the accuracy, a large number of steps would have a significant computational expense. Another way of increasing accuracy is to make 2 or more different multi-step simulations (e.g. 5-step, 10 step and 20 step) with different numbers of steps and then to calculate the solution as an suitable weighted average of these employing a polynominal function of the necessary degree. This process is known as extrapolation[26].

3.3.4 Calibration of CGE Models

Greenaway et al. (1993) defines calibration as a procedure which calculates values for unknown parameters of the functional forms used in an applied CGE model from an observed data set. It is assumed that the data set represents an equilibrium for the general equilibrium model under

[26] More information about the issues discussed in this subsection can be found in appendix I.

consideration (benchmark equilibrium data set). The model is then solved for its unknown parameters as functions of the observed data.

In the linearised model representation, the final model CGE representation used in this study, a large proportion of the benchmark parameters drop out of the equations subordinating the importance of the calibration technique. Indeed, the price and quality variables now represent percentage changes and are therefore not dependent on initial or benchmark values. Notwithstanding, extraneous elasticity of substitution values are still required in the CES functions which has important implications for the responsiveness of the model to a given policy shock[27].

Depending on the choice of functional form, a unique solution of parameters may not be obtained. For example, unless a Cobb-Douglas functional form is chosen, then parameterised values, such as elasticities must be obtained, (usually borrowed from the literature), before the estimation of other parameters. When flexible functional forms are chosen a much greater number of exogenously determined (i.e. income elasticities, elasticities of substitution between factors or between intermediate inputs) parameters are required. Since these values affect the model results, this also implies greater subjectivity of model results.

The process of calibration can be illustrated by a simple numerical example. The derived values of each unknown parameters are based on the hypothetical input-output data which can be found in Table 3.1. In the table it can be observed that the general equilibrium restrictions apply, where household income and expenditure is equal. More information about the input-output table can be found in section 3.4, although an underlying principle is that the rows represent the sales of commodities or factors, whilst the columns are intermediate and final demands by firms and households respectively.

[27] After reading the subsection 3.3.1 and appendix I it would be easer to understand why there no such calibration is needed.

	Industry		Households	Total Sales
	1	**2**		
Commodity: 1	-	-	2	**2**
2	-	-	6	**6**
Primary Factors:				
X_1	1	2	-	**3**
X_2	1	4	-	**5**
Production	**2**	**6**	**8**	**16**

Table 3.1 Hypothetical Input-Output Data

Using the Cobb-Douglas commodity demand derivations from the subsection 3.2.2.1 and rearranging these equations in terms of α and β:

$$\alpha = \frac{X_1 P_1}{Y} \qquad \text{(CAL.1)}$$

$$\beta = \frac{X_2 P_2}{Y} \qquad \text{(CAL.2)}$$

These parameters, α and β, can be easily calibrated from Table 3.1 as:

$$\alpha = \frac{2}{8} = 0.25 \qquad \beta = \frac{6}{8} = 0.75 \qquad \text{(CAL.3)}$$

The calibration of the unknown parameters of the CES function is slightly more complicated. First of all, it is necessary to specify an exogenous value for the elasticity of substitution (σ_1). Assuming that this value is 2 and given that:

$$\sigma_1 = \left(\frac{1}{1+\rho_1} \right) \qquad \text{(CAL.4)}$$

where ρ_1 is -0.5. The calibrations of the other unknown parameters, the distribution parameter (δ_1) and the scale parameter (A_1), are shown below.

Taking the first order conditions from a two input cost minimisation procedure and dividing, gives:

$$\frac{R_1}{R_2} = \frac{\delta_1}{(1-\delta_1)}\left[\frac{X_1}{X_2}\right]^{-(1+\rho_i)} \qquad \text{(CAL.5)}$$

Thus, calibration of δ involves substituting in the value flows and the value of ρ into expression (CAL.5). Noting that the price of factors are worth one currency unit, and using the values of X_1 and X_2 for the fist the industry from Table 3.1 gives:

$$\frac{1}{1} = \frac{\delta_1}{(1-\delta_1)}\left[\frac{1}{1}\right]^{-0.5} \qquad \text{(CAL.6)}$$

by rearranging (CAL.6) δ_1 can be found 0.5. To find $A_{1,}$ substitute the value of the parameter values obtained in Table 3.1 into the CES production function (CES.1). Thus, for the first industry,

$$2 = A_1[0.5\times(1)^{-(-0.5)} + 0.5\times(1)^{-(-0.5)}]^{-\frac{1}{(-0.5)}} \qquad \text{(CAL.7)}$$

Rearranging the equation (CAL.7) in terms of A_1 gives a value of 2.

3.4 A STYLISED CGE MODEL WITH LINEARISED REPRESENTATION

This section gives a simple CGE model example which consists of a system of linearised equations characterising the behavioural characteristics of an economy. The aim is to make a summary of what is mentioned in previous sections of this chapter. This example offers useful information about general equilibrium theory, major concepts of developing computable general equilibrium models like closure, nesting and finally presents some of possible linearised functional forms typically used in nested CGE models.

In Table 3.2 the input-output table of the stylised model is given to show the uses of input-output table in CGE modelling. These tables contain detailed data on the flows among different sectors of an economy and this information can be used to build static models or can be used as a benchmark dataset for dynamic models. For the stylised model given in this text, this table serves as a benchmark whilst the software takes initial values from this benchmark to find a solution. These tables represent the value of economic transactions in a given period of time. (Dixon et al., 1992)

		Intermediate Use		Final Use			OUTPUT (TOTAL)
		Manufacturing	Services	Private	Government	Export	
Domestic Production	Manufacturing	10	5	32	15	36	98
	Services	15	9	62	8	0	94
Value added	Man. Tax	0	0	9	0	0	9
	Svces. Tax	0	0	14	0	0	14
	Capital	33	28	0	0	0	61
	Labour	40	16	0	0	0	56
Imports		0	36	0	0	0	36
INPUT (TOTAL)		98	94	117	23	36	368

Table 3.2 Input-Output Table for the stylised model

To simplify the illustration, the stylised model contains two consumers: private demands by households and public demands by government and two industries, manufacturing and services, each employing two primary production factors (labour and capital). The model also includes inter-industry flows by permitting intermediate good transfer between two industries. The economy is assumed to be 'open' (i.e., external trade) in which the country imports only one of the commodities and exports the other. Government levies commodity taxes to arrange its budget and expenditure. Finally, the model also assumes that labour supply is immobile between the two industries. Behavioural equations are derived from constrained optimisation techniques based on the principles of the neo-classical theory (utility maximisation and cost minimisation).

The structure of the stylised model can also be shown in Table 3.2 where the rows in the yellow sub-matrix show production sector outputs and columns show sectors which use outputs of production as intermediate inputs. In the orange sub-matrix private consumption, government consumption and exports are shown as final demands for the commodities. The information on total domestic production

is given in the red sub-matrix. Blue sub-matrices give information on imports. Information about payments to labour and capital and indirect taxes are given in the green sub-matrices. For a balanced input-output table the column of the grey sub-matrix should be the same as the rows of the red sub-matrix to reflect the fact that total input usage equals to total output sales for production sectors.

The input-output table which is used for this stylised model are in 'basic' prices where tax rows are (presented explicitly) disaggregated. The table does not include margin costs as is characteristic in standard in input-output (I-O) tables. This is an omission of this simple I-O table. These tables also can be expressed in terms of producer and purchaser prices where taxes and transport costs are also included.

3.4.1 Notation

L_j	Demand for labour in industry j
K_j	Demand for capital in industry j
XL_j	Labour supply for industry j
W_j	Wage rate in industry j
WCOMP	Composite wage rate
RCOMP	Composite capital rental
X_j	Supply in industry j
$COMPII_j$	Demand for the composite intermediate inputs in industry j
$COMPVA_j$	Demand for the value added composite inputs in industry j
IIM_j	Demand for intermediate manufacturing input in industry j
IIS_j	Demand for intermediate services input in industry j
PII_j	Composite intermediate input price
PVA_j	Composite value added price
C_j	Private demand for industry output in industry j
G_j	Government (public) demand for industry output in industry j
Y	Private consumer income
PEXP	Private consumer expenditure

T	Total government revenue from taxation
GOVT	Total government expenditures
P_j	Basic price in industry j
Q_j	Purchaser's price in industry j
PW_j	World price in industry j (exogenous)
F	Exchange rate (exogenous)
TC_j	Commodity tax on final (private) demands (exogenous)
LAB	Total labour endowment (exogenous)
CAP	Total capital endowment (exogenous)
EXPOR	Exports
IMPOR	Imports
BOT	Balance of trade
GDP	Gross domestic product

Lower case letters which are used in the text are the percentage change equivalent of the upper case 'levels' variable which are shown here.

3.4.2 Schematic Representation of the Model

This section offers a simple explanation about the model structure by using figures which explain demand (Figure 3.7) and production (Figure 3.8) and also immobility of labour (Figure 3.9) (which is assumed).

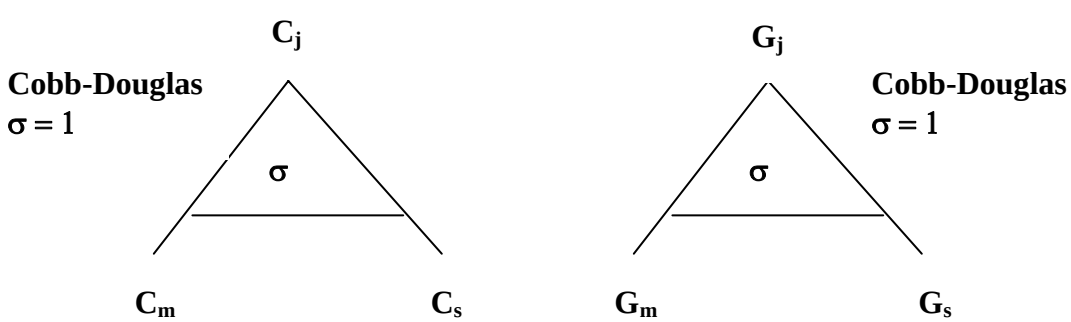


Figure 3.7 Schematic representation of the demand nest

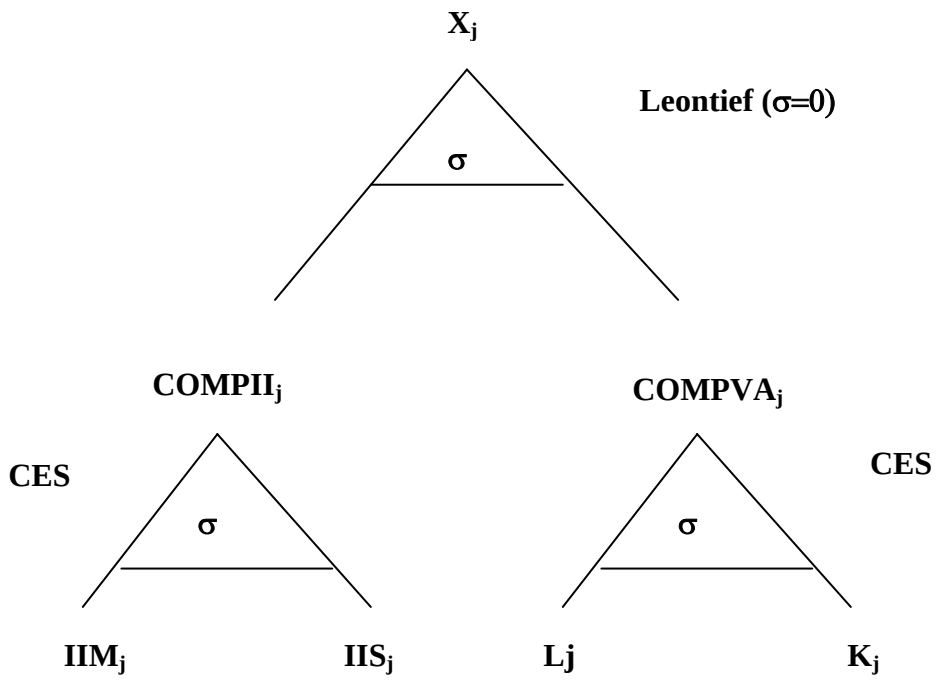


Figure 3.8 Schematic representation of the production nest

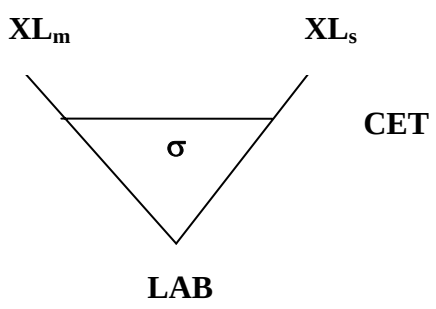


Figure 3.9 Schematic representation of the immobility of labour

3.4.3 Mathematical derivations of linearised functions

In this subsection a set of general equilibrium equations will be derived in linearised form, with the objective to demonstrate how the equations can be derived in linearised form. The mathematical techniques used in this subsection for linearisation are based on Dixon et al. (1992). In subsections

3.4.3.1, 3.4.3.2 and 3.4.3.4 are shown the derivations of supply, demand functions and the labour supply function respectively.

3.4.3.1 Production in the model

3.4.3.1.1 Composite Input Nest

The top nest in the production nest is defined by a single production process Leontief structure. As mentioned before earlier in the text, a Leontief production function implies that the elasticity of substitution (σ) between inputs is zero, hence levels demands for composite inputs are restricted by a fixed share coefficient. Composite intermediate and primary factor demands for industry 'j' are given in equation (CGE.1):

$$COMPII_j = \gamma_j X_j \qquad COMPVA_j = \gamma_j X_j \qquad \text{(CGE.1)}$$

where γ_j are the fixed input-output parameters. Following the same approach which is explained in section 3.3.1, linearised Leontief demands are:

$$compii_j = x_j \qquad compva_j = x_j \qquad \text{(CGE.2)}$$

There are no price effects in equation (CGE.2), which is a result of the zero value of the elasticity of substitution. Therefore, increases in output are translated as equiproportional changes in demands for each composite input which implies CRS.

3.4.3.1.2 Primary Factor Set

In the primary factor nest, to specify the production a constant returns to scale (CRS) CES function is used:

$$COMPVA_j = A_j\left[\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}\right]^{-\frac{1}{\rho}} \qquad \text{(CGE.3)}$$

where A_j is an efficiency parameter, δ_j is a distribution parameter with $\sum_i \delta_i = 1$, ρ_j is an elasticity parameter. Minimising cost subject to (CGE.3) gives first order conditions:

$$W_j = \Lambda A_j\left[\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}\right]^{-\frac{1+\rho}{\rho}}(1-\delta_j)L_j^{-(1+\rho)} \qquad \text{(CGE.4)}$$

$$R = \Lambda A_j\left[\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}\right]^{-\frac{1+\rho}{\rho}}\delta_j K_j^{-(1+\rho)} \qquad \text{(CGE.5)}$$

$$COMPVA_j = A_j\left[\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}\right]^{-\frac{1}{\rho}} \qquad \text{(CGE.6)}$$

Then, substituting (CGE.6) into (CGE.4) and simplifying gives:

$$W_j = \Lambda A_j^{-\rho} COMPVA_j^{(1+\rho)}(1-\delta_j)L_j^{-(1+\rho)} \qquad \text{(CGE.7)}$$

where (CGE.4), (CGE.5) and (CGE.6) are in the levels form. Here, the same method in Dixon et al. (1992) (pp124-125) is followed which linearises the first order conditions and solves. Thus linearisation of (CGE.6) gives:

$$compva_j = PVASHRK_j k_j + PVASHRL_j l_j \qquad \text{(CGE.8)}$$

where

$$PVASHRK_j = \frac{\delta_j K_j^{-\rho}}{\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}} \qquad \text{(CGE.9)}$$

$$PVASHRL_j = \frac{(1-\delta_j)L_j^{-\rho}}{\delta_j K_j^{-\rho} + (1-\delta_j)L_j^{-\rho}} \qquad \text{(CGE.10)}$$

Rearranging the equation (CGE.7) in terms of δ_j and substituting into (CGE.10) gives:

$$PVASHRL_j = \frac{W_j L_j}{RK_j + W_j L_j} \qquad \text{(CGE.11)}$$

With this alternative form of the share $PVASHR_{i,j}$ avoids the process of calibration since it eliminates distribution parameter δ_j.

Furthermore the linearisation of (CGE.7) gives:

$$w_j = \lambda + (1+\rho)compva_j - (1+\rho)l_j \qquad \text{(CGE.12)}$$

Thus, equations (CGE.8) and (CGE.12) are linearised first order conditions, where w, l and λ are percentage changes in W, L, and Λ respectively.

Rearranging (CGE.12) in terms of l_j gives:

$$l_j = -\sigma w_j + \sigma\lambda + compva_j \qquad \text{(CGE.13)}$$

Repeating this process for capital demands gives:

$$k_j = -\sigma r + \sigma\lambda + compva_j \qquad \text{(CGE.14)}$$

where σ is the elasticity of substitution between primary factors (in the example model, labour and capital) in the value added nest:

$$\sigma = \frac{1}{1+\rho} \qquad \text{(CGE.15)}$$

Substituting (CGE.13) and (CGE.14) into (CGE.8) and rearranging in terms of σλ gives:

$$\sigma\lambda = \sigma(PVASHRK_j r + PVASHRL_j w_j) \qquad \text{(CGE.16)}$$

Substituting (CGE.16) into (CGE.14) eliminates the percentage change Langrangian variable λ. Factorising the resulting expression gives linearised CES Hicksian primary factor demands:

$$l_j = compva_j - \sigma\left[w_j - (PVASHRK_j r + PVASHRL_j w_j\right] \qquad \text{(CGE.17)}$$

For consistent aggregation expression (CGE.18) must hold:

$$PVA_j COMPVA_j = RK_j + W_j L_j \qquad \text{(CGE.18)}$$

Linearising (CGE.18), substituting (CGE.8) into linearised (CGE.18) and rearranging gives the derivation of the composite value added price in linearised form:

$$pva_j = PVASHRK_j r + PVASHRL_j w_j \qquad \text{(CGE.19)}$$

where PVASHRLj was defined at the equation (CGE.11). Substituting (CGE.19) into (CGE.17) gives a simplified version of the linearised Hicksian demand function:

$$l_j = compva_j - \sigma\left[w_j - pva_j\right] \qquad \text{(CGE.20)}$$

and using same approach k_j can also be derived as:

$$k_j = compva_j - \sigma\left[r - pva_j\right] \qquad \text{(CGE.21)}$$

Equations (CGE.20) and (CGE.21) implies that in the absence of price changes, all input usage move by the same percentage as output. This reflects the constant returns to scale which is shown by the production function (CGE.3). Moreover, any increase in w_j (or in r) relative to the composite value added price (pva_j), will cause a reduction in the usage of primary factor 'l_j' (or in k_j) relative to other primary factor 'k_j' (or in l_j). The strength of this price substitution effect depends on the size of σ (elasticity of substitution).

3.4.3.1.3. Intermediate Input Nest

The functional form chosen for the specification of the intermediate input nest is also a CRS CES function as used in primary factor nest. The mathematical derivations of demand and price functions are parallel exactly to the derivations which have done in the primary factor nest. Therefore, in this subsection only derived demand and price functions will be given for not to repeat all steps[28].

Thus, the intermediate input demands for the stylised model are:

$$iim_j = compii_j - \sigma\lfloor p_m - pii_j \rfloor \qquad \text{(CGE.22)}$$

$$iis_j = compii_j - \sigma\lfloor p_s - pii_j \rfloor \qquad \text{(CGE.23)}$$

And the composite price in the nest is:

$$pii_j = PIISHRM_j\, p_m + PIISHRS_j\, p_s \qquad \text{(CGE.24)}$$

where

$$PIISHRM_j = \frac{P_m IIM_j}{P_m IIM_j + P_s IIM_j} \quad \text{and} \quad PIISHRS_j = \frac{P_s IIM_j}{P_m IIM_j + P_s IIM_j} \qquad \text{(CGE.25)}$$

[28] The full list of variables is explained in subsection 3.4.1.

The interpretation of the equations (CGE.22) and (CGE.23) can be done with a same way as for the primary factor demand functions (CGE.20) and (CGE.21).

3.4.3.1.4. Immobility of supply of labour

In the stylised model perfect mobility for primary factor capital is assumed and factor immobility is assumed for primary factor labour. As it can be seen in Figure 3.9 a CET functional form is chosen whilst the mathematical derivations of a CET function are exactly parallel to the CES function.

By repeating the steps from (CGE.4) to (CGE.21) after obtaining the first order conditions for revenue maximisation subject to (CET.1) the functional forms to explain labour supply can be obtained:

$$xl_j = lab + \sigma_j \lfloor wcomp - w_j \rfloor \qquad \text{(CGE.26)}$$

The interpretation of (CGE.26) is similar to that of (CGE.20) and (CGE.21). In the absence of price changes, all output volumes move by same percentage as endowment of the primary factor. The only difference is the positive sign which appears for the elasticity of transformation in (CGE.26). This comes from the restriction on ρ, where in CES ρ is greater than or equal to -1, whilst in CET ρ, is less than or equal to -1. Thus, if the wage rate increases in one industry relative to composite wage rate then the supply of labour in that industry will increase too.

3.4.3.2 The derivation of demand functions

In the stylised model as it is shown in Figure 3.7, the Cobb-Douglas function is used to specify the demand functions of private household and government. In this case, the easiest way to derive linearised forms of the demand functions is to derive demand functions in levels form as shown in subsection 3.2.2.1 and then to linearise the resulting equations by following the same approach (see section 3.3.1).

Thus, the private household demand can be expressed as:

$$c_j = y - q_j \qquad \text{(CGE.27)}$$

And government or public demand is:

$$g_j = t - p_j \qquad \text{(CGE.28)}$$

3.4.3.3 The General Equilibrium System of Equations

In addition to the behavioural equations, further market clearing equations are required to satisfy the general equilibrium conditions. These equations appear as equations 5,6,20,21,22,31,32,33,39 in Figure 3.10. The model assumes perfect competition, perfect capital mobility and immobility across the labour market, whilst commodity and primary factor demands are equal to their supplies.

To turn the model into a closed circular flow economy, accounting equations are introduced so that incomes accrued to the household from ownership from the ownership of the factors of production are equal to total household expenditure (CGE.29) and the total tax revenue is equal to total expenditure of the government (CGE.30). The following equations explain this in level form and in Figure 3.10 these equations can be found in linearised form (31,32,33,34).

$$Y = R\sum_j K_j + \sum_j W_j L_j \quad \text{equals to} \quad PEXP = \sum_j Q_j C_j \qquad \text{(CGE.29)}$$

$$TAXREV = \sum_j \left(Q_j - P_j\right) C_j \quad \text{equals to} \quad GOVT = \sum_j P_j G_j \qquad \text{(CGE.30)}$$

COMMODITY MARKETS

Demand	*Household (private)*	$c_j = y - q_j$	(1,2)
	Government	$g_j = t - p_j$	(3,4)

Market Clearing

$$VSALE_m(p_m + x_m) = VMANU_m(p_m + iim_m) + VMANU_s(p_m + iim_s) + HHDEMANDB_m(p_m + c_m) + GODEMANDB_m(p_m + g_m) + EXPORTS(\exp or + p_m) \quad (5)$$

$$VSALE(p_s + x_s) = VSERV_m(p_s + iis_m) + VSERV_s(p_s + iis_s) + HHDEMANDB_s(p_s + c_s) + GODEMANB_s(p_s + g_s) \quad (6)$$

Price Equations $q_j = p_j + tc_j$ (7,8)

INPUT MARKETS

Composite Input Demands (Leontief)	$compii_j = x_j$	(9,10)
	$compva_j = x_j$	(11,12)

Primary Factor Market (CES)

Primary Factor Demands	$k_j = compva_j - \sigma[r - pva_j]$	(13,14)
	$l_j = compva_j - \sigma[w_j - pva_j]$	(15,16)
Composite wage rate	$wcomp = \sum_j REVSHRL_j w_j$	(17)
Labour supply	$xl_j = lab + \sigma_j[w_j - wcomp]$	(18,19)
Labour market clearing	$xl_j = l_j$	(20,21)
Capital market clearing	$cap = REVSHRK_m k_m + REVSHK_s k_s$	(22)
Composite value added price	$pva_j = PVASHRK_j r + PVASHRL_j w_j$	(23,24)

Figure 3.10 The Stylised CGE Model

Intermediate Input Market (CES)

Intermediate Input Demands $iim_j = compii_j - \sigma\lfloor p_m - pii_j \rfloor$ (25,26)

$iis_j = compii_j - \sigma\lfloor p_s - pii_j \rfloor$ (27,28)

Composite intermediate input price $pii_j = PIISHRM_j\, p_m + PIISHRS_j\, p_s$ (29,30)

CONSUMER

Income $y = \sum_j INCSHRK_j \left(r + k_j\right) + \sum_j INCSHRL_j \left(w_j + l_j\right)$ (31)

Expenditure $p\exp = \sum_j INCSHRE_j \left(q_j + c_j\right)$ (32)

PUBLIC SECTOR (GOVERNMENT)

Tax Revenue $t = \sum_j TAXRSHRP_j \left(q_j + c_j\right) - \sum_j TAXRSHRB_j \left(p_j + c_j\right)$ (33)

Expenditure $govt = \sum_j TAXRSHRG_j \left(p_j + g_j\right)$ (34)

FOREIGN SECTOR

Importation $impor = c_s$ (35)

Exportation $EXPORTS(\exp or + p_m) = IMPORTS\left(impor + p_s\right)$ (36)

Price Equations $p_j = f + pw_j$ (37,38)

Balance of Trade $bot = \left(pw_m + \exp or\right) - \left(pw_s + impor\right)$ (39)

GDP (Gross Domestic Product)

$$gdp = GDPSHRB_j \left(p_j + c_j\right) + GDPSHRG_j \left(p_j + g_j\right) + GDPSHRE_j \left(\exp or + p_m\right) - GDPSHRI_j \left(impor + p_s\right) \quad (40)$$

Figure 3.10 (Cont.) The Stylised CGE Model

where

$VSALE_j$ – The value of domestic supply in industry j

$VMANU_j$ – The value of manufactured intermediate inputs in industry j

$VSERV_j$ – The value of services intermediate inputs in industry j

$HHDEMANDB_j$ – The value of private household demands (basic prices)

$GODEMANDB_j$ – The value of government demands (basic prices)

EXPORTS – The value of (manufacturing) exports

IMPORTS – The value of (services) imports

In Figure 3.10 the variables which are notated by SHR letters refer to the share coefficients. Some of them are expressed explicitly in the previous parts of this section and below:

$$REVSHRK_j = \frac{RK_j}{\sum_j RK_j} \quad \text{and} \quad REVSHRL_j = \frac{W_j L_j}{\sum_j W_j L_j} \qquad \text{(CGE.31)}$$

$$INCSHRK_j = \frac{RK_j}{\sum_j R_j K_j + \sum_j W_j L_j} \quad \text{and} \quad INCSHRL_j = \frac{W_j L_j}{\sum_j R_j K_j + \sum_j W_j L_j} \qquad \text{(CGE.32)}$$

$$TAXRSHRP_j = \frac{\sum_j Q_j C_j}{\sum_j Q_j C_j - \sum_j P_j C_j} \quad \text{and} \quad TAXRSHRB_j = \frac{\sum_j P_j C_j}{\sum_j Q_j C_j - \sum_j P_j C_j} \qquad \text{(CGE.33)}$$

$$GDSHRB_j = \frac{\sum_j P_j C_j}{\sum_j P_j C_j + \sum_j P_j G_j + EXPORTS - IMPORTS} \qquad \text{(CGE.34)}$$

Also in appendix IV codes for this stylised model are given for the GEMPACK software. GEMPACK (General Equilibrium Modelling PACKage) software is used to solve this stylised model to find the equilibrium solution.

The model consists of 47 variables as given in subsection 3.4.1 40 of them are endogenous variables and they can be found in Figure 3.10 and the other 7 variables are used as exogenous variables to ensure correct model closure. More information about closure will be given in the next section.

There are two more important issues in CGE model developing which can be easily shown by using this simple stylised model. The first issue to discuss is Walras' law. This law shows that for a given set of prices, the sum of the excess demands over all markets must be equal to zero. Or in other words if N-1 markets are in equilibrium then the Nth market also will be in equilibrium.

A related issue is the zero homogeneity in prices in the demand functions, where changes in the absolute price level have no effect on the level of demand. Accordingly, CGE models are relative price models, where to establish a relative price base, one price variable known as the "numeraire" must be exogenised and held fixed. Thus, given Walras' law, it is possible to omit the Nth market and exogenise a price variable as a price deflator or numeaire whilst maintaining the closure intact. Therefore, all price movements are interpreted in terms of the numeraire variable (Dinwiddly and Teal, 1988). In the stylised model the variable 'F' (exchange rate) is chosen as the numeraire variable.

3.5 CLOSURE

Closure is the process of deciding which variables of the model will be treated as endogenous and which variables are to be held exogenous variables of the model[29]. Once exogenous variables are decided, then shocks can be applied to these variables to make a 'counterfactual' database.

Closure also defines the maintained hypothesis about the macro- and microeconomic mechanisms which underlie the workings of the economy. For example in the model employed here 'a

[29] Endogenous variables are variables whose values are determined by the solution of the model whilst exogenous variables take values determined by the modeller in order to implement assumed shocks.

small country assumption' is used which implies that the country does not have enough market power to affect world prices. Thus, world commodity prices are typically assumed exogenous, and the transmission mechanism between world and domestic prices is via an exchange rate (F in the stylised model) which adjusts to ensure equilibrium in the balance of payments (Shoven and Whalley, 1992, ch.9). In other words, import and export demands are ascertained by a balance of payments market clearing equation. In fact, this assumption and its implications on the closure decision can be seen in the stylised model (section 3.4) too. In the stylised model, world prices for both commodities and the exchange rate are selected as exogenous variables to use the small country assumption. On the other hand, for large country single region models, the import and export demand equations may be specified explicitly using a specific functional form, although simultaneous changes in these demands and the exchange rate must still satisfy the balance of payments constraint (Shoven and Whalley, 1992).

Closure can also be used to capture different time horizons. For example, in the stylised model there are no changes in population, productivity or endowments which would be indicative of a short to medium run time period. On the other hand, a closure change, through closure swap could be used to incorporate, for example, capital accumulation (Francois et al., 1996) thereby giving the model a longer run dimension. It is also possible to introduce closure swaps to characterise microeconomic hypothesis. For example, if a tax variable (now endogenous) is swapped with a quantity variable (now exogenous), it could be possible to characterise a production quota.

To summarise, closure choice is a complex issue which defines the key characteristics of the economy. As a result, the choice of endogenous/exogenous variable split has a significant influence on the model result.

3.6 EVALUATION OF THE METHODOLOGY – CGE

After looking over the principles of CGE modelling, it will be useful to evaluate its utility as a policy appraisal tool. To achieve this objective in this section, the possible strengths and weaknesses of the CGE methodology are given. This section is based on the study done by Greenaway et al. (1993) and the most important features are emphasised in the section.

3.6.1 Strengths

As shown in previous sections, the behavioural functions are derived by using microeconomic theory. This becomes one of the key strengths of CGE models allowing the researcher to asses the impacts of policy changes at the micro level. Another important feature of CGE modeling for policy appraisal is that since these models are multisectoral models, they can capture the interaction between different production sectors of the economy. Since all policy changes have distributional consequences, the ability to compute distributional changes at disaggregated sectoral levels is a great strength of this approach. Moreover, these models generally attempt to model welfare changes by using indicators like compensating and equivalent variation. Thus, as well as specifying the price or quantity effects of a given policy shock, net welfare benefits can be identified too. Thus, CGE is a powerful analytical tool and especially useful for assessing the impact of alternative policy interventions.

Although many of the studies that applies CGE models have been concerned with trade and policy issues, they also can be used to address a wide range of subjects such as; macroeconomics, public finance, environmental analysis etc. Table 3.3 provides some examples of recent CGE models developed for Turkish economy by classifying them according to their application area.

In summary, although CGE models are not suitable for the analysis of individual firms and consumers and for macroeconomic forecasting, they are well suited to the economy-wide analysis of the effects of alternative policy scenarios. In general, CGE, for many large-scale studies, is likely to be the most useful tool given its facility for multi-sectoral modeling.

Application Area	Selected Studies	Application Area	Selected Studies
Trade liberalization	Tıktık (1996) Yeldan et al. (1997)	Development strategy and structural adjustment issues	Hwang (2003)
Agricultural issues	Koç et al. (1998) Doğruel et al. (2003)	Financial CGE models	Yeldan (1997) Tunç (1997)
Economic crisis	Yeldan (1998)	Tax issues	Çelebi (1998)

Table 3.3 Recent CGE modelling studies on Turkish economy

3.6.2 Weaknesses

In theory these models can adapt any kind of functional forms, but in practice depending on calibration and solution method restrictions, favours the use of convenient functions. Therefore, these models lack flexibility. Moreover, there is no statistical test to evaluate the goodness of fit of the selected functions and the parameters. As argued before, some of the parameter estimates are based on subjective modeling assumptions like income elasticities and elasticities of substitution, which conceivably compromises the quality of the model's predictions.

CGE models rely too much on secondary data and this reliability can be questionable since the models are calibrated to a benchmark year. Furthermore, these models require a vast amount of data and obtaining a benchmark data set which is consistent with a general equilibrium can be very difficult.

Another contentious issue is the choice of closure. This decision can affect the results and can also constrain the model in important aspects. Finally, in these models monetary sectors are usually quite primitive and monetary flows are ignored.

3.7 CONCLUSIONS

This chapter summarises the principal issues in CGE modeling and implementation. After a brief introduction to the chapter, the next section examined the properties of the family of 'convenient' functional forms which are generally used in CGE model structures (section 3.2).

The chapter then proceeded to discuss the concepts of model representation and solution methodology in CGE modeling (section 3.3). This section then explained the mathematical derivation of linearisation and related issues of nesting and calibration. The section discussed the use of nesting structures (multi-step optimisation technique) as a remedial tool against the lack of functional flexibility in CGE model structures. To help the reader, more information about the Johansen approach, multi-step procedures and extrapolation is presented in appendix I.

The next section offered a stylised CGE open economy model structure to help the reader interpret the mechanisms of linear model representation and nesting, which play an important role in CGE modelling, and to illustrate the usage of functional forms, which were examined in the section 3.2, and their linearisation process (section 3.4). Also the code of this stylised model for GEMPACK software is laid out in appendix IV.

The chapter continued with two small sections, while one of them discussed the issue of closure (section 3.5) and the other one evaluated the CGE modeling approach by giving its strengths, weaknesses (section 3.6).

CHAPTER IV

METHODOLOGY – GTAP MODEL

CHAPTER IV

METHODOLOGY – GTAP MODEL

4.1 INTRODUCTION

This study employs the GTAP (Global Trade Analysis Project) standard multi-regional static CGE trade model. Having discussed the principles of CGE theory in chapter III, this chapter intents to provide information about the theory behind the GTAP model and its database.

The chapter is organized as follows. The second section (4.2) gives an overview of the GTAP model. In the following section (4.3), the accounting relationships within the database and the model by tracking value flows from production and sales to intermediate and final demands are discussed. In the fourth section (4.4), behavioural equations in linearised form are provided to describe the behavioural patterns of producers and consumers within the economy. This section also discusses some of the welfare measures in the model. The chapter continues with section 4.5 which provides information about the GTAP database (Version 6) by discussing data construction and giving an outline of both the sets and parameter estimations provided by the database. Finally, the section 4.6 concludes the chapter.

4.2 OVERVIEW OF THE GTAP MODEL

The GTAP model (version 6 of the database) covers 87 regions and 57 commodities. Given the coverage of the model (regions and sectors), the GTAP is necessarily complex. Accordingly, in this section, an intuitive description of the model following the description in Brockmeier (2001) is offered.

Figure 4.1 offers a graphical overview of the model (taken from Brockmeier, 2001). The arrows indicate the direction of the income flows. At the top of the figure there is a regional household which

collects all income. This regional income is distributed over the three forms of final demands: private, government and savings by using a Cobb-Douglas function. The available regional income consists of the *Value of Output at Agents' prices* (VOA_{endow}) paid by firms for the use of *endowment commodities* and the sum over all taxes net of subsidies received from private household, government, firms and rest of the world (import taxes '*MTAX*' and export taxes '*XTAXD*')[30].

On the production side, the producers receive payments from domestic consumption of private households (*Value of Domestic Purchases by Private Households at Agent's prices VDPA*) and the government (*Value of Domestic Purchases by Government Household at Agent's prices VDGA*), other producers' intermediate input purchases (*Value of Domestic Purchases by Firms at Agent's prices VDFA and Value of Exports at Agent's prices VXMD*) and from the investment goods purchases of the global savings sector (*NETINV*).

Figure 4.1 combines all other regions in the model in a region called rest of the world to integrate the trading sector of the model. The rest of the world receives import payments from private households (*Value of Imported Purchases by Private Households at Agent's prices VIPA*), government (*Value of Imported Purchases by Government Household at Agent's prices VIGA*) and firms (*Value of Imported Purchases by Firms at Agent's prices VIFA*).

The model also includes two global sectors. The first one is called global bank and shown in the Figure 4.1. The global bank intermediates between global savings and regional investment. The second global sector is a transportation sector which is not displayed in the figure.

After giving an overview of the GTAP model, the theory behind the model and the derivation of the behavioural equations will be covered in more detail in the following sections of this chapter. Much of the discussion in these following sections, 4.3 and 4.4, follows Hertel and Tsigas (1997).

[30] To simplify the presentation, the figure only shows the value flows in the economy but there are also corresponding flows of goods and services in opposite direction except tax flows which are not accompanied by these flows.

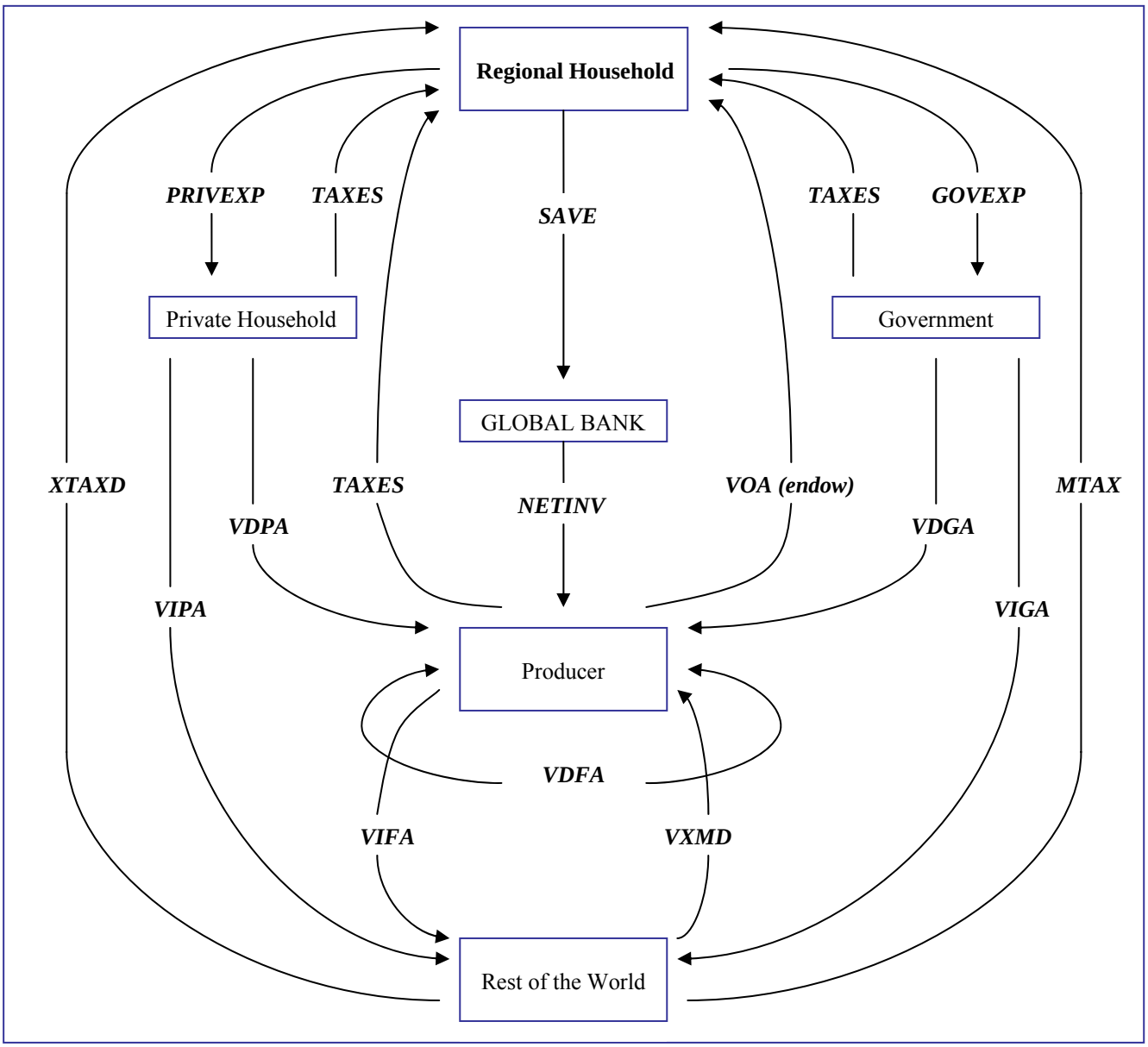


Figure 4.1 A Graphical Exposition of The GTAP Model (Brockmeier, 2001)

4.3 ACCOUNTING RELATIONSHIPS IN THE GTAP

According to Hertel and Tsigas (1997), the basic accounting relationships in the database/model can be understood better in the context of a flow chart. Following this approach, in this section the accounting relationships are given by tracking the value flows from production and sales to intermediate and final demands. Attention is paid to the prices at which each of these flows are evaluated, and also the presence of distortions in the form of taxes and subsidies. On the right hand side of all Figures 4.2 to 4.4, price and quality units corresponding to the value flows are provided.

4.3.1 Distribution of Sales

The first accounting relationship is the distribution of receipts to regional markets. In the centre of Figure 4.2 are the 'value flows' in the model, whilst on the right hand side are the corresponding price and quantity variables. At the top of the Figure 4.2, $VOA_{i,r}$, the *Value of Output at Agents' prices*, represents the payments received by the firms in industry 'i' (commodity i) in region 'r'. Adding a production tax (or subsidy), denoted as $PTAX_{i,r}$, gives the value of the same output at market prices, $VOM_{i,r}$. As it can be seen in the Figure 4.2, this value is the sum of the *Value of Domestic sales at Market prices*, $VDM_{i,r}$, *Value of eXports of ' i' from 'r' at domestic Market prices (in r) to region 's'*, $VXMD_{i,r,s}$ and international transport sector, $VST_{i,r}$, which covers the international transport margins. The domestic sales, $VDM_{i,r}$, are distributed across the final demands of private household, $VDPM_{i,r}$, government, $VDGM_{i,r}$ and intermediate input demands by each sector 'j', $VDFM_{i,j,r}$, as shown on the left hand side of Figure 4.2.

By adding a destination specific export tax, $XTAXD_{i,r,s}$, exports are converted from market price to 'free on board' (fob) values. Adding the cost of shipping freight, $VTMFSD_{i,r,s}$, gives the 'cost insurance freight' (cif) based *Value of Imports at World prices by Source*, $VIWS_{i,r,s}$. Adding the destination specific import tax in region 's', $MTAX_{i,r,s}$, gives the *Value of Imports at Market prices by Source*, $VIMS_{i,r,s}$. These imports are combined into a single composite import, $VIM_{i,s}$, the *Value of*

Imports of i into s at Market prices, and are distributed across final demands of private household, $VIPM_{i,s}$, government, $VIGM_{i,s}$ and intermediate, $VIFM_{i,j,s}$.

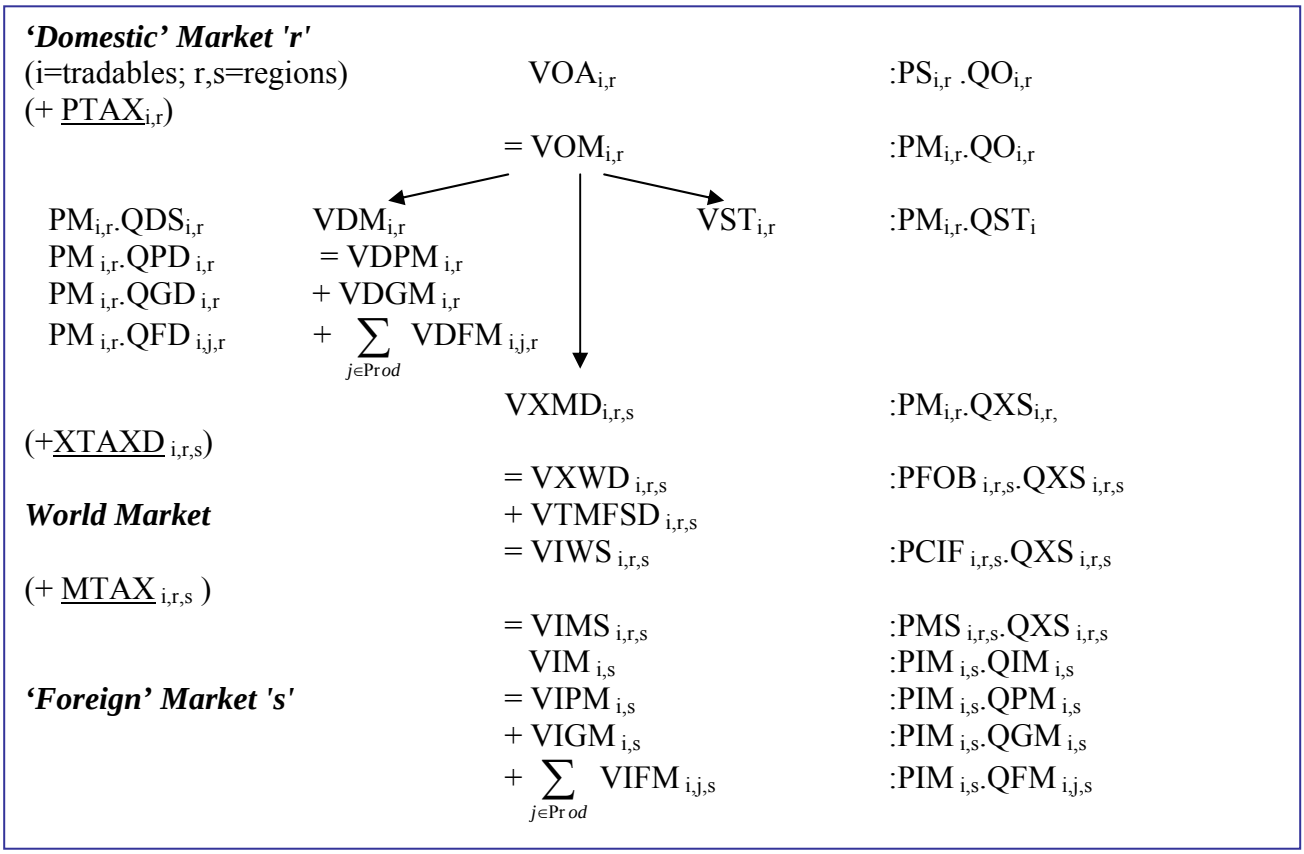


Figure 4.2 Distribution of Sales (Hertel and Tsigas, 1997)

4.3.2 Agents in the model

Figures 4.3 and 4.4 outline interactions between agents in each of these markets. At the top of the Figure 4.3, $VPA_{i,r}$, refers the *Value of Private household purchases of commodity 'i' at Agents' prices in region 'r'*. This value is the sum of domestic purchases, $VDPA_{i,r}$, and imports, $VIPA_{i,r}$, both at agents' prices. Deducting domestic and foreign private household commodity taxes respectively ($IPTAX_{i,r}$ and $DPTAX_{i,r}$) from these values gives the respective market values, $VDPM_{i,r}$ and $VIPM_{i,r}$. At the bottom half of the Figure 4.3, the same structure is used for government purchases, only *P* is replaced by *G* to represent the government.

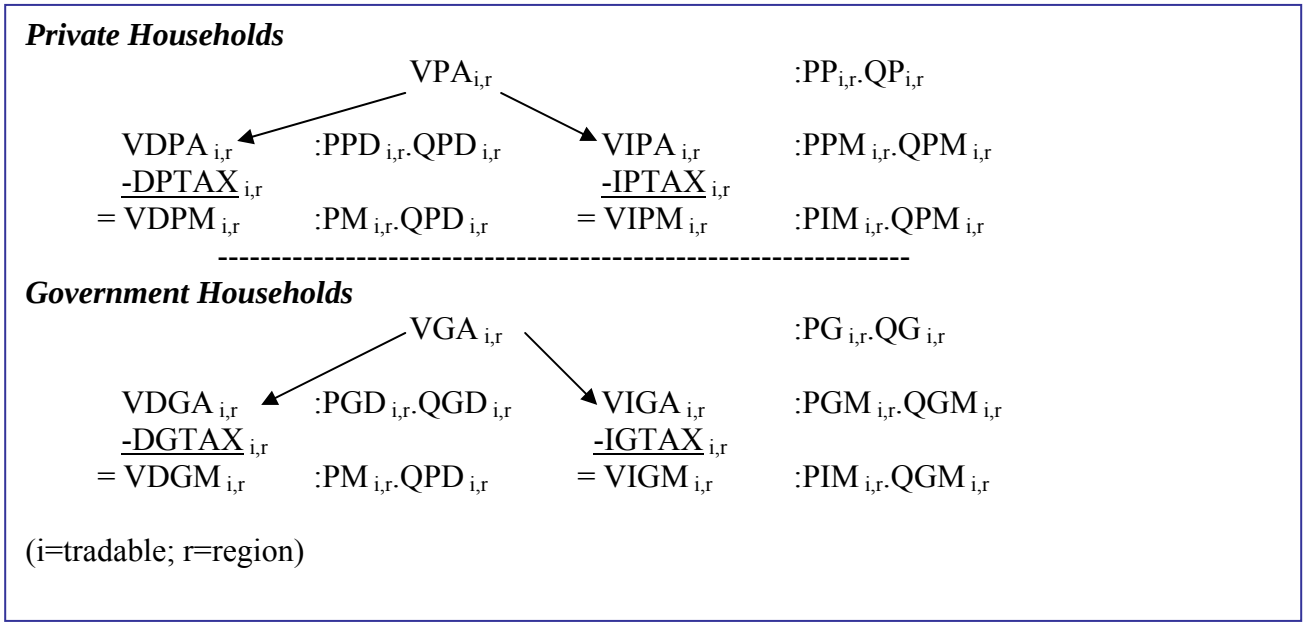


Figure 4.3 Sources of Private Household and Government Purchases (Hertel and Tsigas, 1997)

Figure 4.4 shows the distribution of firms' purchases of intermediate and primary endowment factors, which are non-tradable across regions. The top half of the figure shows intermediate inputs purchases, denoted as $VFA_{i,j,r}$, to represent the *Value of Firms' purchases of 'i', by sector 'j' in region 'r' at Agents' prices*. This is broken into domestic purchases and imports $VDFA_{i,j,r}$ and $VIFA_{i,j,r}$, respectively. Subtracting domestic and foreign private intermediate taxes respectively ($DFTAX_{i,r}$ and $IFTAX_{i,r}$) from these values gives the respective market values, $VDFM_{i,r}$ and $VIFM_{i,r}$. In the model it is assumed that private household owns and supplies primary endowment factors. The 'supply' value of endowments *'i'* to each using sector *'j'* is $VFM_{i,j,r}$. After imposition of the purchase tax ($ETAX_{i,j,r}$) on primary factors the purchaser's or agent's value *is* $VFA_{i,j,r}$ is derived.

To link firms' expenditures ($VFA_{i,j,r}$) to firms' receipts ($VOA_{j,r}$) a zero profit condition is employed which means that revenues of each sector 'j' at agents' prices must be equal to the expenditures on primary factors and all intermediate goods.

$$VOA_{j,r} = \sum_{i \in trad} VFA_{i,j,r} + \sum_{i \in endw} VFA_{i,j,r} \qquad \text{(AC.1)}$$

Intermediate Input Purchases

$VFA_{i,j,r}$ $:PF_{i,j,r}.QF_{i,j,r}$

$VDFA_{i,j,r}$ $:PFD_{i,j,r}.QFD_{i,j,r}$ $VIFA_{i,j,r}$ $:PFM_{i,j,r}.QFM_{i,j,r}$

$\underline{-DFTAX}_{i,j,r}$ $\underline{-IFTAX}_{i,j,r}$

$= VDFM_{i,j,r}$ $:PM_{i,r}.QFD_{i,j,r}$ $= VIFM_{i,j,r}$ $:PIM_{i,r}.QFM_{i,j,r}$

(i=tradables; j=sector r=region)

Primary Factor Purchases

$VFA_{i,j,r}$ $:PFE_{i,j,r}.QFE_{i,j,r}$

$\underline{-ETAX}_{i,j,r}$

$= VFM_{i,j,r}$ $:PM_{i,r}.QFE_{i,j,r}$

(i=endowments; j=sector r=region)

Figure 4.4 Sources of Firms' Purchases (Hertel and Tsigas, 1997)

4.3.3 Regional Income

Equation (AC.2) shows income decomposition by source in each region. The regional household receives income from primary endowment factor sales ($VOA_{i,r}$) after subtracting depreciation expenses, $VDEP_r$, in order to maintain the initial capital stock. The remaining terms in the equation are all other possible sources of tax revenue/subsidy expenditures in each region. These consist of: taxes on output of non-savings commodities ($PTAX_{i,r}$), primary factor taxes on firms ($ETAX_{i,r}$), commodity taxes on households' and firms' purchases of tradable goods ($IPTAX_{i,r}$, $DPTAX_{i,r}$, $IGTAX_{i,r}$,$DGTAX_{i,r}$, $IFTAX_{i,j,r}$, $DFTAX_{i,j,r}$) and export ($XTAX_{i,s,r}$) and import taxes ($MTAX_{i,s,r}$).

$$
\begin{aligned}
INCOME_r &= \sum_{i \in endw} VOA_{i,r} - VDEP_r \\
&+ \sum_{i \in nsav} PTAX_{i,r} + \sum_{i \in endw} \sum_{j \in prod} ETAX_{i,j,r} \\
&+ \sum_{i \in trad} IPTAX_{i,r} + \sum_{i \in trad} DPTAX_{i,r} + \sum_{i \in trad} IGTAX_{i,r} + \sum_{i \in trad} DGTAX_{i,r} \\
&+ \sum_{i \in trad} \sum_{j \in prod} IFTAX_{i,j,r} + \sum_{i \in trad} \sum_{j \in prod} DFTAX_{i,j,r} + \sum_{i \in trad} \sum_{s \in reg} XTAXD_{i,s,r} + \sum_{i \in trad} \sum_{s \in reg} MTAX_{i,s,r}
\end{aligned}
\tag{AC.2}
$$

As noted in the previous section, regional income is exhausted over private household and government expenditures and regional savings which gives equation (AC.3).

$$EXPENDITURE_r = PRIVEXP_r + GOVEXP_r + SAVE_r \qquad \text{(AC.3)}$$

where

$$PRIVEXP_r = \sum_{i=Trad} VPA_{i,r} \qquad GOVEXP_r = \sum_{i=Trad} VGA_{i,r} \qquad \text{(AC.4)}$$

4.3.4 Global Transport Sector

The global transport sector provides the services which are the margins between the free on board (fob) and cost insurance freight (cif) values for a commodity shipped along a specific bilateral trade route. Summing all routes and commodities gives the total demand for global transport services which is shown in equation (AC.5).

$$VT = \sum_{i \in trad} \sum_{r \in reg} \sum_{s \in reg} VTMFSD_{i,r,s} \qquad \text{(AC.5)}$$

The supply of transport services, $VST_{m,r}$, is assumed to come from each transport sector (air, land and sea) in each region, which is exported to the global sector (*VT*). Since it is difficult to obtain information to link regional transport services to particular commodities and routes, it is assumed that all transport service demand is met from total transport services (*VT*), where there is a composite price of all transport services.

$$\sum_{m \in m\arg} \sum_{r \in reg} VST_{m,r} = VT \qquad \text{(AC.6)}$$

4.3.5 Global Banking Sector

As in the case of global transport services, the GTAP database does not have information on bilateral investment levels. Therefore, a global banking sector is created which intermediates between

global savings and investment. The global bank creates a global investment good (*GLOBINV*) (gross investment less depreciation) which is used to satisfy each region's savings demand.

$$GLOBINV = \sum_{r \in reg} \left[REGINV_r - VDEP_r \right] \qquad \text{(AC.7)}$$

Gross regional investment in each region equals the sum total of all inputs ($VOA_{i,r}$ under zero profits condition) in the capital goods (non-tradable) sector:

$$REGINV_r = VOA_{i,r} \qquad \text{(AC.8)}$$

where the index 'i' pertains to the capital goods producing sector. The value of ending period capital stocks, VKE_r, is calculated by the addition of beginning period capital stocks, VKB_r, plus regional gross investment, $REGINV_r$, minus regional depreciation, $VDEP_r$, (AC.9).

$$VKE_r = VKB_r + REGINV_r - VDEP_r \qquad \text{(AC.9)}$$

4.4 BEHAVIOURAL EQUATIONS

This section describes the economic behaviour of various agents in the model (e.g., consumers, firms, global savings and investment). This is done by providing technology tree figures and linearised behavioural equations for each agent.

4.4.1 Armington Structure

Before discussing behavioural patterns of the agents, in this subsection attention is paid to the armington structure which is adapted by the model to model regional intermediate and final import demands. This structure follows the Armington (1969) assumption that permits the model to

differentiate internationally traded products by country of origin. The Armington assumption is based on a two stage nested function. In the first stage, a weakly separable function (CES function) is used to aggregate the composite import demands and the domestic substitute into a composite tradeable (see the bottom right 'trees' in Figures 4.6 and 4.9 for the first stage of the armington structure). In the second stage an elasticity of substitution parameter (σ_m) is used to differentiate imports by region of origin 'r' and to allow imperfect substitution possibilities between each export demands by importing region 's' (see Figure 4.5).

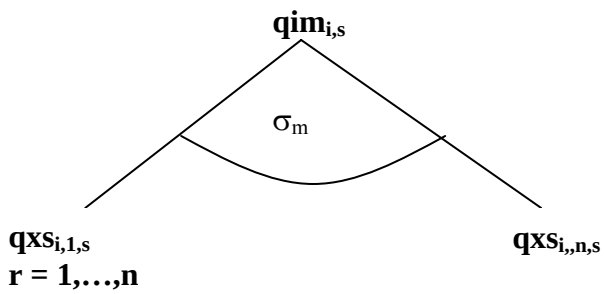


Figure 4.5 The lower Armington Nest in the GTAP model

Equation (B.1) determines import demands for good 'i' (both intermediate and final) from exporting region 'r' to importing region 's'.

$$qxs_{i,r,s} = qim_{i,s} - \sigma_i^m \left[pms_{i,r,s} - pim_{i,s} \right] \qquad \text{(B.1)}$$

Thus, imports of 'i' from 'r' to 's' have a price component and a quantity component. If the individual market price ($pms_{i,r,s}$) for that tradable is relatively cheaper compared with the composite import price ($pim_{i,s}$), then imports will rise. This is known as the 'substitution effect'. The composite price is given as:

$$pim_{i,s} = \sum_{r \in reg} MSHRS_{i,r,s}\, pms_{i,r,s} \qquad \text{(B.2)}$$

where $MSHRS_{i,r,s}$ refers to the share of imports of tradable commodity 'i' from region 'r' in the composite imports of 'i' in region 's'. Imports of tradable 'i' along a bilateral route may also rise due to increases in aggregate imports of 'i' to region 's' ($qim_{i,s}$), known as the 'expansion effect'. The increase in aggregate import is given by the linearised market clearing expression (B.3), over intermediate, private and public demands:

$$VIM_{i,s}qim_{i,s} = \sum_{j \in prod} VIFM_{i,j,s}.qfm_{i,j,s} + VIPM_{i,s}.qpm_{i,s} + VIGM_{i,s}.qgm_{i,s} \qquad \text{(B.3)}$$

where the composite import quantity indices ($qfm_{i,j,s}$, $qpm_{i,s}$, $qgm_{i,s}$) appear in the upper part of the Armington nest for both intermediate and final demands (see Figures 4.6 and 4.9 respectively).

4.4.2 Firm Behaviour

A schematic representation of the production nest for each sector 'j' is given in Figure 4.6, where each sectoral production function produces a single output in a perfectly competitive market structure and is assumed to show constant returns to scale (CRS). Figure 4.7 provides linear behavioural equations. For each nest of the production tree, there are two types of equations. The first one contains conditional (Hicksian) demand equations and the second one is a composite price equation.

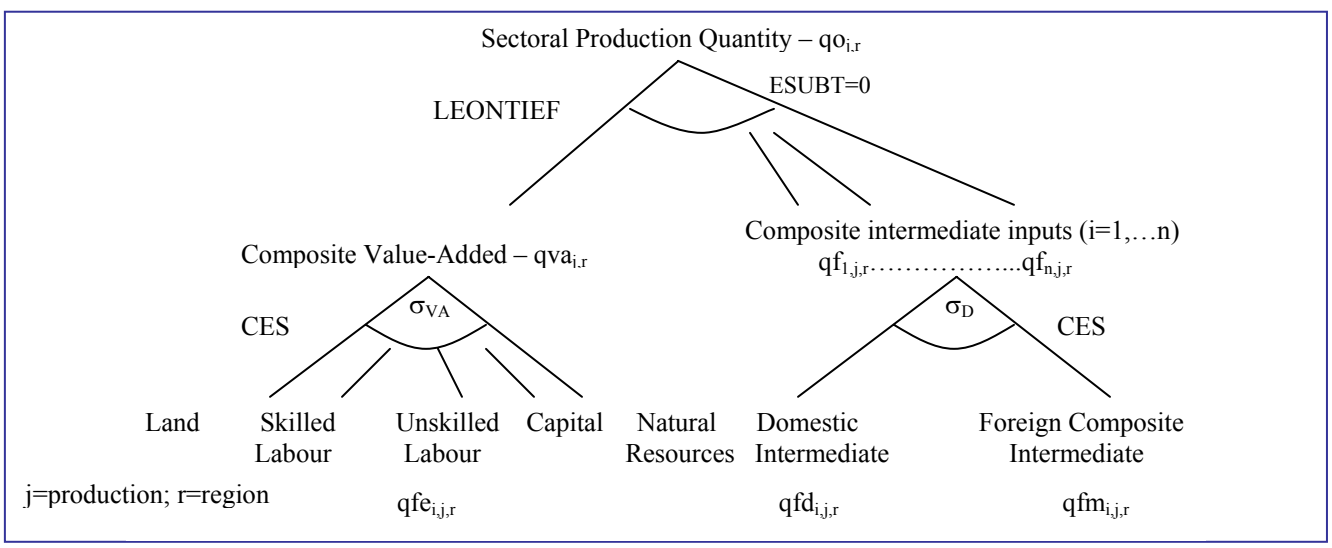


Figure 4.6 The Production Nest

Upper Nest – Composite Value added/intermediate input demands

$$qva_{j,r} = qo_{j,r} \qquad \text{(composite value added demand)} \quad (1)$$

$$qf_{i,j,r} = qo_{j,r} \qquad \text{(composite intermediate input demand)} \quad (2)$$

$$VOA_{j,r}.ps_{j,r} = \sum_{i \in endw} VFA_{i,j,r}.pfe_{i,j,r} + \sum_{i \in trad} VFA_{i,j,r}.pf_{i,j,r} \qquad \text{(composite price/zero profit)} \quad (3)$$

Lower Nest - Composite Intermediate Inputs:

$$pf_{i,j,r} = FMSHR_{i,j,r}.pfm_{i,j,r} + \left[1 - FMSHR_{i,j,r}\right].pfd_{i,j,r} \qquad \text{(composite price)} \quad (4)$$

$$qfm_{i,j,r} = qf_{i,j,r} - \sigma_i^D.\left[pfm_{i,j,r} - pf_{i,j,r}\right] \qquad \text{(composite import demand)} \quad (5)$$

$$qfd_{i,j,r} = qf_{i,j,r} - \sigma_i^D.\left[pfd_{i,j,r} - pf_{i,j,r}\right] \qquad \text{(domestic tradable demand)} \quad (6)$$

where FMSHR is the share of the import composite or domestic good in the total purchases of ‘i’ by sector ‘j’ in the nest.

Lower Nest - Value Added Nest:

$$pva_{j,r} = \sum_{i \in endw} SVA_{i,j,r}.pfe_{i,j,r} \qquad \text{(composite price)} \quad (7)$$

$$qfe_{i,j,r} = qva_{j,r} - \sigma_i^{va}\left[pfe_{i,j,r} - pva_{j,r}\right] \qquad \text{(endowment demands)} \quad (8)$$

where SVA is the share of a given endowment ‘i’ in the total endowment purchases by sector ‘j’ in the nest.

Figure 4.7 Linearized Behavioural Equations of the Production Nest

The top nest which produces the demand for composite value-added and intermediate inputs is specified by a Leontief function[31]. As it is discussed in chapter III, this implies zero substitutability between value-added and intermediate. Thus, there is no relative price effect as shown in Figure 4.6 (equations 1 and 2). The composite price in this nest is determined by the zero profits condition (equation 3).

In the lower part of the production nest, CES (Constant Elasticity of Substitution) aggregator functions are used to collect primary factor inputs and intermediate inputs into composite value-added and composite intermediate respectively. Since the substitution possibilities are defined by a single parameter, the input components of both of these aggregator functions are imperfectly substitutable for one other within each separable group. As it is assumed that the technology is weakly separable between primary factors and intermediate inputs, firms decide their optimal mix of primary factors independently of the prices of intermediate inputs (for further discussion on nesting see section 3.3.2). Furthermore, the intermediate input part of the lower nest is the upper level of the armington structure discussed in previous subsection (4.4.1).

4.4.3 (Sluggish) Factor Mobility

Within each region, the GTAP model distinguishes between primary factors, 'i', that are perfectly mobile across sectors and those that are sluggish (typically land and natural resources). To characterise imperfect or sluggish factor mobility, the model employs a single nested Constant Elasticity of Transformation (CET) function as it is done in the stylised model which is given in section 3.4.3.1.4 of chapter III. A schematic presentation of sluggish factor mobility is given in Figure 4.8.

Two equations (B.4 and B.5) describe the responsiveness of a sluggish factor 'i' to changes in the regional quantity ($qo_{i,r}$) (exogenous variable) and the sectoral prices ($pmes_{i,j,r}$). The first equation (B.4) determines the optimum supply allocations ($qoes_{i,j,r}$) of a sluggish factor 'i' whilst the second one

[31] In the GTAP model code, although this nest is specified by a CES function, in the database the default setting of the elasticity of substitution parameter (ESUBT) is zero which drops the relative price effect. The reason why, this nest is specified by a CES function in the model code is to permit the researcher, who has the sufficient information about the elasticity of substitution, to specify ESUBT in order to make the model to account for the substitution at this nest.

gives the composite sluggish primary factor price ($pm_{i,r}$) (for further discussion on mathematical derivations see section 3.4.3.1.4).

$$qoes_{i,j,r} = qo_{i,r} + \sigma_i^T \left[pm_{i,r} - pmes_{i,j,r} \right] \qquad \text{(B.4)}$$

$$pm_{i,r} = \sum_{j \in prod} REVSHR_{i,j,r} . pmes_{i,j,r} \qquad \text{(B.5)}$$

where $REVSHR_{i,j,r}$ is the value of market demands, (i.e., the cost to the using sector inclusive of taxes/subsidies) for sluggish factor 'i' by sector 'j' in region 'r' as a share of the demand for sluggish factor 'i' by *all* using sectors 'j' in region 'r'.

The degree of factor mobility of the sluggish factor ‘i’ between using sectors ‘j’ is specified by the elasticity of transformation parameter (σ_T). As this parameter becomes larger in absolute value, the factor becomes more mobile (for more information see sections 3.2.2.3 and 3.4.3.1.4).

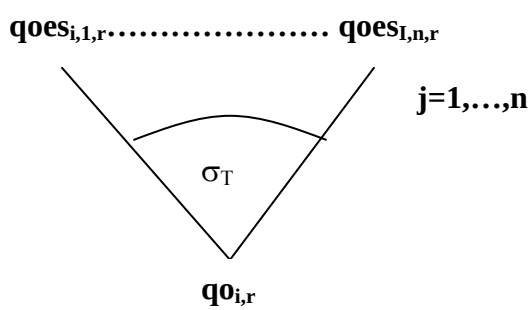


Figure 4.8 Sluggish Factor Mobility in the GTAP model

Since market prices are equal for perfectly mobile primary factors, the market clearing equation can be expressed as equation (B.6) where the sum over all usage of the factor is equal to regional quantity (supply). In the case of the sluggish factor, there is no single price to clear aggregate factor

markets[32]. Therefore, market clearing in each region ‘r’ is expressed on a sectoral basis of quantities only (equation B.7).

$$VOM_{i,r}.qo_{i,r} = \sum_{j \in prod} VFM_{i,j,r}.qfe_{i,j,r} \qquad \text{(B.6)}$$

$$qoes_{i,j,r} = qfe_{i,j,r} \qquad \text{(B.7)}$$

$qfe_{i,j,r}$ – Quantity demanded of factor 'i' (sluggish or mobile) by sector 'j' in region 'r'

$VOM_{i,r}$ - Total market value of mobile endowment 'i' in region 'r'.

$VFM_{i,j,r}$ - Sectoral market demand value for mobile endowment 'i' by sector ‘j’ in region 'r'.

4.4.4 Household Behaviour

Final demands in the GTAP model are based on a three stage nested structure. A schematic representation of the consumption nest is presented in Figure 4.9. The linearised behavioural equations for regional households are provided in Figure 4.10. As previously noted at section 4.2, the regional household allocates available income so as to maximise per capita aggregate utility according to a Cobb-Douglas utility function. In GTAP, private demands are characterised by a non-homothetic Constant Difference of Elasticities (CDE) function. The CDE implicit expenditure function is given below (B.8) by using the GTAP model notation:

$$\sum_{i \in TRAD} A_{i,r}.UP_r^{SUBPAR_{i,r}.INCPAR_{i,r}} \left[PP_{i,r} / E\left(PP_r, UP_r\right)\right]^{SUBPAR_{i,r}} \equiv 1 \qquad \text{(B.8)}$$

where, UP_r denotes utility from private consumption, $PP_{i,r}$, the price of private consumption and *E(.)*, expenditure. $A_{i,r}$, $SUBPAR_{i,r}$ and $INCPAR_{i,r}$ are the CDE parameters; $A_{i,r}$, are scale parameters, $SUBPAR_{i,r}$, are substitution parameters that determine the substitution possibilities among commodities

[32] As in the case of a perfectly mobile factor.

in consumption and $INCPAR_{i,r}$, are expansion parameters that allow non-unity income elasticities. These parameters must conform to the following conditions: $A_{i,r} > 0$, $INCPAR_{i,r} > 0$ and $SUBPAR_{i,r} < 1$ and either $SUBPAR_{i,r} \leq 0$ or $0 < SUBPAR_{i,r} < 1$ (Hanoch, 1975).

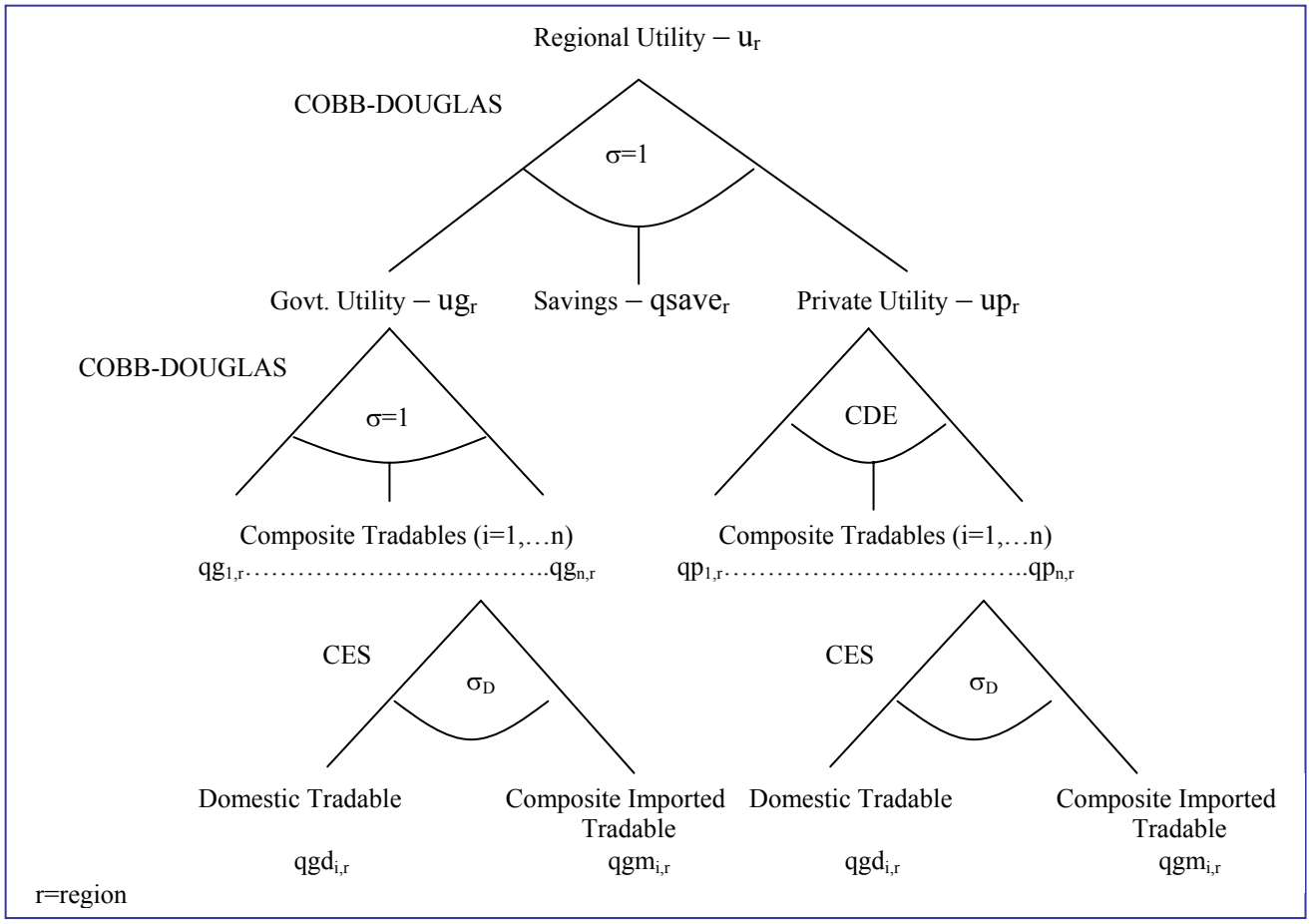


Figure 4.9 The Utility Tree for Final Demands

Since the CDE function is non-homothetic it implies that the budget shares are not invariant to increases in the level of expenditure[33]. As a result, it is not possible to aggregate over consumers consistently since a consumer with a lower income will have a different set of preferences (or budget shares) to a consumer with a higher income. Put another way, it can be said that changes in expenditure are not a constant function of changes in utility. If regional household expenditure increases 10%, public utility will increase 10% but private household utility will not increase 10%.

[33] With homothetic functions, regardless of the level of expenditure, *ceteris paribus*, the budget shares remain unchanged.

With this aggregation problem in mind, McDougall (2003) introduces the elasticity of expenditure with respect to changes in utility to deal with this problem. Maximising utility with respect to the budget constraint and following the mathematical manipulations in Hertel (2001) yields the fundamental (modified) relationship between utility and expenditure. In percentage change terms:

$$e_r = p_r + \phi u_r \qquad \text{(B.9)}$$

where e_r is the percentage change in expenditure, p_r is the weighted percentage change in regional price and ϕ is the elasticity of expenditure with respect to changes in utility. Clearly, the relationship between expenditure and utility is within a non-homothetic function no longer constant (given changes in ϕ). In the GTAP model, (B.8) is the equivalent of the public and private demand equations (see equations 3 and 4 in Figure 4.10 respectively) which determine the variables up_r and ug_r.

Since public demands are Cobb-Douglas (i.e., homothetic), the parameter $UELASGOV_r$ (the elasticity of expenditure with respect to changes in utility for the final public demands) is equal to 1 so effectively drops out of equation 3 in Figure 4.10. In the derivations, $UELASPRIV_r$ is equal to:

$$UELASPRIV_r = \sum_{i \in Trad} CONSHR_{i,r} . INCPAR_{i,r} \qquad \text{(B.10)}$$

where private share expenditure shares on commodity 'i' are:

$$CONSHR_{i,r} = VPA_{i,r} / \sum_{i \in Trad} VPA_{i,r} \qquad \text{(B.11)}$$

and $INCPAR_{i,r}$ is an 'expansion' parameter in the CDE functional form.

Top Nest – Regional Utility

$$u_r = au_r + \left(DPARPRIV_r \log(UP_r) dppriv_r\right) + \left(DPARGOV_r \log(UG_r) dpgov_r\right)$$
$$+ \left(DPARSAVE_r \log(QSAVE_r) dpsave_r\right) + \left(1/\phi_r\right)\left(y_r - pop_r - p_r\right)$$

(aggregate utility) (1)

where variables *dppriv, dpgrov, dpsave*, represent the percentage change of the Cobb-Douglas distribution parameters corresponding level variables $DPARPRIV_r$,$DPARGOV_r$,*DPARSAVE* and au_r is efficiency parameter.

$$ysave_r = psave_r + qsave_r \qquad \text{(regional savings)} \quad (2)$$

$$yg_r - pop_r = pgov_r + ug_r \qquad \text{(government purchases)} \quad (3)$$

$$yp_r - pop_r = ppriv_r + UELASPRIV_r.up_r \qquad \text{(private household purchases)} \quad (4)$$

Second Level – Agents' demands for composite tradables:

$$qg_{i,r} - pop_r = ug_r - \left[pg_{i,r} - pgov_r\right] \qquad \text{(government demand for 'i')} \quad (5)$$

$$pgov_r = \left[\sum_{i \in Trad} VGA_{i,r} / GOVEXP_r\right].pg_{i,r} \qquad \text{(composite government price)} \quad (6)$$

$$ppriv_r = \left[\sum_{i \in Trad} VPA_{i,r} / PRIVEXP_r\right].pp_{i,r} \qquad \text{(composite private household price)} \quad (7)$$

$$qp_{i,r} = \sum_{k \in TRAD} EP_{i,k,r}\, pp_{k,r} + EY_{i,r}\left[yp_r - pop_r\right] + pop_r \qquad \text{(priv. household demand for 'i')} \quad (8)$$

where $EP_{i,k,r}$ and $EY_{i,r}$ are targetted price and income elasticities of demand respectively. In the case of the CDE function these elasticities are not constants, they can vary with expenditure shares/relative prices. Therefore, in the model there are supplementary formulas to update their values but these formulas are not shown here.

Figure 4.10 Linearised Equations in the Utility Tree

Third Level – Demand for import composite/domestic tradables

$$pg_{i,r} = GMSHR_{i,r}.pgm_{i,r} + \left[1 - GMSHR_{i,r}\right].pgd_{i,r} \quad \text{(composite price)} \quad (9)$$

$$qgm_{i,r} = qg_{i,r} + \sigma_i^D\left[pg_{i,r} - pgm_{i,r}\right] \quad \text{(composite import demand)} \quad (10)$$

$$qgd_{i,r} = qg_{i,r} + \sigma_i^D\left[pg_{i,r} - pgd_{i,r}\right] \quad \text{(domestic tradable demand)} \quad (11)$$

$$pp_{i,r} = PMSHR_{i,r}.ppm_{i,r} + \left[1 - PMSHR_{i,r}\right].ppd_{i,r} \quad \text{(composite price)} \quad (12)$$

$$qpm_{i,r} = qp_{i,r} + \sigma_i^D\left[pp_{i,r} - ppm_{i,r}\right] \quad \text{(composite import demand)} \quad (13)$$

$$qpd_{i,r} = qp_{i,r} + \sigma_i^D\left[pp_{i,r} - ppd_{i,r}\right] \quad \text{(domestic tradable demand)} \quad (14)$$

where GMSHR and PMSHR represent the share of domestic/import composite 'i' in total purchases of 'i' in the nest.

Figure 4.10 (Cont.) Linearised Equations in the Utility Tree

Having determined the changes in utility in the private (up_r) and public (ug_r) households, it is now needed to ensure that budget shares over each form of final demand add up. So, starting with the Cobb-Douglas aggregator function (first level of the nest in Figure 4.9):

$$U_r = UP^{B_P}.UG^{B_G}.QSAVE^{B_S} \quad \text{(B.12)}$$

From (B.12), Hertel (2001) derives the resulting expenditure share equations as:

$$YP_r / Y_r = UELASPRIV_r^{-1}.B_P / UELAS_r^{-1} \quad \text{(B.13)}$$

$$YG_r / Y_r = UELASGOV_r^{-1}.B_G / UELAS_r^{-1} \quad \text{(B.14)}$$

$$YSAVE_r / Y_r = UELASSAVE_r^{-1}.B_S / UELAS_r^{-1} \quad \text{(B.15)}$$

where YP_r/Y_r, YG_r/Y_r and $YSAVE_r/Y_r$ are budget shares, B_i are distribution parameters, $UELASPRIV_r$, $UELASGOV_r$ and $UELASSAVE_r$ are the elasticity of expenditure with respect to changes in utility for each of the final household demands and $UELAS_r$ is the elasticity of expenditure with respect to changes in utility for the regional household.

In the GTAP model these are linearised as:

$$yp_r - y_r = -(uepriv_r - uelas_r) + dppriv_r \qquad \text{(B.16)}$$

$$yg_r - y_r = uelas_r + dpgov_r \qquad \text{(B.17)}$$

$$psave_r + qsave_r - y_r = uelas_r + dpsave_r \qquad \text{(B.18)}$$

where $dppriv_r$, $dpgov_r$ and $dpsave_r$ are distribution parameters (same as B_i in equations B.12, B.13 and B.14) and $uepriv_r$ is the percentage change of the elasticity of expenditure with respect to changes in utility of the final private household demand ($UELASPRIV_r$)[34]. Since $UELASGOV_r$ and $UELASSAVE_r$ are equal to 1, the percentage is zero, so they drop out of the linearisation. The distribution variables are exogenous and can be used to alter the distribution of regional income shares across the three forms of final demand. The percentage change in the private demands elasticity of expenditure with respect to changes in utility is given as:

$$uepriv_r = \sum_{i \in Trad} XWCONSHR_{i,r}.(pp_{i,r} + qp_{i,r} - yp_r) \qquad \text{(B.19)}$$

where

$$XWCONSHR_{i,r} = CONSHR_{i,r}.INCPAR_{i,r} / UELASPRIV_r \qquad \text{(B.20)}$$

[34] Since GEMPACK (the program used to solve GTAP model) is not case-sensitive names used for the percentage change variables differ from the level variables.

The percentage change in aggregate household elasticity of expenditure with respect to changes in utility is given as:

$$uelas_r = XSHRPRIV_r.uepriv_r - dpav_r \qquad \text{(B.21)}$$

where $XSHRPRIV_r$ is the private expenditure share in regional income and $dpav_r$ is an expenditure weighted average of the exogenous distribution parameters ($dppriv_r$, $dpgov_r$, $dpsave_r$).

To asses the impacts of this demand system structure on the model results, the example of an increase in real income (EV) is used. The *INCPAR* parameter is more or less interpreted as the income elasticity of demand, where in the CDE function non-food commodities have higher *INCPAR* values than food goods. Thus, equations (B.22) and (B.23) are used to highlight. Equation (B.22) is derived by substituting equations (B.9) and (B.20) into equation (B19).

$$uepriv_r = \left(\frac{CONSHR_{i,r}.INCPAR_{i,r}}{\sum_{i \in Trad} CONSHR_{i,r}.INCPAR_{i,r}} \right).(pp_{i,r} + qp_{i,r} - yp_r) \qquad \text{(B.22)}$$

$$yp_r - y_r = -(uepriv_r - uelas_r) + dppriv_r \qquad \text{(B.23)}$$

If regional income is increased, the homothetic public CD function maintains the expenditure shares on public goods (within the public household) constant. In the private nest, food has a lower *INCPAR* value than non-food, so increasing income will increase non-food demand more than food demand resulting falls in expenditure shares on food demand within the private household relative to expenditures shares on non-food demand. From equation (B.22) it can be seen that if expenditure share rises on non-food (i.e., $pp_{i,r} + qp_{i,r} > yp_r$) and *INCPAR* is larger, then this will outweigh the fall in food expenditure shares (i.e., $pp_{i,r} + qp_{i,r} < yp_r$) with a smaller *INCPAR*, such that $uepriv_r$ increases. In other words, the expenditure necessary to gain an additional unit of utility has risen, or put another way the unit price of utility has increased for the private household.

If $uepriv_r$ rises more than $uelas_r$ (the cost of utility to aggregate household) then by equation (B.22), yp_r must fall relative to y_r. This implies that yg_r and $ysave_r$ increase. Thus, if a region gets richer, more private expenditure is spent on non-food products[35] and there is a shift away from private to public and investment consumption (i.e., less current consumption and more future consumption).

With greater savings (investment demand), this will affect the capital account and consequently the trade balance although the extent to which the trade balance must adjust depends on the investment allocation rule (see subsection 4.4.6 for further information on investment in the GTAP model).

In the third level of the utility tree in Figure 4.9 is the upper level of the Armington structure for both private and government household, where the final demand quantities for composite import and domestic goods are derived from a CES cost minimisation procedure.

4.4.5 Global Transport Sector

As it is noted previously, the global transport sector intermediates between the supply of, and demand for, transport services. The supply quantities of transport services ($qst_{m,r}$) are aggregated into the composite global transport commodity (qtm_m) with a Cobb-Douglas aggregator function. The corresponding price of global transport services supplied (pt_m), is a composite of regional transport services' prices ($pm_{m,r}$). These expressions are provided below:

$$qst_{m,r} = qtm_m + \left[pt_m - pm_{m,r}\right] \qquad \text{(B.24)}$$

$$pt_m = \sum_{r \in reg} VTSUPPSHR_{m,r} . pm_{m,r} \qquad \text{(B.25)}$$

where *VTSUPPSHR* represent the share of region 'r' in the global supply of transport sector (margin) 'm'.

[35] Such a property is also supported by the empirical Engel's law of demand for food that as income rise, the proportion of income spent on food declines.

Changes in the quantity demanded for the transport services ($qtmfsd_{m,i,r,s}$) are assumed to be some fixed proportion of the quantity of exported commodity 'i' being transported along a particular bilateral trade route ($qxs_{i,r,s}$). In percentage terms, the two change at the same rate:

$$qtmfsd_{m,i,r,s} = qxs_{i,r,s} \qquad \text{(B.26)}$$

For market clearing, global transport supplies should be equal to the sum of all bilateral shipping demands:

$$qtm_m = \sum_{i \in trad} \sum_{r \in reg} \sum_{s \in reg} VTMUSESHR_{m,i,r,s} . qtmfsd_{m,i,r,s} \qquad \text{(B.27)}$$

where *VTMUSESHR* represent the share of the shipment of commodity 'i' from region 'r' to region 's' in the global demand for transport sector (margin) 'm'.

4.4.6 The Global Bank

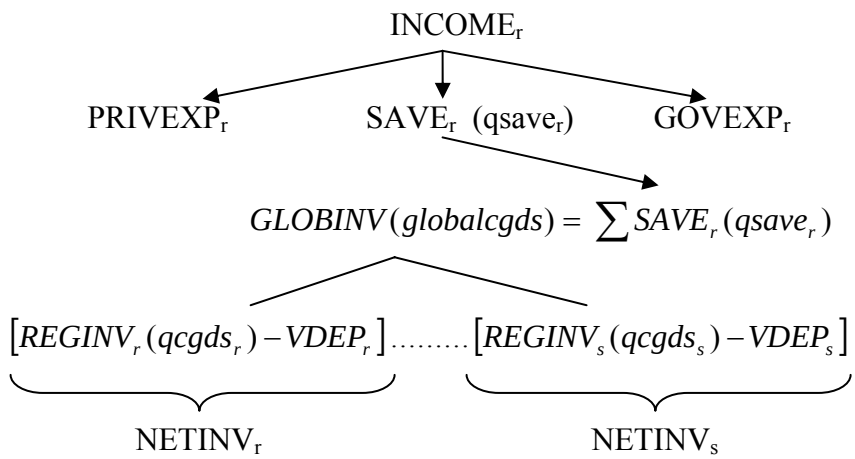
As it is noted before, GTAP is a comparative static CGE model. Therefore, in the model current investment is assumed not to augment the capital stock (i.e., no adaptive expectations mechanism), and therefore affect the productive capacity of industries in the model. However, a re-allocaion of investment across regions will affect economic activity (production and trade) through its effects on the pattern of production.

To solve the problem of indeterminacy of investment in the model, a macro-economic closure at regional level is used. This can be expressed by the equation (B.28):

$$S_r - I_r = X_r - M_r \qquad \text{(B.28)}$$

which states that savings (*S*) minus investment (*I*) is equal to the trade balance (exports (*X*) minus imports (*M*)) or expressed in a different way, changes in the capital account must be compansated by

changes in the current account (and vice versa). A '*global bank*' is used to ensure that global demand for savings is equal to the global demand for investment. A global investment good (*GLOBINV*) made up from capital good producing sectors in each region is offered to satisfy the global demand for investment. The role of the global bank in the GTAP model is shown Figure 4.11.



where variables in lower case letters (in parenthesis) represent the percentage change of the corresponding level variables in upper case. As GEMPACK (the program used to solve GTAP model) is not case-sensitive names used for the percentage change variables differ from the level variables.

Figure 4.11 Global savings and investment (Adapted from Philippidis, 1999)

Having established the accounting link between savings and investment, the model incorporates two investment components to allocate investment (and thus capital) across regions. The first mechanism allocates regional investment to equate the change in the expected regional rates of return on capital ($rore_r$) across regions. The second component assumes that the composition of net regional investment shares in the global capital stocks is constant and thus allocates regional investment across regions to maintain the existing composition of capital stocks.

The model combines the equations of these two mechanisms into a single set of composite equations (see equations B.29 and B.30).

$$
\begin{aligned}
& RORDELTA.rore_r + (1 - RORDELTA) \\
& * [(REGINV_r / NETINV_r).qcgds_r - (VDEP_r / NETINV_r).kb_r] \\
& = RORDELTA.rorg + (1 - RORDELTA).globalcgds
\end{aligned}
\tag{B.29}
$$

$$
\begin{aligned}
& RORDELTA.globalcgds + (1 - RORDELTA).rorg \\
& = RORDELTA.\sum_{r \in reg} [(REGINV_r / GLOBINV).qcgds_r - (VDEP_r / GLOBINV).kb_r] \\
& + (1 - RORDELTA).\sum_{r \in reg} (NETINV_r / GLOBINV).rore_r
\end{aligned}
\tag{B.30}
$$

where *RORDELTA* is a binary parameter which takes the value of 0 or 1, *rorg* is the percentage change in a global rate of return, $rore_r$ and $rorc_r$ are the expected and current rate of return respectively. When *RORDELTA* is 1, equation (B.29) shows that the expected rate of return ($rore_r$) in all regions moves at the same rate as the global rate, *rorg* (i.e., perfect capital mobility – first mechanism). Equation (B.30) shows that under this allocation mechanism, market clearing in the capital market applies. When *RORDELTA* is 0, (B.29) imposes the investment market clearing over all regions, whilst equation (B.30) merely assumes that the global rate of return is a weighted average of the expected rate of return in each region ($rore_r$), which are not constrained to be equal.

The expected rate of return ($rore_r$) is determined in equation (B.31) as the current rate of return ($rorc_r$) and the ratio of end of period (ke_r) to beginning period (kb_r) capital stocks.

$$rore_r = rorc_r - RORFLEX_r.(ke_r - kb_r) \tag{B.31}$$

The current rate of return is given as:

$$rorc_r = GRNETRATIO_r.[rental_r - pcgds_r] \tag{B.32}$$

The sensitivity of capital allocation to changes in expected rate of return ($rore_r$) is controlled by the flexibility parameter, $RORFLEX_r$, in equation (B.31). *RORFLEX* is the flexibility of the expected net rate of return on the capital stock, in region 'r', with respect to investment. If a region's capital

stock (ke_r) increases by 1 per cent, then it is expected that the expected rate of return on capital will decline by RORFLEX %. $GRNETRATIO_r$ is the ratio of gross to net returns on investment, $rental_r$, is the price of capital services (primary factor) and $pcgds_r$ is the construction price of capital goods.

Thus, in the first mechanism, if $rore_r$ is restricted to move (i.e., fall) with *rorg*, then investment changes can be quite large in the form of increases in capital goods production (ke_r) and/or reductions in the current rate of return ($rorc_r$). If for example, regional income and therefore regional savings increased by a small proportion, whilst investment (i.e., new capital goods) rose by a large proportion, then there may be a large imbalance on the capital account, which will affect the current account (and the terms of trade – subsection 4.4.7.1) in order to ensure a balance of payments equilibrium.

Under the second mechanism (i.e., *RORDELTA* = 0), changes in global investment (*globalcgds*) and regional net investment move together such that the composition of investment allocation across regions remains unchanged. Moreover, the expected rate of return is now only a summary statistic which determines global rate of return but does not affect the allocation of investment across regions. Thus, changes in the capital account ($S - I$) are steady, with the result that the current account is much less affected by this investment mechanism.

In response to the capital good production, each region in the model has a capital good producing sector which combines domestic and imported intermediate inputs. Although this process is analogous to the production of tradable commodities which is explained in subsection 4.4.2, the production of capital goods does not require primary factors. This is because the use of primary factors is already embodied in the production of the intermediate inputs assembled by the capital good producing sectors.

4.4.7 Welfare (Summary) Indices

In this subsection some of the key welfare measures included in the GTAP model are examined. All of the equations used to compute these indices do not affect the solution of the model. Instead, they are used to provide various counterfactual equilibrium results in percentage changes which can be calculated from the exogenously and endogenously determined variables in the model solution.

4.4.7.1 Terms of Trade

The terms of trade (TOT) is one of the summary indices used in the model. It is defined as the rate of exchange between the return on sales (i.e., exports) for a region to the cost of purchases (i.e., imports) to a region. Thus, if the unit value of exports can purchase greater units of imports, this is recognised as a welfare gain.

In the model, the terms of trade is calculated as the ratio of the price indices PSW_r and PDW_r for tradables. The expression PSW_r is the price index received for *all* tradables produced in region 'r' including 'sales' of savings to the global bank. The price index PDW_r reflects prices paid for tradables by region 'r', including investment from the global bank. In linear form, the terms of trade are given as:

$$tot_r = psw_r - pdw_r \qquad \text{(B.33)}$$

4.4.7.2 Equivalent Variation

The equivalent variation (*EV*) is a measure of welfare change which uses initial prices (pre-shock) as the base and asks how much money at the initial prices should be (given) taken away (to) from the consumer to make him as well of as he would be facing after the price change (Varian, 1992).

In the model, the regional household's EV, measured in millions of dollars, is equal to the difference between the expenditure (or income) required to obtain the new (post-shock) level of utility at initial prices ($INCOMEEV_r$) and that available initially:

$$EV_r = \frac{INCOMEEV_r}{100}.yev_r \qquad \text{(B.34)}^{36}$$

where yev_r is the percentage change in regional income in pre-shock prices, and updates the value $INCOMEEV_r$.

Further analysis of welfare changes can be done by breaking the equivalent variation into its components. This allows the user to analyze the sources of welfare gains in the GTAP model (for further discussion on decomposition of welfare changes in the GTAP model see Huff and Hertel, 2000).

Finally, the model also calculates a world equivalent variation, *WEV*, as the sum of the all regional equivalent variations:

$$WEV = \sum_{r \in reg} EV_r \qquad \text{(B.35)}$$

4.5 GTAP DATABASE

After having discussed accounting relationships and behavioural equation within the GTAP, the aim of this section is to give an overview of the GTAP database (version 6). It provides a guide to the GTAP database files; sets, behavioural parameters (elasticities), main data and energy volume data which is not included in this study (for further information on GTAP database see Dimaranan, 2006a).

Version 6 of the GTAP database consists of 87 regions and 57 sectors. It combines detailed bilateral trade (including transport sector) and protection data characterising economic linkages

[36] Note of $x = \frac{dX}{X}100$ then $dX = \frac{X}{100}x$

between regions, together with each country's input-output (I-O) table which includes inter-sectoral linkages within regions (see section 3.4 for further information on I-O tables). These are included in the main data file as a system of flows of goods and services, measured as money values, in millions of 2001 U.S. dollars.

The first two subsections examine sets and parameter data files provided by the GTAP database. Subsection 4.5.3 briefly discusses some of issues involved in sources and construction of the regional input-output tables, and international data sets comprised in the main data file.

4.5.1 Sets file

The function of the sets file is to enumerate the GTAP regions, commodities and other sets used in the model framework. Table 4.1 shows the arrays in the GTAP sets file.

Header	Set Size	Description
H1	r	Regions (REG)
H2	t	Traded commodities (TRAD_COMM)
H3	$s+m+t+l$	Non-saving commodities (NSAV_COMM)
H4	$s+m+t$	Demanded commodities (DEMD_COMM)
H5	$t+l$	Produced commodities (PROD_COMM)
H6	$s+m$	Endowment commodities (ENDW_COMM)
H7	s	Sluggish commodities (ENDWS_COMM)
H8	m	Mobile endowment commodities (ENDWM_COMM)
H9	l	Capital endowment commodities (CGDS_COMM)
MARG	g	Margin commodities (MARG_COMM)

r – number of regions

t - number of tradable commodities

s – number of primary factors not perfectly mobile across industries

m – number of primary factors perfectly mobile across industries

g – number of margin commodities

Table 4.1 Arrays in the GTAP Sets File (Adapted from Dimaranan and McDougall, 2006)

The first array (H1) gives a list of regions in the model. H2 lists commodities that can be traded between regions. This is in contrast with non-tradable primary factors (or endowment commodities), listed in H6. There are five endowment commodities: land, capital, skilled labour, unskilled labour and natural resources. A capital good produced commodity is indexed in H9 for use in implementing the investment theory in the model.

The arrays H7 and H8 split endowment commodities into two groups, classified by sectoral mobility. In the standard data, the long run approach is taken where skilled and unskilled labour and capital are classified as mobile (H8), with land and natural resources classified as sluggish between sectors (H7). For short run simulations, users may wish to move capital from H8 to H7.

The remaining arrays are provided to aid implementation of the model. The non-savings commodities (H3) comprise the endowment commodities, the traded commodities and an investment good. The demanded commodities, H4, are a subset of H3 and only contain endowments and traded commodities. The produced commodities, H5, include all traded commodities and the investment good (the capital good producing sector). Finally, array MARG lists the margin commodities (transport sector). An example of the sets arrays for a four region (REG), four tradables (TRAD_COMM) aggregation is provided in Figure 4.12.

REG – Turkey, European Union, United States of America, Rest of the World
TRAD_COMM – Agriculture, agro-food, manufacturing, services
NSAV_COMM – Land, skilled labour, unskilled labour, capital, natural resources, agriculture, agro-food, manufacturing, services, capital goods
DEMD_COMM – Land, skilled labour, unskilled labour, capital, natural resources, agriculture, agro-food, manufacturing, services
PROD_COMM – Agriculture, agro-food, manufacturing, services, capital goods
ENDW_COMM – Land, skilled labour, unskilled labour, capital, natural resources
ENDWS_COMM – Land, natural resources
ENDWM_COMM – Skilled labour, unskilled labour, capital
CGDS_COMM – Capital goods
MRG_COMM – Services

Figure 4.12 A 4x4 GTAP Sets Aggregation

4.5.2 Parameters File

The parameters file contains invariant behavioural parameters and switch parameters, listed in Table 4.2.

Header	Set Size	Description
ESUBD - σ_D	*t*	Elasticity of substitution between domestic and imported goods
ESUBM - σ_M	*t*	Elasticity of substitution between imports from different regions
ESUBVA - σ_{VA}	*t*	Elasticity of substitution between primary factors in the production of the value-added
ESUBT	*t*	Elasticity of substitution between composite intermediate inputs and value-added
ETRAE - σ_T	*s*	Elasticity of transformation between industries for sluggish primary factor endowments
SLUG	*e*	Sluggish-mobile switch parameter
RORFLEX	*r*	Flexibility of expected net rate of return on capital stock with respect to investment
RORDELTA	*l*	Binary switch mechanism of allocating investment funds
SUBPAR	*t x r*	Substitution parameter in the CDE function
INCPAR	*t x r*	Expansion parameter in the CDE function

r – number of regions

t - number of tradable commodities

s – number of primary factors not perfectly mobile across industries

e – number of factor endowments

Table 4.2 Arrays in the GTAP Parameters File (Adapted from Dimaranan et al., 2006)

4.5.2.1 Source Substitution Elasticities

The GTAP data contains both elasticities of substitution between domestic products and imports, and substitution elasticities between imports from different regions. The model assumes that, for each tradable commodity 'i', all agents in all regions display the same substitution elasticity.

The elasticities of substitution among imports from different regions incorporated in the model, σ_M, are obtained from the econometric work done by Hertel et al. (2004) and the substitution elasticities between domestic and imported commodities, σ_D, are calculated using the rule of two which was first proposed by Jomini et al. (1991); $\sigma_M = 2\sigma_D$.

4.5.2.2 Factor Substitution Elasticities

As previously mentioned in subsection 4.4.2, primary factors of production are assumed to substitute for one another accordingly to a CES substitution elasticity parameter, σ_{VA}, while the substitution possibilities between composite value-added and intermediate inputs within each sector is Leontief. The size of the substitution elasticity among primary factors (σ_{VA}) determines the supply response of each sector to changes in relative prices, changes in the endowments in these factors and especially in those cases where certain endowments are sluggish. For example, with land characterised as sluggish in primary agricultural sectors, the ability of agriculture to increase output is dependent on the substitution possibilities between land and labour types, and land and capital. The estimates of these elasticities are taken from the SALTER[37] (Jomini et al., 1991) database.

4.5.2.3 Factor Transformation Elasticities

As discussed in subsection 4.4.3, these elasticities describe the degree of primary factor mobility between using sectors. Moreover, the value of the elasticity of transformation, $\sigma_T < 0$, determines the size of the disparity between sectoral returns to the sluggish factor. Thus, if σ_T is close to zero, then the allocation of factors between sectors is nearly fixed and therefore factor supply across using sectors is unresponsive to changes in relative returns. The parameter, σ_T may take on larger negative values until at the limit, $\sigma_T = -\infty$, the factor is perfectly mobile and no differential return can be sustained over the simulation period, in which case the factor should be reclassified as perfectly mobile.

The binary parameter SLUG allows users to change the default setting and switch the specification of an endowment from sluggish to mobile.

[37] The SALTER project is a complete model and database characterisation of the Australian economy funded by the Australian Industry Commission.

4.5.2.4 Investment Flexibility Parameters

In the GTAP model, if the user chooses to allow the allocation of global investment to regional economies to be responsive to region specific rates of return on capital (*RORDELTA* = 1) (see subsection 4.4.6 for further discussion), then this requires a suitable specification of the parameter *RORFLEX*. For example, if the user believes that changes in the rate of return will have a great impact on regional investment, then the value of $RORFLEX_r$ should be set to closer to zero. As $RORFLEX_r$ is indexed over regions, it allows the user to characterize some regions' investment sensitive to changes in the rate of return and vice versa.

4.5.2.5 Consumer Demand Elasticities

The last class of behavioural parameters in GTAP is used in the calibration procedure of the CDE function which specifies private household demands (see subsection 4.4.4). These parameters are $SUBPAR_{i,r}$ which is used to replicate the desired compensated own-price elasticities of demand and $INCPAR_{i,r}$ to replicate the targeted income elasticities of demand. Using the methods explained in Dimaranan et al. (2006) estimates for income and compensated own-price elasticities of demand for 10 commodity categories and 87 regions are obtained and then used as targets in the CDE calibration procedure.

4.5.3 Main Data

The main data file consists of dollar values of flows of goods and services. It also includes arrays summarising the value of revenue generated from protection measure and the subsidy expenditures related to support measures.

4.5.3.1 I-O Data

The GTAP main data file consists mainly of a set of I-O tables for the various countries (if available), which can be in different currencies and different years. Each regional I-O table needs to be

based on a consistent structure and sectoral classification, ready to be updated to a given base year (2001 in the case of GTAP 6 database). To do this; after all I-O tables are received, they are checked if they satisfy certain requirements. Then, as the GTAP 6 database uses a 57 sector classification, the I-O tables that do not contain details on all 57 sectors are disaggregated while tables that contain such detail are taken to calculate a representative table[38] from them. Two types of disaggregation is performed; agricultural and non-agricultural disaggregation. The reason for using two different disaggregation processes is that the geographic factors such as climate and soil influence the structure of the agricultural sector heavily. The disaggregation of the agricultural sectors in the contributed (received) I-O tables is done by using country-specific agricultural I-O tables, provided by Peterson (2006). This table is fully disaggregated in agriculture, but highly aggregated in non-agricultural sectors. To bring these two tables into contact with each other, a sectoral classification called the finest common aggregation (FCA) is used. Then, the agricultural I-O table is rebalanced to be consistent with the contributed I-O table at this sectoral classification (FCA). This rebalanced agricultural I-O table is a disaggregation of the contributed I-O table in agriculture.

The disaggregation of non-agricultural sectors is similar to that for the agricultural disaggregation but it is based on the representative I-O table instead of a region-specific agricultural I-O table. Neither a sectoral classification (FCA) is created since the representative table uses the full GTAP sectoral classification. The non-agricultural disagregation is performed after the agricultural disaggregation.

Another issue is that there are some regions in the GTAP database where the I-O table data is not available. These regions are called composite regions and their I-O tables are constructed from the I-O tables of primary regions[39] which have similar GDP per capita as the countries that comprise the composite regions.

Thus, one first identifies all the countries in each the composite regions where no I-O data is available. Then, using the GDP per capita data, it is possible to match these countries to primary

[38] A representative table is an I-O table created as a linear combination of the set of I-O tables which have full sectoral disaggregation (Dimaranan, 2006b).
[39] Primary regions are regions for which national I-O table data are available.

regions. It is assumed that the average patterns of production, consumption and savings in any individual country in the composite regions can be approximated by patterns observed in one of its neighboring primary regions. Therefore, only primary regions within the geographic area of the composite region are matched to the countries in a composite region. Each primary region may have several individual countries attached to it within a given composite region. Weights are then assigned to each primary region based on the ratio of the primary region's GDP to total GDP of the composite region. Having calculated these weights for each of the primary regions, it is then possible to use the known I-O tables to calculate the I-O parameters for each composite region using 'linear approximation'.

After having disaggregated the I-O tables and constructed composite I-O tables, the regional I-O tables are adapted to the database reference year. The update is done by adjusting these tables to the international data sets (macroeconomic, protection and trade). This adjustment procedure applies a technique developed by the Australian Industry Commission (James and McDougall, 1993) which shocks key economic variables to match the economic conditions in the base year (2001), which are based on a variety of external data sources examining GDP, private and government consumption and investment.

4.5.3.2 Trade Data

The GTAP trade data contain several arrays. These are bilateral arrays showing value of trade at different prices and other arrays on international trade margins. The primary source for bilateral trade in the GTAP trade data is COMTRADE, provided by the United Nation's Statistical Division. However this data only covers merchandise trade in goods not in services (UNSO, 2001). Therefore, IMF balance of payment statistics is used for services (IMF, 2003).

Since large discrepancies in reported import/export trade flows are found in COMTRADE data, a reconciliation method is established to achieve consistency between the export flow and its corresponding import flow for all partner pairs. This reconciliation method involves a selection process for accepting or rejecting reported trade flows based on each reporter's reliability record with its

partners. The reliability is measured for both importer and exporter. To construct importer reliability, first of all total trade, $M^T_{i,s}$, reported by the importers for commodity 'i' is calculated. This is given as:

$$M^T_{i,s} = \sum_r M^{fob}_{i,r,s} \qquad \text{(DB.1)}$$

where $M_{i,r,s}$ refers the value of trade reported by importer for commodity 'i' imported from region 'r' to region 's'. Then, the total reported imports which are accurately matched with partner's reported export, $M^A_{i,s}$, (the difference between reported exports and imports has to be equal to or smaller then 20%) is calculated as shown as:

$$M^A_{i,s} = \sum_r M^{fob}_{i,r,s} \qquad \text{(DB.2)}$$

Finally, the percentage of accurate transactions to total imports reported gives the importer reliability, $RIM_{i,s}$:

$$RIM_{i,s} = \frac{M^A_{i,s}}{M^T_{i,s}}.100 \qquad \text{(DB.3)}$$

The exporter reliability index, $RIX_{i,r}$, is calculated in the same manner as $RIM_{i,s}$:

$$\begin{aligned} X^T_{i,r} &= \sum_s X^{fob}_{i,r,s} \\ X^A_{i,r} &= \sum_s X^{fob}_{i,r,s} \\ RIX_{i,r} &= \frac{X^A_{i,r}}{X^T_{i,r}} \end{aligned} \qquad \text{(DB.4)}$$

Once these reliability indices are generated, the reconciliation is nothing more than accepting the reported trade flows of the more reliable partners.

The services trade data contain four trade data sets, covering non-margin services, margin services usage, margin services supply and travellers' expenditures[40]. As mentioned, this data is mainly based on the IMF balance of payments statistics. The merchandise trade data is also used for margin services.

4.5.3.3 Protection Data

The protection dataset covers ordinary import tariff rates, ordinary export subsidy rates, domestic support instruments, ATC (Agreement on Textiles and Clothing) export subsidies and other protection measures[41]. The domestic support data include the rates of total domestic support and the shares to total payments of output subsidies, intermediate input subsidies, land-based payments and capital-based payments. The data sources for the domestic support data are the Organisation of Economic Cooperation and Development (OECD) producer and consumer subsidy equivalent (PSE and CSE) database and the European Guarantee and Guidance Fund (EAGGF). The included comprehensive rates for import duties and export subsidies represent all import and export instruments respectively. These rates are used in the update procedure of the regional I-O tables (see section 4.5.3.1). Thus, the trade distortions are reflected as differences between market price and world price valuation of the same trade flow. The rates for import duties are from the Market Access Maps (MacMap) contributed by the *Centre d'Etudes Prospectives et d'Information Internationales* (CEPII).

4.6 CONCLUSIONS

This chapter provided a description of a multi-regional CGE trade model called the Global Trade Analysis Project (GTAP) model and its accompanying database. After a brief introduction to the chapter, the next section (4.2) provided an overview of the GTAP model structure by using a simplified graphical exposition of the model.

[40] The travellers' expenditures include spending abroad by tourists, people working overseas for short periods etc.
[41] Other protection measures cover anti-dumping duties, price undertakings and voluntary export restraints (VERs). Due to absence of up-to-date data zero rates are reported for all of these measures in the GTAP database 6.

In section 4.3 an overview of the basic accounting relationships in the database/model were provided, which was done by tracking the value flows from production and sales to intermediate and final demands. In the following section (4.4) attention was given to the neo-classical behavioural equations within the production and consumption nests, as well as, stylised behavioural characterisations of the global bank and transport sector.

Finally, in section 4.5 a guide to the GTAP database (version 6) is provided. Details on the types of data sources and their construction were given. This section also discussed some of the GTAP data reconciliation issues and parameter estimates.

CHAPTER V

SCENARIO DESIGN AND RESULTS

CHAPTER V

SCENARIO DESIGN AND RESULTS

5.1 INTRODUCTION

To assess the likely implications of the Turkish accession to the European Union on Turkish agricultural sectors, a baseline is constructed for the year 2025 in which it is assumed that the relationship between Turkey and the EU remains as it is today. Subsequently two experiments are simulated under two alternative accession scenarios based on the theoretical investigations and the literature revision on EU enlargement done in chapter two.

The structure of the chapter is as follows: Section 5.2 discusses the chosen sectoral and regional aggregation for the simulations. The following section (5.3) describes the experimental design employing a plausible set of assumptions. This section also provides a quantitative description of the scenarios which includes border protection (import tariff and export subsidy rates) and agricultural domestic support rates for different regions in the model before and after the implementation of the scenarios. Section 5.4 is devoted to detailed analysis of simulation results. This is done by examining sectoral effects and welfare effects for various regions, especially for Turkey. Finally, section 5.5 concludes the chapter.

5.2 AGGREGATION

The data used in this study is the GTAP Database version 6, which covers 57 sectors and 87 regions and takes the year 2001 as its base year. To keep the model within computational limits and focus on the issues of interest the data is aggregated into 13 regions/countries and 21 sectors. Regional and sectoral aggregations are shown in Figure 5.1.

The choice of regional aggregation is taken considering the most important trade partners of Turkey and covers Turkey, France, Germany, Greece, Italy, Netherlands (NL), Spain, United Kingdom (UK), the rest of the EU-15 region, accession ten (AC-10), AC-2 (Bulgaria and Romania), USA and the Rest of the World (ROW). In this chapter, in order to simplify the illustration of the results, results for the existing EU members before the enlargement in 2004 are given under the EU-15, for the new members under the AC-12. With the same purpose results for the USA and ROW are given under the ROW (some results for all regions included in the simulations can be found in appendices V and VI).

As noted previously, the aim of this study is to investigate likely effects of the accession of Turkey to the EU on disaggregated Turkish agricultural sectors. For this reason, 18 agricultural sectors (1-18) are specified and three non-agricultural sectors (19-21) are captured through composite sector aggregates (see Figure 5.1). The agricultural sectors can be considered as two groups which are 'primary' agricultural sectors (1-11) and 'processed' agricultural sectors (12-18).

Chosen Regional Aggregation (13 Regions)

Turkey	
France	
Germany	
Greece	
Italy	
The Netherlands (NL)	
Spain	
United Kingdom (UK)	
Rest of the EU-15	Austria, Belgium, Denmark, Finland, Ireland, Luxembourg, Portugal, Sweden
Accession-10 (AC-10)	Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
Accession-2 (AC-2)	Bulgaria, Romania
USA	
Rest of the World (ROW)	All other GTAP regions

Figure 5.1 Chosen aggregation of regions and sectors

Chosen Sectoral Aggregation (21 sectors)

1. Wheat	Soft and durum wheat
2. Other Grains (Ograins)	Maize, barley, rye, oats, other cereals
3. Vegetables, Fruit and Nuts (VegFruitNuts)	Potato, peas, cauliflower, tomato, pulses, other vegetables, nuts, olives, onions, apple, pears and peaches, bananas, other fruits, citrus fruits
4. Oilseeds	Sunflower seed, olive for oil, soya beans, cotton seed, sesame seed, rape and mustard seed
5. Sugar	Sugar cane, sugar beet
6. Plant-based fibers (Plants)	Raw vegetable materials used in textiles
7. Other crops (Ocrops)	Cut flowers and flower buds; flower, fruit an vegetable seeds; beverage and spice crops; tobacco; food fed to livestock (straw, hay, alfalfa, clover, lupines, vetches and similar forage plants); sugar beet seeds and seeds of forage plants; other raw vegetable materials
8. Cattle and Sheep (Catshp)	Bovine cattle, sheep, goats, horses, asses, mules and hinnies for fattening
9. Pigs and Poultry (Pigspoultry)	Pigs for fattening, laying hens, poultry for fattening, other animals (frog, snail etc.), hides and skins
10. Raw milk (RawMilk)	Dairy cows and other cows
11. Other Agriculture (Oagric)	Paddy rice, wool, silk-worm cocoons
12. Meat processing (Meatpro)	Meat products (bovine, sheep, goat, horses and mules)
13. Other meat processing (Omeatpro)	Eggs and egg products, meat products (pigs, poultry)
14. Vegetable oils and fats (Vegailsfats)	Coconut oil, cottonseed oil, groundnut oils, oilseed oils, olive oil, palmkernel oils, rice bran oils, rape and mustard oils, soyabean oil, sunflower seed oils, maize oils animal or vegetable fats and oils, margarine and similar products
15. Dairy	Butter, cheese, cream, whey and products, skimmed milk
16. Sugar processing	Refined sugar, sweeteners
17. Other food processing (Ofoodpro)	Processed rice; sea food products; processed vegetables and fruits; fruit and vegetable juices; flour (wheat and other cereals); starches and starch products; bakery products; cocoa, chocolate and sugar confectionery; farinaceous products (macaroni, noodles etc.)

Figure 5.1 (Cont.) Chosen aggregation of regions and sectors

18. Beverages and Tobacco (BevsTobac)	Cigarettes, cigars etc., wines and spirits, beer
19. Raw materials (RawMat)	Coal, oil, gas, minerals, petroleum and coal products, forestry, fishing
20. Manufacturing (Mnfs)	Textiles; wearing apparel; leather products; wood products; paper products and publishing; chemical, rubber and plastic products; ferrous metals; other metal products; motor vehicles and parts; transport equipment; electronic equipment; machinery and parts
21. Services (Svces)	Utilities (Gas, water, electricity); construction; trade services; transport (air, sea, road); communications; other financial services; insurance; other business services; recreation and other services; dwellings; public administration/defence/health/education.

Figure 5.1 (Cont.) Chosen aggregation of regions and sectors

5.3 EXPERIMENTAL DESIGN

In many model simulations where the economic implications of the EU enlargement are investigated, the usual approach is to construct a 'baseline' scenario in which the current situation is extrapolated into the future. The baseline can therefore be seen as a 'status quo' scenario of the world economy where enlargement has not occured. Following this approach, a baseline is constructed for the period 2001-2025 in which the relationship between Turkey and the EU remains as it is today.

Some assumptions are used in order to shape the baseline. These assumptions reflect some developments which can take place inside and outside Turkey and they are summarised in Figure 5.2. To construct the baseline with a projection of the world economies as they might look in the year 2025 total population, factor endowments (skilled labour, unskilled labour, capital) and total factor productivity (TFP) are shocked. The shocks which are used are given in Table 5.1.

Baseline Scenario Assumptions: 2001-2025

Projections

Shocks to GDP, total population, factor endowments, productivity

Stylised Doha Round Shocks

Import tariff reductions for developed, developing and least developed countries (LDCs)

Elimination of export subsidies for all products in all countries

Implementation of Uruguay Round and other commitments (including Chinese accession)

EU Enlargement

Elimination of all border protection (i.e., import tariffs, export subsidies) between old and new member states (including Romania and Bulgaria)

Impose common external tariff for all 12 new EU member states (2004 and 2007 accessions)

Agricultural domestic support

Elimination of agricultural support (output - input subsidies and land – capital based payments) in all countries

Figure 5.2 Assumptions shaping the baseline 2001-2025

The projections for gross domestic product (GDP), labour force and total factor productivity except Turkey are collected from another CGE study (Jensen and Frandsen, 2003). Population growth rates are calculated from population projections of UN World Population Division (2007). The capital endowment growth is determined endogenously by the exogenous variables given in Table 5.1 and by the model and associated data. In the case of Turkey, annual growth rate of GDP is obtained from a recent study of Bergheim (2005) and labour projections are based on the growth rates of the total skilled and unskilled labour stock in Turkey between years 1995 and 2000 (to obtain these growth rates, data on educational attainment provided by Barro and Lee (2000)[42] is used).

[42] This data includes the stock of human capital for every schooling level for approximately one hundred countries. These levels are: no education, primary, secondary and higher education. Following the same approach used by Jensen et al. (1998) and CPB (1999) skilled labour is characterised by those who have secondary or higher education.

			Labour Force		Total factor productivity (TFP)			
	GDP	Population	Skilled	Unskilled	Agriculture	Industry	Services	Capital
France	2,63	0,42	0,19	0,28	1,40	1,00	0,50	2,00
Germany	1,97	-0,08	-0,47	-0,38	1,40	1,00	0,50	5,12
Greece	3,00	0,26	-0,14	-0,05	1,40	1,00	0,50	2,53
Italy	2,39	0,04	-0,50	-0,41	1,40	1,00	0,50	4,35
Netherlands	3,16	0,25	-0,06	0,03	1,40	1,00	0,50	4,31
Spain	3,19	0,70	-0,21	-0,12	1,40	1,00	0,50	3,39
United Kingdom	2,52	0,40	0,09	0,18	1,40	1,00	0,50	4,30
Rest of the EU-15	3,08	0,37	0,01	0,10	1,40	1,00	0,50	4,36
AC-10	3,87	-0,24	0,37	0,14	1,40	1,00	0,50	2,50
AC-2	2,68	-0,65	0,10	-0,16	0,70	0,50	0,25	1,69
Turkey	4,10	1,27	1,47	1,77	0,70	0,50	0,25	5,38
USA	3,01	1,03	0,72	0,90	1,40	1,00	0,50	3,64
Rest of the world	3,09	1,15	2,99	1,63	0,70	0,50	0,25	3,15

Table 5.1 Exogenous assumptions in the projections, annual changes, 2001-2025, per cent (Jensen and Frandsen, 2003, UN World Population Division, 2007, Bergheim, 2005, Lee and Barro, 2000, ILO, 2007 and own calculations)

The baseline also features foreseeable policy changes as shown in Figure 5.1. One of these policy changes will be a possible Doha Round agreement. Although an agreement on tariffs has not yet been reached, a recent work by Jean et al. (2005) provides a series of scenarios with accompanying tariff shocks for Doha Round tariff reductions which makes it possible to explore and enumerate a range of possible alternatives that are currently on the negotiating table. Two different tariff shock formulas are employed in this study according to the product category. For agri-food products a scenario based on a revised Harbinson formula[43] (see Table 5.2) is used. This scenario also allows countries to choose a list of sensitive products (2% of the most sensitive tariff lines), which will receive special treatment (i.e., lower tariff cuts). On the other hand for the non agri-food products a scenario in

[43] The Harbinson formula is a proposal which was produced by the Chairman of the Agriculture Negotiating Committee (Stuart Harbinson) in 2003. Although the original Harbinson proposal was not accepted, as a tariff reduction formula, it still reflects a solid negotiating position between World Trade Organization (WTO) members (Jean et al., 2005). Indeed, the Framework Agreement (WTO, 2004) indicates that the reductions should be undertaken using a tiered formula as proposed in the Harbinson formula. Thus, in this study a scenario which involves a revised Harbinson formula is implemented.

which binding tariff rates are reduced 50% in developed countries, 33% in developing countries, and zero % in the Least Developed Countries (LDCs) is employed. Finally all export subsidies are eliminated following the agreement reached at the Hong Kong summit[44] in December 2005.

Developed Countries		Developing Countries	
Existing Binding Tariff	Tariff Cut	Existing binding tariff	Tariff Cut
> 90 per cent	75%	> 120 per cent	60%
> 15 and ≤ 90 per cent	70%	> 60 ≤ 120 per cent	50%
≤ 15 per cent	45%	> 20 ≤ 60 per cent	40%
		≤ 20 per cent	35%

Table 5.2 Implemented tariff reductions according to the revised Harbinson formula (Jean et al., 2005)

The last assumption used for shaping the baseline takes into account possible changes in agricultural domestic support policies. The declarations on agricultural domestic support from the Fourth and the Sixth WTO Ministerial Conferences held in Doha and Hong Kong in 2001 and 2005 and the draft proposal presented in June 2006 (WTO, 2006) by the Chairman for the agricultural negotiations, Crawford Falconer, show the intention of the WTO for further reductions in trade-distorting domestic support (amber box, blue box and *de minimis* support[45]). In this study, it is assumed that by the year 2025 all of the trade-distorting support policies (i.e., output – intermediate input subsidies and land – capital based payments) are phased out. This assumption is also employed in different CGE studies which focus on the effects of the liberalisation of world trade and global agricultural trade (see Diao et al., 2001, Cooper et al., 2003, Frandsen et al., 2003 and World Bank, 2003).

[44] At the Sixth WTO Ministerial Conference which took place in Hong Kong, in December 2005, trade ministers representing most of the world's governments agreed to totally eliminate export subsidies in agriculture and cotton by the end of 2013 and 2006 respectively (WTO, 2005).

[45] The WTO identifies domestic support by boxes (amber, blue and green box for agriculture). Amber box includes all domestic support measures considered to distort production and trade such as market price supports or input and output subsidies. Blue box includes any support that would normally be in the amber box but which also requires farmer to limit production like direct payments to farmers linked to production of specific crops which impose offsetting limits on output. Green box contains measures that are decoupled from production such as direct payments to producers that do not depend on current production decisions or prices. Accordingly to the *de minimis* rule, developed countries are not required to reduce their amber box measures where such measure does not exceed 5% of the total value of production (10% for developing countries).

In comparison with the baseline, two alternative accession scenarios are examined (The design of scenarios is illustrated in Figure 5.3). *Scenario-1* analyses the economic effects of Turkey's accession to the EU[46] by the year 2025 in a world as shaped by the baseline. Accession of Turkey implies that all tariffs between the EU and Turkey are abolished. Finally, all sectors in Turkey are given the same level of protection against third countries as found in the EU at the time of accession in order to mimic the EU common external tariff (CET)[47].

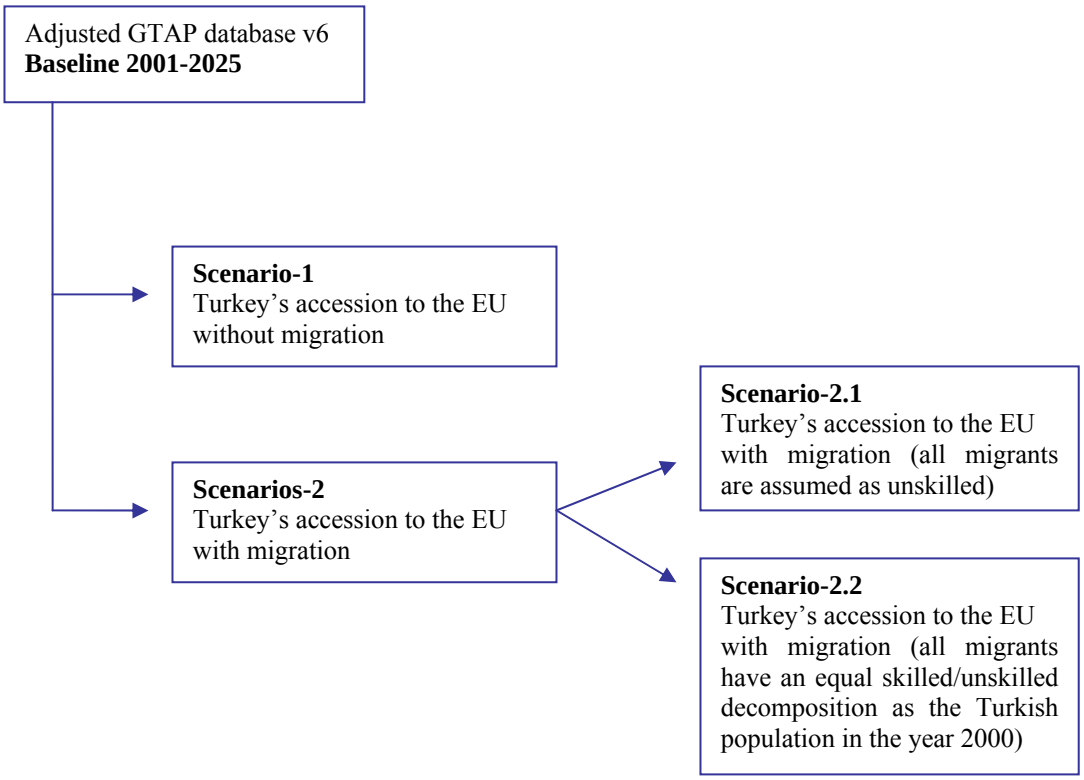


Figure 5.3 Experimental design

[46] Given the uncertainty surrounding Turkey's potential membership, we use a working assumption that by 2025, Turkey will be fully integrated into the EU.

[47] Although it would be interesting to include the EU budget in simulations, in this study this is not done since the rules on the allocation of EU funds are likely to be reformed before Turkey's accession to the EU and it is difficult to predict how these reforms will be.

Scenario-2 is an alternative accession scenario in which migration flows from Turkey to the EU in the case of free movement of labour are also included. Estimating the migration from Turkey to the EU when Turkey becomes a member state is difficult. However, various studies have intended to estimate the migration potential from Turkey. According to a European Commission report (2004b) these estimates range between 0.5 to 4.4 million persons. Here, calculations of a recent study done by Lejour et al. (2004) are used, which estimates potential migration at 2.7 million on the basis of the historical immigration patterns and the income differentials between the EU and Turkey. The migration flows are distributed across EU countries assuming that new migrants go to countries where previous migrants have settled (see Table 5.3). Borjas (1999) notes that the economic effect of the migration for the host countries and the countries of origin depends on the skill level of the migrants. Since it is difficult to know the skill composition of the migrants two simulations with different assumptions on migrant skill level are performed. Under the first simulation (called *scenario 2.1*), it is assumed that all Turkish migrants are unskilled, whilst in the second simulation (called *scenario-2.2*) it is assumed that the composition of Turkish migrants is equal to the composition of Turkish population in year 2000 (data on educational attainment provided by Barro and Lee (2000) is used to calculate this composition).

	In %	S-2.1 (In 1000)	S-2.2 (In 1000)	
Countries		Unskilled	Skilled	Unskilled
France	8	216	58	158
Germany	76	2052	554	1498
Greece	3	77	21	56
Italy	1	27	7	20
Netherlands	4	108	29	79
UK	2	54	14	39
Rest of the EU-15	6	166	45	121
Total	100	2700	729	1971

Table 5.3 Expected number and destination of Turkish migrants based on stocks on EU countries in 1999 (Barro and Lee, 2000, Lejour et al., 2004, OECD, 2007b and own calculations)

Quantitative description of the scenarios

The initial (benchmark values - 2001) and resulting import tariffs in 2025 following baseline and scenario assumptions are given in Table 5.4 (Turkish imports), 5.5 (EU-15 and AC-12 imports) and 5.6 (ROW imports). In the first three columns of these tables, the tariff rates used by the importer on incoming products according to its country of origin are shown for the benchmark year. The following columns show the resulting tariff rates after the creation of the baseline and implementation of the scenarios (*scenario-1* and *2* are shown together as they have same impacts on import tariff rates).

	Benchmark (2001)			Baseline (2025)			S-1-2 (2025)
Sectors[48]	EU-15	AC-12	ROW	EU-15	AC-12	ROW	ROW
Wheat	27.3	27.3	27.2	27,4	27,3	27,2	0,7
Ograins	41.9	58.3	57.2	42,1	58,3	57,5	10,4
VegFruitNuts	42.8	42.9	37.0	29,1	29,5	34,1	17,3
Oilseeds	10.2	15.8	7.2	13,6	15,8	5,9	0,0
Sugar	0.0	21.9	17.5	0,0	12,5	17,5	3,8
Plants	0.0	0.0	0.0	0,0	0,0	0,0	0,0
Ocrops	18.9	10.9	44.9	17,2	11,3	38,7	1,7
Catshp	3.7	20.2	1.1	2,5	16,0	0,6	0,4
PigsPoultry	1.9	1.2	1.7	1,9	1,0	1,4	1,0
Oagric	0.7	0.0	8.2	0,8	0,0	6,6	8,9
Meatpro	32.5	103.8	6.5	76,1	61,4	4,5	16,6
Omeatpro	72.2	84.5	65.2	63,2	54,0	58,0	21,3
Vegoilsfats	13.7	14.6	10.8	13,2	14,3	10,5	3,9
Dairy	83.4	74.6	73.2	77,0	74,5	81,2	21,1
Sugarpro	78.6	90.8	31.4	63,4	64,5	24,1	30,3
Ofoodpro	10.2	15.6	21.0	9,1	12,9	18,7	9,1
BevsTobac	1.8	51.0	30.7	1,7	51,0	30,9	6,2
RawMat	0.1	0.3	0.0	0,1	0,0	0,0	0,0
Mnfcs	0.0	1.6	3.7	0,0	0,0	3,6	1,1
Svces	0.0	0.0	0.0	0,0	0,0	0,0	0,0

Table 5.4 Import tariff rates, Turkey, per cent (GTAP Database version 6 and own calculations)

[48] Values for the raw milk sector are not provided in Tables 5.4, 5.5, 5.6 5.7 since products of this sector are almost entirely used only as intermediate inputs in downstream sector (dairy).

In Table 5.4, reductions in import tariff lines realised by Turkey are shown. In the case of products imported from the EU-15, the rates for sugar processing (-15.2%), vegetables, fruits and nuts (-13,7%), and other meat processing (-9%) are reduced[49] within their Doha Round commitments. Turkey also reduces its import tariff rates for products from AC-12, in particular for meat processing (-42,4%), other meat processing (-30,5%) and sugar processing (-26,3%). In *scenarios 1* and *2*, all import tariff rates on purchases from the EU-15 and AC-12 are eliminated, as Turkey becomes an EU member state (accordingly, these columns are not shown in Table 5.4 since they are all zero). As a EU member, its pattern of 'third country' agro-food protection changes dramatically. Turkey has to reduce its import tariff rates for some sectors especially dairy (-60,1% relative to the baseline), other grains (-47,1%) other crops (-37%), other meat processing (-36,7%) and wheat (-26,5%). Turkey also increases its import tariff rates in other sectors such as meat processing (12,1% relative to the baseline), sugar processing (6,2%) and other agriculture products (2,3%) after the accession.

In Table 5.5 import tariff rates for the EU-15 (first five columns) and AC-12 are shown. Resulting rates after implementing accession *scenarios 1* and *2* are not given in the table as import tariffs are eliminated between Turkey and the EU-27, whilst there is no change in the EU-27 rates for the rest of the world. The EU-15 import tariff rates for Turkish products decrease considerably in some sectors like sugar (-170,9%) and vegetable oils and fats (-34,9%) after the Doha Round commitments are applied. The EU-15 also reduces its tariff rates for products from the rest of the world like sugar processing (-19,2%), dairy (-8,3%) and other meat processing (-6,4%). In the case of the AC-12, import tariff rates for Turkish products decrease for most sectors especially for meat processing (-225,7%), dairy (-87,9%), other meat processing (-82,3%) and beverages and tobacco sector (-54,3%). This reduction is due to accession of these twelve countries to the EU and Doha Round commitments. Accession of these twelve countries (in the baseline) leads to reductions and increases in their import tariff rates against rest of the world. They increase their import tariff rates especially for sugar processing (65,4%) and vegetables, fruits and nuts (13,5%) while decrease them particulary in the case of beverages and tobacco sector (-23,4%) and other crops (-9,1%).

[49] The values in parenthesis show tariff reduction in percentage points. They are calculated by subtracting the post shock value from the pre-shock value. For example in the case of the sugar processing sector; 78,6 – 63,4 = 15,2%

	Benchmark (2001) by EU-15			Baseline (2025) by EU-15		Benchmark (2001) by AC-12			Baseline (2025) by AC-12	
Sectors	TR	AC-12[50]	ROW	TR	ROW	TR	EU-15[50]	ROW	TR	ROW
Wheat	3,7	0,3	0,9	3,8	0,9	19,5	18,9	7,7	3,3	1,5
Ograins	4,1	14,7	18,6	3,8	18,2	0,5	28,0	9,5	7,1	17,0
VegFruitNuts	2,5	5,0	18,7	2,0	15,8	19,8	10,9	11,2	3,0	24,7
Oilseeds	0,0	0,0	0,0	0,0	0,0	9,1	4,9	3,6	0,0	0,0
Sugar	261,2	41,6	8,0	90,3	4,7	0,0	5,8	1,8	0,2	2,0
Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,7	0,1	0,0	0,0
Ocrops	0,0	2,4	2,6	0,0	2,6	33,1	14,5	10,9	0,0	1,8
Catshp	0,0	26,0	0,7	0,0	0,4	0,8	2,8	6,1	0,0	0,7
PigsPoultry	0,0	1,2	1,3	0,0	1,0	28,3	6,9	8,4	10,6	0,7
Oagric	0,8	2,4	12,7	0,5	9,3	4,7	0,8	2,7	3,2	2,0
Meatpro	39,0	43,9	46,4	41,1	40,5	272,0	30,5	24,7	46,3	23,4
Omeatpro	23,4	14,7	20,3	17,4	13,9	101,8	25,8	31,2	19,5	27,4
Vegoilsfats	59,7	3,9	9,5	24,8	5,3	16,1	6,1	7,2	11,7	2,6
Dairy	34,1	40,4	37,4	27,5	29,1	112,3	37,7	28,3	24,4	29,9
Sugarpro	70,3	27,1	114,7	61,7	95,5	29,4	28,2	16,9	54,2	82,3
Ofoodpro	2,3	10,3	10,2	1,7	7,9	39,2	17,7	13,8	3,5	11,9
BevsTobac	2,7	10,6	7,2	2,5	5,3	55,0	37,1	40,8	0,7	17,4
RawMat	0,0	0,2	0,0	0,0	0,0	2,4	1,0	0,2	0,0	0,0
Mnfcs	0,4	0,3	2,1	0,0	1,1	6,0	2,7	6,1	0,0	1,2
Svces	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0

Table 5.5 Import tariff rates, EU-15 and AC-12, per cent (GTAP Database version 6 and own calculations)

Finally, in Table 5.6 import tariff rates for the ROW (including USA) are shown. Import tariff rates for the ROW decrease for most sectors and for all countries under the Doha Round commitments. In the case of Turkish products the largest reductions are observed for other meat processing (-5,6%) and manufacturing (-3,3%) while for the products imported from the EU-15 and AC-12 the most important reductions are observed for sugar processing (-9,1% and -6,9% respectively), meat

[50] Corresponding tariff rates for these columns are not provided in the baseline columns of the table as in the baseline AC-12 accede to the EU and all intra-import tariffs are eliminated.

processing (-5,7% and -2,3%), other grains (-8% and -2,5%) and sugar (-6,9% for the EU-15). In the rest of the world, countries reduce the import tariffs between themselves, especially in oilseeds (-34,5%), sugar processing (-5,1%) and other agriculture (-4,3%) sectors. Tariff rates after the implementation of the accession scenarios do not affect the ROW's tariff structure.

	Benchmark (2001)				Baseline (2025)			
Sectors	TR	EU-15	AC-12	ROW	TR	EU-15	AC-12	ROW
Wheat	21,1	16,3	27,6	23,2	18,1	16,2	26,6	21,6
Ograins	15,2	22,2	13,7	57,6	13,3	14,2	11,2	49,1
VegFruitNuts	10,9	18,5	18,7	8,6	9,8	15,0	17,6	7,4
Oilseeds	7,7	11,5	15,0	53,0	6,2	9,4	13,7	18,5
Sugar	0,7	38,9	0,0	3,3	0,3	32,0	0,0	5,4
Plants	0,8	4,5	1,0	2,0	0,7	2,8	1,0	1,9
Ocrops	15,9	10,2	7,4	8,4	16,4	8,9	7,7	8,8
Catshp	0,3	1,8	13,1	1,7	0,3	1,9	13,2	2,1
PigsPoultry	24,5	8,4	7,2	4,1	21,5	6,5	6,6	3,7
Oagric	14,5	6,7	4,9	21,3	14,3	5,8	3,5	17,0
Meatpro	5,6	24,9	16,9	18,8	7,0	19,2	14,3	18,4
Omeatpro	15,2	34,8	38,9	24,6	9,6	30,7	37,3	29,6
Vegoilsfats	8,9	10,0	16,8	23,4	9,0	10,8	18,1	22,4
Dairy	16,0	19,3	25,3	17,8	13,0	15,8	21,6	13,9
Sugarpro	6,3	34,8	26,7	37,6	6,2	25,7	19,8	32,5
Ofoodpro	15,3	14,3	13,8	11,5	14,0	12,4	12,2	10,4
BevsTobac	58,8	15,1	18,3	19,8	56,4	13,6	16,6	18,9
RawMat	4,0	1,6	2,0	1,7	3,3	2,1	2,3	1,9
Mnfcs	11,8	5,6	6,1	4,4	8,5	4,4	4,8	3,1
Svces	0,0	0,0	0,1	0,0	0,0	0,0	0,1	0,0

Table 5.6 Import tariff rates, ROW, per cent (GTAP Database version 6 and own calculations)

	Turkey	EU-15	AC-12			ROW			
Sectors	All	All	TR	EU-15	ROW	TR	EU-15	AC-12	ROW
Wheat	0,0	8,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ograins	0,0	33,4	0,0	0,1	0,0	0,0	0,0	0,0	0,0
VegFruitNuts	0,3	2,3	0,1	0,1	0,0	0,3	0,2	0,1	0,1
Oilseeds	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Sugar	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Plants	0,0	0,0	0,0	0,0	0,0	0,6	0,5	0,2	0,2
Ocrops	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Catshp	0,0	0,0	0,0	0,0	0,0	0,0	0,5	0,8	0,0
PigsPoultry	0,2	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Oagric	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Meatpro	0,0	84,6	0,0	0,0	0,0	0,0	0,1	0,0	0,0
Omeatpro	0,9	5,7	0,1	0,6	0,4	0,0	0,2	0,2	0,0
Vegoilsfats	2,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Dairy	0,0	30,8	1,3	2,8	2,6	5,2	9,7	0,6	1,4
Sugarpro	1,4	60,2	0,1	5,5	4,9	0,0	0,0	0,0	0,0
Ofoodpro	2,0	3,5	0,4	0,3	0,2	0,3	0,3	0,2	0,0
BevsTobac	0,0	0,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Table 5.7 Export subsidy rates in 2001, per cent (GTAP Database version 6 and own calculations)

In Table 5.7 initial (benchmark values - 2001) export subsidy rates applied by all regions are provided. In the first row exporter countries are shown while in the second row the export destination regions are given. Values for Turkey and the EU-15 are not separated according to the export destination as they apply same rates for every region in the model. Final export subsidy rates are not provided in the table since all export subsidies are eliminated in the construction of the baseline according to the Doha Round agreements. As can be observed from the table export subsidies are mostly used by the EU-15[51] especially for meat processing (84,6%), sugar processing (60,2%), other grains (33,4%) and dairy products (30,8%).

[51] Over 90 % of the export subsidies in the GTAP database are concentrated within the EU-15.

Sectors	Turkey	EU-15	AC-12	USA	ROW
Wheat	1,01	1,74	1,03	1,64	1,03
Ograins	1,00	1,70	1,02	1,30	1,02
VegFruitNuts	1,03	1,02	1,01	1,09	0,99
Oilseeds	1,01	1,58	1,04	1,24	1,01
Sugar	1,01	1,02	1,03	1,05	1,01
Plants	1,04	1,28	1,01	1,09	1,00
Ocrops	1,03	1,06	1,02	1,09	1,01
Catshp	1,00	1,42	1,01	1,03	0,99
Pigspoultry	1,00	1,02	1,01	1,03	0,99
RawMilk	1,01	1,07	1,02	1,06	1,01
Oagric	1,00	1,11	1,00	1,53	1,01

Table 5.8 Power of domestic support, in year 2001, per cent (GTAP Database version 6 and own calculations)

In Table 5.8 above the aggregate power of agricultural domestic in 2001 (benchmark values) for all regions (USA and ROW are separated in this table) in the model is shown. The power of support equals 1 plus the ratio of total value of the payment (the sum of the value of output subsidies, intermediate input subsidies, land-based payments and capital-based payments from the GTAP database version 6) over the value of production (Values less than 1 in Table 5.8 shows taxes). The table shows that domestic support measures are used significantly in the EU-15 and USA. In the case of other grains and wheat in the EU-15, the domestic support measures add up to 70 and 74 percent respectively of the value of the domestic production in 2001. Compared to the EU-15 and USA, Turkey and other regions support domestic agricultural production to a much smaller degree.

5.4 RESULTS

In this section the simulation results of the baseline and the Turkish accession to the EU are presented. Firstly, sectoral effects (i.e., production, commodity and primary factor prices, trade flow etc.) are discussed for various regions of the model in particular for Turkey and then macroeconomic effects (i.e., welfare decompsition etc.) are presented[52].

5.4.1 Sectoral Effects

5.4.1.1 Turkey

In Table 5.9, the benchmark value[53] and the percentage changes in production for Turkey are provided for the baseline and accession scenarios[54]. In the baseline both an expansionary and a substitution effect determine the changes. The expansionary effect reflects the effects of growth and foreign demand shaped by income and population growth (and the assumed income elasticities). The substitution effect represents the changes in relative competitiveness shaped by changes in relative productivity, cost of production as well as of any policy changes assumed in the baseline period. During the period considered the impact of assumed policy changes is, in general, relatively small in comparison to the effects of the projections[55].

These policy changes lead to increases in production in most sectors in Turkey especially in meat processing (*104,5%*[56]), other meat processing (*103,2%*) and vegetable oils and fats (*52,9%*) sectors due to lower import tariffs applied by the EU-15 and AC-12. In the other crops (*-7,7%*),

[52] The model is solved using GEMPACK software (Harrison and Pearson, 1996).
[53] Benchmark values are provided in 2001 prices, in millions of euro, to show that percentage changes in some cases can be from a large base as in composite sectors such as manufacturing and services.
[54] The results for the baseline are presented as accumulated changes during the period 2001-2025 (second column), while accession scenarios are presented as percentage changes relative to the baseline (third, forth and fifth columns). (The same approach is followed in Tables 5.10,5.11, 5.12, 5.13, 5.14, 5.15, 5.16, 5.17)
[55] Although decomposed results for each shock applied in the simulations are available they are not presented in the study since this would make the discussion unwieldy.
[56] All italicised results in the text are not provided in the tables.

vegetables, fruit and nuts (*-3,6%*) and plant-based fibers (*-2,6%*) sectors production falls as a result of the elimination of the agricultural domestic support in Turkey.

Sectors	Benchmark Value (2001) (€ million)	Baseline (2001-2025) (%)	S-1 (2025) (%)	S-2.1 (2025) (%)	S-2.2 (2025) (%)
Wheat	1956	110,5	-2,6	-2,9	-2,5
Ograins	841	81,3	1,7	0,2	0,4
VegFruitNuts	11217	64,0	-	-1,6	-1,4
Oilseeds	492	99,4	7,7	6,4	6,7
Sugar	601	79,0	9,2	7,3	7,4
Plants	3293	104,3	-0,2	-1,6	-1,4
Ocrops	1770	68,3	-9,3	-10,0	-9,4
Catshp	1560	119,9	11,8	10,0	10,2
PigsPoultry	1049	111,7	6,6	4,8	5,1
RawMilk	1644	102,0	0,6	-1,1	-0,9
Oagric	75	269,8	-	1,1	1,5
Meatpro	600	249,2	88,1	85,9	86,3
Omeatpro	355	295,0	60,6	56,6	57,5
Vegoilsfats	1317	254,1	44,7	41,7	41,9
Dairy	3436	91,8	2,1	0,2	0,3
Sugarpro	8080	101,7	9,1	7,3	7,3
Ofoodpro	1952	105,8	3,0	1,9	2,0
BevsTobac	2698	104,9	2,4	0,6	0,6
RawMat	4235	56,4	-	-0,1	-0,1
Mnfcs	89803	168,5	-1,8	-4,5	-4,3
Svces	147365	155,3	-0,2	-1,9	-2,0

Table 5.9 Change in production, Turkey (Simulation results and own calculations)

+/- indicates less than + or - 0,1 %; Changes for the scenarios are given relative to the baseline

To better appreciate the results of a CGE model one must be aware of the fact that simultaneous policy shocks make the job of interpretation extremely challenging. In the context of the shocks in *scenarios 1* and *2*, numerous changes are occurring in each of the markets. For example, from a Turkish perspective if the import tariff is eliminated (or is lowered to mimic CET) Turkey faces

stronger competition as the relative price of imported products falls. This causes an increase in consumer demand for imported products, resulting in lower demand for the domestic substitute. Moreover, the drop in domestic product demand causes a shift in resources away from that sector. The second shock is where the EU eliminates its import tariff for Turkish products causing an increase in production of those Turkish products. Clearly, a competing foreign sector is likely to expand if (i) a large import tariff is eliminated (ii) a large part of the production of that sector is exported to the EU and (iii) the elasticity of substitution for that product in the import nest is large. On the other hand, if sales of a sector are mainly in the domestic market, cheaper products from the EU (from ROW region) may have negative effects on that sector. The elimination of import tariffs also causes changes in the production cost by changes in the price of intermediate inputs and primary factors. In the former case, cheaper imported intermediate inputs can reduce the costs of production, thereby improving competitiveness. In the latter case, large regional trade deficits (in the extreme case of an uncompetitive region) are unsustainable in the long run, where improvements in the real exchange rate (i.e., falling factor prices) are necessary to improve exports and redress the trade imbalance.

The results suggest that Turkey is relatively competitive in the agro-food sectors, where Turkish accession to the EU, *scenario-1*, leads to increases in production in most agricultural sectors compared to the baseline, with concurrent falls in non-agricultural sectors (i.e., manufacturing and services) (see Table 5.9). The largest increases in Turkish agricultural output occur in the meat processing (88,1%), other meat processing (60,6%) and vegetable oils and fats (44,7%) sectors, with market price (Table 5.10) increases due to the elimination of import tariffs imposed by the EU-15 and AC-12. In the upstream cattle and sheep, oilseeds and sugar sectors production increases as a result of higher demand from downstream meat processing, other meat processing, vegetable oils and fats and sugar processing sectors. In some sectors, (other crops, wheat and plant-based fibers) the accession leads to production falls (-9,3%, -2,6%, -0,2% respectively). The production of other crops falls due to the reductions on import tariffs imposed by Turkey to USA products while falls in wheat and plant-based fibers sectors are a result of the elimination of import tariffs on the EU-15 and the AC-12 products by Turkey. In the largest agricultural sector (in value terms), vegetables fruits and nuts, no changes are observed after the

accession. This can be explained by a low level of EU-15 import protection and the AC-12[57] on this sector before the accession and by the small overall volume of Turkish imports (i.e., although Turkey lowers its import tariffs on vegetables, fruits and nuts sector, the domestic production remains largely unaffected.).

In *scenarios 2.1* and *2.2* where a migration flow of 2.7 million Turkish people is included, the production of all sectors falls relative to *scenario-1* as a result of lower supply of skilled (only for *scenario-2.2*) and unskilled workers in Turkey. In comparison with *scenario-1*, the production changes in manufacturing, services and vegetables fruits and nuts sectors appear to be significant while the effects for the other sectors remain fairly small.

As mentioned before in this section, these two scenarios differ with respect to their assumptions on the skill composition of the migrants. Because of this the effects of migration are different in both scenarios. If all migrants are unskilled (*scenario-2.1*) falls in the production of all sectors are bigger compared to *scenario-2.2* where migrants have the same skill composition as the Turkish population in year 2000. This is due to the relatively higher intensity of unskilled labour in all sectors especially in the agricultural sectors. Only the production of services falls by 2% in *scenario-2.2* as compared to 1,9% in *scenario-2.1* as a result of higher usage of skilled labour in this sector than other sectors.

Table 5.10 shows percentage changes in market prices of primary factors and commodities in Turkey for the baseline and accession scenarios. Due to assumed total factor growth rates, the reductions in import prices and the increases in production, the market prices decline over the considered period for the baseline. In the baseline period wages and the price of capital fall as a result of assumed high growth rates for these factor endowments while the land price increases due to higher demand from the primary agricultural sectors.

[57] According to the baseline nearly 64% of all exported products of this sector from Turkey are bought by the EU.

Sectors	Baseline (2001-2025) (%)	S-1 (2025) (%)	S-2.1 (2025) (%)	S-2.2 (2025) (%)
Land	518,2	2,1	-4,3	-3,6
Unskilled Labour	-15,6	1,2	5,4	4,1
Skilled Labour	-11,6	1,0	0,5	3,5
Capital	-57,1	1,0	0,4	0,5
Natural Resources	2214,4	-0,2	-1,1	-1,0
Wheat	-10,1	0,5	-	-0,1
Ograins	-15,2	1,6	1,0	0,8
VegFruitNuts	-7,2	1,3	0,7	0,4
Oilseeds	-8,7	3,7	2,8	2,7
Sugar	-13,6	3,7	2,9	2,7
Plants	-21,8	0,7	0,3	0,2
Ocrops	-5,7	-1,8	-2,1	-2,2
Catshp	-19,7	1,7	1,0	0,8
PigsPoultry	-19,1	0,6	-0,1	-0,2
RawMilk	-18,3	-0,2	-0,8	-0,9
Oagric	-10,8	0,3	-0,3	-0,3
Meatpro	-37,7	0,5	0,7	0,7
Omeatpro	-37,7	0,4	0,6	0,6
Vegoilsfats	-40,2	0,3	0,7	0,7
Dairy	-15,5	-0,1	0,1	+
Sugarpro	-36,6	0,4	0,8	0,7
Ofoodpro	-30,3	-1,4	-1,3	-1,3
BevsTobac	-34,1	-7,7	-7,6	-7,6
RawMat	214,6	+	-0,3	-0,3
Mnfcs	-29,3	0,3	0,6	0,6
Svces	-36,6	0,7	1,3	1,4

Table 5.10 Change in market prices, Turkey (Simulation results and own calculations)

+/- indicates less than + or - 0,1 %; Changes for the scenarios are given relative to the baseline

Expansion of the most agricultural sectors following the Turkish accession to the EU (*scenario-1*) causes minor increases in the primary factor prices. These price changes of primary factors outweigh the potential reductions in intermediate input costs through cheaper access to imports, resulting in increases in market prices. In *scenarios 2.1* and *2.2* overall contraction of all sectors relative to the *scenario-1* leads to reductions in the land and capital prices while wage rates for unskilled and skilled labour (only for the *scenario-2.2*) increase reflecting the fact that these factors become relatively scarce resources compared to the *scenario-1*. Accession with free movement of labour (migration) causes falls in the market prices in the primary agricultural sectors while in non-agricultural sectors the market prices increase relative to the *scenario-1*. This is due to the fall in land prices in *scenarios 2.1* and *2.2* and as land is specific to the primary agriculture sectors the market prices decline in these sectors. Higher wage rates for unskilled labour in *scenario 2.1* lead to higher market prices in the primary agriculture sectors than *scenario 2.2* due to the relatively higher intensity of unskilled labour in these sectors.

Tables 5.11, 5.12 and 5.13 show the changes in exports, imports and trade balances by sector in Turkey for the baseline and accession scenarios. During the period considered for the baseline, the impact of assumed policy changes (import tariff reductions, elimination of export subsidies and agricultural domestic support) is relatively small in non-agricultural sectors by comparison to the effects of the projections while in agricultural sectors these policy changes have more impacts. At the end of the baseline period Turkey's aggregate balance improves by € 1931 m while the aggregate trade balance in agricultural and food sectors improves by € 2270 m (see Table 5.13).

In the *scenario-1*, changes in Turkish exports to the EU regions (EU-15 and AC-12) reflect the production changes in Turkey (compare Tables 5.9 and 5.11), although in the case of oilseeds, cattle and sheep, pigs and poultry sectors exports fall relative to the baseline despite production increases. The reason for this lies in the higher demand from downstream meat processing, other meat processing, vegetable oils and fats sectors. For example, in cattle and sheep sectors, firms' domestic intermediate input demands account for approximately *60,1%* of total cattle and sheep production in Turkey. The *8,8%* of total production is used as intermediate input by meat processing sector and this demand increases by *102%* in Turkey after the *scenario-1*. A similar effect is also responsible for the falls in

Turkish oilseeds and pigs and poultry exports to the EU relative to the baseline, where production increases in Turkish vegetable oils and fats and other meat processing sectors increase domestic intermediate demands for Turkish oilseeds and pigs and poultry sectors which undergo export falls despite increases in their production. On the other hand, Turkish exports to the rest of the world fall (relative to the baseline) in nearly all sectors as import tariff reductions made by the EU-15 and the AC-12 makes the EU market more attractive for Turkish products (i.e., trade diversion). Moreover, production falls in manufacturing and services sectors (see Table 5.9) also result in falls in exports from these sectors.

Elimination of import tariffs and the adoption of the CET from Turkey after the accession (*scenario-1*) lead to increases in import demands in Turkish agricultural and non-agricultural sectors with the exception of raw material sector where imports from the EU-15, AC-12 and ROW fall due to falls in domestic production of downstream manufacturing and services sectors. Regarding, cattle and sheep, pigs and poultry and plant-based fibers sectors, imports increase despite relatively small import tariff reductions realized by Turkey after the accession. This is due to higher imported intermediate demand from expanded downstream sectors. In the case of meat processing, sugar processing, dairy and other agricultural sectors imports from ROW fall. The reasons for these falls are twofold. Firstly, falls in import tariff rates applied by Turkey to the EU-15 and the AC-12 are large (except sugar processing and other agricultural sectors). Secondly, the adoption of the CET obligates Turkey to increase its import tariff rates applied to ROW in these sectors (see Table 5.4).

	Baseline (2001-2025) (%)			S-1 (2025) (%)			S-2.1 (2025) (%)			S-2.2 (2025) (%)		
Sectors	EU-15	AC-12	ROW	EU-15	AC-12	ROW	EU-15	AC-12	ROW	EU-15	AC-12	ROW
Wheat	1,0	58,4	413,6	33,0	27,0	-3,5	37,6	30,3	-0,6	39,3	31,7	0,4
Ograins	5,7	26,8	96,0	5,5	13,6	-3,9	7,2	15,2	-2,8	7,8	15,8	-2,3
VegFruitNuts	-21,1	62,2	107,0	2,6	6,2	-4,3	5,1	7,7	-2,5	6,1	8,6	-1,7
Oilseeds	107,2	129,6	43,4	-17,4	-15,9	-16,0	-13,3	-12,6	-13,0	-12,8	-11,9	-12,3
Sugar	1161,7	98,1	342,9	316,5	-14,6	-11,3	315,9	-11,3	-10,6	318,7	-10,2	-9,6
Plants	214,3	224,7	282,0	-3,2	-4,1	-3,3	-1,1	-2,9	-2,1	-0,8	-2,3	-1,6
Ocrops	-29,2	204,2	66,1	11,1	9,9	11,5	11,6	9,8	12,3	13,3	11,4	13,6
Catshp	31,4	10,7	126,9	-6,8	-12,5	-4,7	-4,2	-10,3	-3,0	-3,6	-9,7	-2,6
PigsPoultry	-17,9	59,2	121,4	-1,7	29,1	-1,4	1,4	30,6	-0,1	1,5	31,2	0,3
RawMilk	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
Oagric	116,1	32,6	1904,2	10,3	62,0	-2,8	15,8	68,2	1,7	16,4	69,4	2,1
Meatpro	771,5	272294,4	261,6	1325,2	209,5	-4,0	1299,4	207,7	-5,7	1305,9	207,9	-5,3
Omeatpro	79,2	10955,5	530,2	318,4	217,1	-3,0	304,0	209,8	-6,1	308,0	211,1	-5,4
Vegoilsfats	1278,2	185,1	426,2	144,3	112,7	-1,6	140,0	106,7	-4,7	140,3	107,2	-4,5
Dairy	-64,8	1182,7	-23,7	695,5	325,0	0,6	689,2	318,2	-1,2	693,6	320,4	-0,6
Sugarpro	135,0	80,8	195,4	1339,9	709,0	-2,2	1356,4	696,3	-4,2	1355,8	699,6	-3,7
Ofoodpro	51,5	311,6	153,6	12,6	20,3	5,4	13,2	19,4	4,7	13,3	19,7	4,9
BevsTobac	56,0	259,9	96,3	25,4	19,9	18,8	27,5	19,8	18,5	27,2	19,8	18,6
RawMat	40,4	98,4	133,7	-1,0	-0,8	-1,0	5,0	4,8	4,1	4,7	4,6	4,0
Mnfcs	161,5	242,6	258,3	-1,8	-1,8	-1,7	-4,8	-5,9	-4,6	-4,7	-5,6	-4,3
Svces	243,6	135,3	233,9	-2,3	-1,0	-2,2	-3,3	-1,8	-4,2	-3,8	-2,0	-4,5

Table 5.11 Change in exports, Turkey (Simulation results and own calculations)

nt: non-tradable; Changes for the scenarios are given relative to the baseline

	Baseline (2001-2025) (%)			S-1 (2025) (%)			S-2.1 (2025) (%)			S-2.2 (2025) (%)		
Sectors	EU-15	AC-12	ROW	EU-15	AC-12	ROW	EU-15	AC-12	ROW	EU-15	AC-12	ROW
Wheat	142,8	591,5	-18,2	187,9	183,9	167,0	178,6	177,5	159,7	177,1	176,6	159,1
Ograins	22,1	155,9	81,3	32,9	75,8	33,1	30,4	72,5	30,6	30,2	72,5	30,6
VegFruitNuts	420,5	211,8	27,6	99,3	99,6	23,4	95,5	93,3	19,5	94,1	92,6	19,1
Oilseeds	56,7	428,7	57,1	50,9	57,8	10,8	46,9	54,8	8,3	46,9	54,9	8,4
Sugar	699,5	899,7	23,3	-29,1	33,0	38,2	-29,8	29,7	35,0	-30,4	29,8	35,0
Plants	255,1	347,5	26,8	4,7	4,7	4,9	3,3	2,4	2,7	3,3	2,5	2,8
Ocrops	506,8	452,6	39,9	-26,9	-51,6	95,0	-25,5	-52,8	90,0	-26,5	-52,8	90,1
Catshp	118,0	526,9	283,4	103,6	252,4	85,3	99,1	244,9	80,7	98,9	244,5	80,7
PigsPoultry	326,3	277,2	83,3	15,8	12,7	11,3	15,0	11,9	10,3	15,0	12,0	10,4
RawMilk	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
Oagric	987,1	5166,7	-78,1	53,9	24,7	-13,4	51,5	21,0	-16,0	51,0	21,3	-15,8
Meatpro	-92,2	1561,0	108,6	11384,9	2338,7	-72,3	11448,5	2314,0	-72,7	11413,8	2310,5	-72,7
Omeatpro	426,6	494,4	-17,4	237,1	36,1	-74,1	233,2	32,6	-74,8	233,0	32,7	-74,8
Vegoilsfats	37,3	95,4	22,4	67,1	76,8	10,8	65,9	75,8	9,8	65,8	75,6	9,8
Dairy	-9,1	422,8	100,6	332,8	178,5	-7,2	329,2	174,2	-8,6	328,2	174,2	-8,6
Sugarpro	-81,4	384,2	32,0	443,5	326,9	-88,7	438,4	323,7	-88,8	437,6	322,8	-88,8
Ofoodpro	81,8	163,5	80,3	9,8	25,7	7,8	8,3	23,7	5,9	8,3	23,7	6,0
BevsTobac	82,6	99,0	91,1	-17,9	103,9	27,5	-19,5	100,4	25,3	-19,5	100,4	25,3
RawMat	1697,1	1179,8	142,9	-0,3	-1,0	-1,3	-5,2	-4,0	-3,9	-4,7	-3,8	-3,8
Mnfcs	105,8	139,4	105,9	-5,9	-4,9	12,4	-5,0	-6,2	10,4	-5,3	-6,0	10,7
Svces	13,1	68,3	91,6	1,3	1,2	1,2	0,7	0,7	0,6	1,0	0,9	0,8

Table 5.12 Change in imports, Turkey (Simulation results and own calculations)

nt: non-tradable; Changes for the scenarios are given relative to the baseline

Sectors	Baseline (2001-2025) (€ million)	S-1 (2025) (€ million)	S-2.1 (2025) (€ million)	S-2.2 (2025) (€ million)
Wheat	641	-170	-141	-132
Ograins	-42	-48	-44	-44
VegFruitNuts	259	-57	-24	-10
Oilseeds	-112	-74	-64	-64
Sugar	-1	0	0	0
Plants	-27	-52	-30	-29
Ocrops	-126	-303	-277	-266
Catshp	27	-29	-27	-26
PigsPoultry	-477	-121	-111	-112
RawMilk	nt	nt	nt	nt
Oagric	35	-27	-19	-19
Meatpro	454	1135	1126	1129
Omeatpro	384	534	513	519
Vegoilsfats	866	1013	986	989
Dairy	12	135	132	134
Sugarpro	53	700	709	709
Ofoodpro	288	46	55	57
BevsTobac	-5	7	13	13
Agro-food total	**2270**	**2688**	**2798**	**2847**
RawMat	-35789	500	1860	1789
Mnfcs	14803	-2306	-3758	-3559
Svces	20648	-799	-1161	-1318
Total	**1931**	**83**	**-260**	**-238**

Table 5.13 Change in trade balance, Turkey (Simulation results and own calculations)

nt: non-tradable; Changes for the scenarios are given relative to the baseline

Increased multilateral market access under the *scenario-1* increases Turkish exports relatively to imports in meat processing, other meat processing, vegetables oils and fats, dairy, other food processing and beverages and tobacco sectors, which results in improving sectoral trade balances (see Table 5.13). The trade balance contractions in the case of oilseeds, cattle and sheep and pigs and poultry sectors as mentioned before is a result of higher demand for imported intermediate inputs from expanding downstream sectors. Furthermore, wheat, vegetables fruits and nuts and other crops sectors,

undergo relative deteriorations in the trade balance as they are not comparatively competitive (higher baseline tariff rates applied by Turkey). Although Turkey's aggregate agricultural and food trade balance improves by € 2688 m (Table 5.13) compared to the baseline the aggregate trade balance only improves by € 83 m due to declining trade balances in manufacturing and services sectors as a result of the reallocation of resources from these sectors to agricultural sectors.

Under the *scenarios 2.1* and *2.2* Turkish imports fall relative to *scenario-1* due to lower productive capacity and subsequently regional income owing to migratory outflows from Turkey to the EU. Relatively higher falls in the levels of production in manufacturing and services sectors under the *scenarios 2.1* and *2.2* are reflected in falls in their exports while changes in agricultural sectors remain fairly small. Due to large falls in manufacturing and services sectors exports Turkey's aggregate trade balance declines between -€ 238 m to -€ 260 m (see Table 5.13) compared with the baseline. Higher production falls in nearly in all sectors under the *scenario-2.1* (see Table 5.9) results in greater import substitution and consequently a larger deterioration in the aggregate trade balance, compared to *scenario-2.2*.

5.4.1.2 European Union

In Table 5.14 below the benchmark value and the percentage changes in production for the EU-15 and the AC-12 are provided for the baseline and accession scenarios[58]. In the baseline as it is mentioned before, assumed projections and policy changes determine the changes. As it was in the case of Turkey, the impact of assumed policy changes remains relatively small in the baseline compared to the effects of the projections. During the period considered for the baseline assumed policy changes lead to falls in production in most sectors in the EU-15 especially in plant-based fibers (*-70,2%*), oilseeds (*-34,4%*), cattle and sheep (*-20%*) and wheat (*-18,2%*) sectors due to the elimination of domestic agricultural support and export subsidies. On the other hand, in the AC-12 policy change effects remain small due to this region's relatively lower agricultural protection level.

[58] In appendix V production changes are provided for all 21 commodities in each of the 10 regions (except Turkey) in the model.

	Benchmark Value (2001) (€ million)		Baseline (2001-2025) (%)		S-1 (2025) (%)		S-2.1 (2025) (%)		S-2.2 (2025) (%)	
Sectors	EU-15	AC-12	EU-15	AC-12	EU-15	AC-12	EU-15	AC-12	EU-15	AC-12
Wheat	11469	7516	49,5	41,6	0,4	0,2	0,8	0,3	0,6	0,3
Ograins	12800	7980	9,5	23,6	0,0	-	0,9	-	0,7	-
VegFruitNuts	51047	12292	54,0	28,4	+	0,1	0,8	0,1	0,7	0,1
Oilseeds	6326	1384	17,3	58,1	-2,3	1,5	-1,9	1,8	-2,0	1,7
Sugar	4405	1183	10,1	27,0	-3,4	-1,0	-2,4	-1,0	-2,6	-1,0
Plants	1222	582	90,9	50,8	0,9	0,2	1,0	0,0	0,8	+
Ocrops	52624	10554	67,3	30,7	-	-	1,2	-0,3	0,9	-0,2
Catshp	26752	4175	9,8	61,7	-0,3	-1,1	0,4	-1,1	0,3	-1,1
PigsPoultry	50686	14531	52,0	45,5	-	-0,5	0,8	-0,5	0,7	-0,5
RawMilk	42922	10932	14,8	50,0	-0,1	-0,1	1,2	-0,1	1,0	-0,1
Oagric	1204	774	619,0	153,6	0,2	1,4	0,5	1,0	0,3	1,1
Meatpro	68890	7700	38,1	104,1	-0,4	-10,0	0,4	-10,0	0,3	-10,0
Omeatpro	108728	16903	65,7	86,1	-0,2	-2,0	0,7	-2,0	0,5	-2,0
Vegoilsfats	49137	6601	32,5	55,5	-1,9	-0,1	-	-0,1	-0,3	-0,1
Dairy	123432	10490	40,4	129,2	-0,1	-0,4	0,9	-0,3	0,8	-0,3
Sugarpro	21945	6538	29,6	51,9	-3,7	-1,2	-2,9	-1,1	-3,0	-1,1
Ofoodpro	298776	39030	46,5	61,3	-	-	0,7	0,1	0,6	0,1
BevsTobac	159842	32574	51,0	60,1	0,0	0,1	1,0	0,1	0,8	0,1
RawMat	116982	24064	65,2	57,5	0,0	+	+	+	+	+
Mnfcs	4849610	425263	52,3	72,2	+	0,2	1,6	-	1,3	+
Svces	10246621	550407	62,8	98,7	+	+	1,0	0,1	0,8	0,1

Table 5.14 Change in production, EU-15 and AC-12 (Simulation results and own calculations)

+/- indicates less than + or - 0,1 %; Changes for the scenarios are given relative to the baseline

Integrating Turkey into the EU under *scenario-1* leads to production falls in most agricultural sectors in the EU-15 and AC-12 compared to the baseline while in non-agricultural sectors increases are observed as a result of reallocation of resources from agricultural sectors to non-agricultural sectors. In wheat, other crops, other agriculture and plant-based fibers sectors Turkish accession leads to

production increases in the EU-15 and the AC-12 while in Turkey production falls in these sectors (see Table 5.9)[59].

Under the *scenarios 2.1* and *2.2* production in all sectors increases in the EU-15 relative to the *scenario-1* while production level remains unchanged in the AC-12 as assumed migration flows in these scenarios do not include migrants to the AC-12 countries. In the case of the EU-15, if all immigrants are unskilled (*scenario-2.1*) increases in the production of all sectors are bigger compared to the *scenario-2.2* where migrants have the same skill composition as the Turkish population in year 2000. This is due to the relatively higher intensity of unskilled labour in all sectors.

Table 5.15 shows percentage changes in market prices of primary factors and commodities in the EU-15 and the AC-12 for the baseline and accession scenarios. Due to assumed total factor growth rates, the reductions in import tariffs, the elimination of export subsidies and the increases in the production, the market prices decline over the considered period for the baseline in both regions. In the baseline period the price of capital falls as a result of assumed high growth rates for these factor endowments while wages increase due to lower or negative growth rates assumed for these regions.

Falls in production relative to the baseline in the EU-15 and the AC-12 after the Turkish accession, (*scenario-1*) lead to lower demands for primary factors which causes minor falls in the primary factor prices in both regions. These price changes of primary factors with reductions in import prices of the intermediate inputs from Turkey lead to small falls in market prices in nearly all sectors. In *scenarios 2.1* and *2.2* higher supply of unskilled labour in the EU-15 is reflected by lower wages for unskilled labour in the same region. On the other hand, overall expansion of all sectors relative to the *scenario-1* leads to increases in the other primary factor prices. Although nearly all market prices of primary factors increase except unskilled labour wages, market prices in most sectors fall compared with the *scenario-1* (higher unskilled labour wage fall leads to higher market prices falls in *scenario 2.1* than *scenario 2.*2) due to the relatively higher intensity of unskilled labour in all sectors.

[59] In the case of the EU-15 and the AC-12, the percentage changes are smaller than in Turkey since the percentage changes are calculated from a larger base value.

	Baseline (2001-2025) (%)		S-1 (2025) (%)		S-2.1 (2025) (%)		S-2.2 (2025) (%)	
Sectors	EU-15	AC-12	EU-15	AC-12	EU-15	AC-12	EU-15	AC-12
Land	-52,0	82,6	-0,2	-0,7	3,0	-0,9	2,3	-0,8
Unskilled Labour	39,7	41,6	-	-0,1	-1,9	-0,2	-1,4	-0,2
Skilled Labour	42,7	37,6	-	-0,1	0,7	-0,1	0,2	-0,1
Capital	-19,4	-30,2	-	-0,1	0,8	-0,1	0,6	-0,1
Natural Resources	1746,0	2557,9	-	-	0,3	0,1	0,2	0,1
Wheat	-14,3	-16,5	+	-	-0,1	-0,2	-	-0,1
Ograins	-17,0	-19,5	-	-0,1	-0,2	-0,2	-0,1	-0,2
VegFruitNuts	-24,3	-10,7	-	-0,2	-0,4	-0,4	-0,3	-0,3
Oilseeds	6,5	-13,6	-0,3	0,1	-0,3	+	-0,3	+
Sugar	-28,6	-18,3	-0,2	-0,6	-0,9	-0,7	-0,7	-0,6
Plants	-14,7	-26,4	-	-0,1	-0,3	-0,2	-0,2	-0,1
Ocrops	-21,7	-24,2	-	-0,1	-0,6	-0,3	-0,4	-0,2
Catshp	-11,0	-24,3	-	-0,3	-0,3	-0,5	-0,2	-0,4
PigsPoultry	-36,6	-27,6	-0,1	-0,4	-0,4	-0,5	-0,3	-0,4
RawMilk	-26,5	-26,0	-	-0,2	-0,7	-0,3	-0,5	-0,3
Oagric	-20,3	-26,6	-	0,1	-0,2	-0,1	-0,1	-0,1
Meatpro	-29,3	-31,4	-0,1	-0,9	-0,3	-1,0	-0,2	-0,9
Omeatpro	-37,8	-39,5	-	-0,4	-0,3	-0,5	-0,2	-0,5
Vegoilsfats	-27,4	-32,6	-0,1	-0,2	+	-0,3	+	-0,2
Dairy	-32,9	-34,8	-	-0,2	-0,2	-0,3	-0,2	-0,2
Sugarpro	-31,2	-31,9	-0,1	-0,2	-0,2	-0,3	-0,1	-0,2
Ofoodpro	-27,4	-31,6	-0,1	-0,1	-0,2	-0,2	-0,2	-0,2
BevsTobac	-31,0	-35,8	-0,1	-0,1	0,1	-0,2	0,1	-0,2
RawMat	177,6	188,4	-	-0,1	0,1	0,1	0,1	+
Mnfcs	-23,3	-25,2	-	-0,1	-0,4	-0,2	-0,3	-0,1
Svces	-13,5	-20,3	-	-0,1	0,0	-0,2	-	-0,1

Table 5.15 Changes in market prices, EU-15 and AC-12 (Simulation results and own calculations)

+/- indicates less than + or - 0,1 %; Changes for the scenarios are given relative to the baseline

Tables 5.16 and 5.17 show the changes in exports, imports and trade balances by sector in the EU-15 and the AC-12 for the baseline and accession scenarios. In the baseline period deterioration of the non-agricultural sector trade balances in the EU-15 and the AC-12 results in negative aggregate

trade balances (-€ 97956 m and -€ 5797 m respectively). In the same period aggregate agricultural and food trade balances improve by *€ 52811 m* in the EU-15 and *€ 10203 m* in the AC-12.

Turkish accession into the EU, *scenario-1*, seem to have considerable effects on meat processing, other meat processing, vegetable oils and fats, and sugar processing sectors in the EU-15. The elimination of the high baseline import tariffs between the EU-15 and Turkey in these sectors causes falls in exports and increases in imports resulting in negative trade balances (this also reflects the production changes in these sectors in the EU-15). Due to these falls aggregate trade balance in the EU-15 declines by -€ 85 m compared with the baseline despite improving trade balances in non-agricultural sectors. Migratory flows from Turkey to the EU-15 countries, under the *scenarios 2.1* and *2.2*, results in increases in the EU-15 exports and imports relative to the *scenario-1* as a result of higher productivity and factor income. A relatively higher increase in manufacturing sector production (see Table 5.14) under the *scenarios 2.1* and *2.2* is reflected in higher exports in this sector while changes in agricultural sectors remain fairly small. Due to large increases in manufacturing sector exports, aggregate trade balance improves between € 10918 m to € 13696 m compared with the baseline.

In the case of the AC-12, the elimination of import tariffs between the AC-12 and Turkey after the Turkish accession (*scenario-1*) leads to increases in production and exports and falls in the imports of the most primary agricultural sectors resulting in improving trade balances in these sectors. In the case of cattle and sheep and pigs and poultry sectors, exports increase despite production falls (see Table 5.14) due to lower intermediate input domestic demand from downstream meat processing, other meat processing (this also leads to falls in imports of these sectors) and higher demand from Turkish meat and other meat processing sectors. In meat processing, other meat processing, diary and sugar processing sectors the elimination of high import tariffs applied by the AC-12 to Turkey in the baseline leads to increases in imports resulting in deteriorating trade balances in these sectors. As a result of these falls, the aggregate trade balance in the AC-12 declines by -€ 24 m compared with the baseline despite improving trade balances in non-agricultural sectors. *Scenarios 2.1* and *2.2* do not have significant effects on the AC-12 countries since migratory flows from Turkey are only assumed to the EU-15. Higher imports from the EU-15 in manufacturing sector leads the aggregate trade balance to decline between -€ 136 m to -€ 166 m compared with the baseline.

	Exports (%)				Imports (%)				Trade Balance (€ million)			
Sectors	Baseline	S-1	S-2.1	S-2.2	Baseline	S-1	S-2.1	S-2.2	Baseline	S-1	S-2.1	S-2.2
Wheat	173,1	1,2	0,9	0,6	-38,4	1,1	1,8	1,9	3563	58	32	22
Ograins	26,2	0,1	0,2	0,1	-1,7	0,1	0,7	0,7	472	1	-2	-3
VegFruitNuts	168,7	0,2	0,7	0,5	-20,0	0,1	0,6	0,7	9527	2	-25	-47
Oilseeds	122,9	0,3	-1,2	-0,9	15,7	-1,7	-0,5	-0,7	-961	111	39	49
Sugar	519,7	0,3	2,1	1,5	-51,1	15,2	14,5	14,9	40	-1	-1	-1
Plants	127,7	1,2	1,1	1,0	5,0	-0,3	0,4	0,4	474	18	6	6
Ocrops	329,2	-0,2	1,6	1,0	-27,4	-0,2	-0,9	-0,4	17432	-30	211	105
Catshp	13,2	1,9	2,5	2,2	85,2	0,3	0,3	0,4	-497	15	18	14
PigsPoultry	198,2	1,5	1,9	1,7	-10,6	-0,1	0,6	0,6	3401	79	70	69
RawMilk	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
Oagric	2325,8	0,4	0,4	0,3	-54,5	0,0	0,0	0,1	4832	15	12	7
Meatpro	-52,8	-0,2	1,3	0,9	96,3	3,7	3,5	3,6	-3707	-244	-228	-238
Omeatpro	228,6	-1,0	0,0	-0,2	43,0	0,8	0,7	0,9	7448	-209	-122	-147
Vegoilsfats	76,4	1,2	1,3	1,3	76,6	30,4	30,4	30,3	40	-840	-842	-841
Dairy	0,8	-0,2	0,6	0,4	102,4	0,3	0,8	0,9	-3703	-59	-51	-60
Sugarpro	-26,2	-7,7	-7,3	-7,4	25,1	35,2	36,3	36,2	-124	-567	-582	-581
Ofoodpro	91,1	0,1	0,5	0,4	25,1	0,0	0,6	0,5	11733	39	-30	-33
BevsTobac	69,9	-0,1	-0,1	-0,1	59,4	0,0	1,2	1,0	2666	-27	-97	-85
RawMat	386,2	-	-1,5	-1,2	14,1	0,0	1,6	1,3	-126115	16	-7529	-6124
Mnfcs	74,3	0,0	2,0	1,6	65,5	-0,1	-0,5	-0,4	144897	557	27651	21961
Svces	32,5	0,1	0,2	0,2	106,7	-0,1	1,0	0,7	-169550	980	-4936	-3166
Total									**-97956**	**-85**	**13696**	**10918**

Table 5.16 Change in exports, imports and trade balance, EU-15 (Simulation results and own calculations)

+/- indicates less than + or -0,1 %; nt: non-tradable; Changes for the scenarios are given relative to the baseline

	Exports (%)				Imports (%)				Trade Balance (€ million)			
Sectors	Baseline	S-1	S-2.1	S-2.2	Baseline	S-1	S-2.1	S-2.2	Baseline	S-1	S-2.1	S-2.2
Wheat	425,5	1,8	2,0	1,9	140,7	-1,1	-0,9	-1,0	1072	30	31	31
Ograins	99,5	1,2	1,3	1,3	15,5	-0,8	-0,7	-0,8	81	7	7	7
VegFruitNuts	32,4	1,3	1,5	1,6	89,8	-0,6	-0,2	-0,3	-863	21	19	19
Oilseeds	111,9	4,1	4,8	4,6	-3,5	-1,4	-1,3	-1,2	341	32	36	35
Sugar	489,0	8,2	6,5	6,8	-21,9	-3,3	-2,8	-2,9	1	0	0	0
Plants	194,3	1,3	0,8	0,9	27,9	-0,8	-0,7	-0,8	-64	6	6	6
Ocrops	331,1	0,5	-0,1	0,2	67,4	-0,9	-0,1	-0,3	250	27	10	15
Catshp	184,6	1,2	1,2	1,3	-16,1	-7,3	-6,1	-6,4	466	8	7	8
PigsPoultry	54,0	2,2	2,4	2,4	83,7	-1,3	-0,8	-0,9	-120	17	17	17
RawMilk	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
Oagric	6326,9	3,3	2,7	2,7	-25,0	-2,5	-1,7	-1,2	662	23	18	19
Meatpro	2000,8	6,8	6,6	6,7	320,1	209,9	208,7	209,1	2333	-828	-831	-828
Omeatpro	416,8	3,6	3,5	3,5	234,7	21,8	21,9	22,0	1532	-268	-272	-270
Vegoilsfats	167,9	2,6	2,8	2,8	32,1	0,7	0,1	0,3	101	4	5	5
Dairy	555,9	1,9	2,1	2,1	76,5	25,3	25,5	25,5	3746	-45	-39	-37
Sugarpro	257,7	-17,1	-16,6	-16,8	-68,2	43,1	42,4	42,6	305	-68	-66	-67
Ofoodpro	155,6	0,5	1,3	1,2	70,3	+	0,2	0,2	568	26	50	46
BevsTobac	101,5	0,9	1,6	1,5	129,0	0,1	-	+	-268	12	21	19
RawMat	282,5	+	0,7	0,6	50,4	0,1	0,1	0,1	-30765	-59	118	85
Mnfcs	96,6	0,4	0,5	0,5	66,1	-0,1	0,6	0,5	16461	785	168	299
Svces	65,3	0,4	0,9	0,7	102,4	-0,2	-0,2	-0,2	-1696	243	527	451
Total									**-5797**	**-24**	**-162**	**-132**

Table 5.17 Change in exports, imports and trade balance, AC-12 (Simulation results and own calculations)

+/- indicates less than + or -0,1 %; nt: non-tradable; Changes for the scenarios are given relative to the baseline

5.4.2 Macroeconomic (Welfare) effects

Changes in welfare are measured using a regional equivalent variation (EV) (see chapter IV-4.4.7.2. for further discussion on EV) summary statistic. The welfare results of accession *scenarios 1* and *2* for Turkey, EU-15, AC-12 and ROW[60] are shown in Table 5.18. In the table the total EV is decomposed into allocative efficiency effects, terms of trade (ToT) on tradables effects, terms of trade on capital account goods effects and other effects. Allocative efficiency is measured as the value of changes in resource or product usage from changes a given market distortion (e.g., tax or subsidy). Thus, a tariff on a product implies an under usage of resources as the economy is using less compared with free or undistorted market forces. Conversely, subsidies encourage over-production (i.e., more than under free market conditions) and therefore are a waste of resources (Huff and Hertel, 2000). Thus, those activities which are taxed (subsidized) have a positive (negative) marginal social value. For example, increasing (decreasing) the level of a relatively highly taxed (subsidized) activity leads to an efficiency gain since these involve the reallocation of resources from a low value use into a relatively high social marginal value product use (Huff and Hertel, 2000).

The ToT on tradables gives changes in the ratio of the price of exports to the price of imports as mentioned in chapter IV (see subsection 4.4.7.1). Briefly, the ToT on tradables measures gains or losses from changes in trade flows. For example, a unilateral reduction in tariffs leads to increases in imports (determined by the elasticity of substitution - σ_D) which, *ceteris paribus,* would result in a deficit. To ensure a long run balance of payments, exports must rise to compensate, so export prices must fall which implies a fall in primary factor prices and subsequently a fall in domestic market prices. This would result in a negative ToT.

The ToT on capital account is the second part of the price effect contributions to the welfare and measures changes in the ratio of the price of the capital good relative to the price of savings. Savings may be conceptualised as imports in that they are used for purchasing investment goods. Capital goods, on the other hand, are produced and sold (exported) to the global bank. Thus, if a

[60] In appendix VI welfare effects are provided in each of the 10 regions (except Turkey) in the model.

country is a net exporter of capital goods (i.e., *NETINV* > *SAVE*) then a fall in the price of capital goods relative to the price of savings results in a ToT loss on the capital account.

S-1		Turkey	EU-15	AC-12	ROW
Per capita utility (%)		0,243	-0,001	0,004	0,000
Equivalent variation	(€ m)	754	-199	25	795
Of which:					
Allocative efficieny	(€ m)	-72	215	338	160
ToT on tradables	(€ m)	445	-308	-283	125
ToT capital account	(€ m)	2	24	-19	-20
Other effects	(€ m)	381	-135	-14	370
S-2.1		**Turkey**	**EU-15**	**AC-12**	**ROW**
Per capita utility (%)		1,445	0,462	0,072	0,013
Equivalent variation	(€ m)	-5016	158433	663	6632
Of which:					
Allocative efficieny	(€ m)	129	45486	312	-35
ToT on tradables	(€ m)	2073	-10103	371	8717
ToT capital account	(€ m)	-98	854	-27	-876
Other effects	(€ m)	-7122	122185	7	-1227
Population effects	(€ m)	-7034	69554	-19	523
Endowment effects	(€ m)	1135	23167	124	-227
S-2.2		**Turkey**	**EU-15**	**AC-12**	**ROW**
Per capita utility (%)		1,515	0,240	0,071	0,010
Equivalent variation	(€ m)	-4811	128121	531	5322
Of which:					
Allocative efficieny	(€ m)	197	30755	313	-78
ToT on tradables	(€ m)	2050	-8342	247	6923
ToT capital account	(€ m)	-96	713	-23	-719
Other effects	(€ m)	-6962	104993	-7	-809
Population effects	(€ m)	-7010	69381	-16	413
Endowment effects	(€ m)	1237	11081	97	-123

Table 5.18 Changes in welfare, Turkey, EU-15, AC-12 and ROW (Simulation results and own calculations)

The remaining 'other effects' includes changes in returns to primary production factors from exogenous endowment shocks, values of production and demands from exogenous productivity shocks and population impacts on per capita welfare. The total of effects under this category is relatively small under the *scenario-1* given that results are given relative to the baseline and these mentioned exogenous shocks also feature in the baseline scenario.

Under the *scenario-1*, Turkey is estimated to make a welfare gain of € 754 m, which is equivalent to an increase of 0,243 % in per capita utility. A large part of this economic welfare gain originates from increased terms of trade on tradables (€ 445 m). This is due to the bilateral elimination of import tariffs which leads to falls in import prices (for the EU products) in Turkey and increases in export prices due to enhanced foreign demand (it is important to recall that Turkey trades primarily with the EU). A reallocation of resources away from relatively high social marginal value sectors leads to a deterioration of allocative efficiency in Turkey (-€ 72 m).

Examining the results of the *scenario-1* from the European perspective, the Turkish accession has a very minor effect on welfare. The bilateral elimination of import tariffs causes higher falls in exports prices than import prices in the EU-15 and the AC-12 to ensure their balance of payments leading to the deterioration in terms of trade on tradables in both regions (-€ 308 m and -€ 283 m respectively). On the other hand, improvements in the allocative efficiency due to the reallocation of resources from agricultural sectors to relatively efficient non-agricultural sectors (i.e., manufacturing and services) improves the net welfare in both of the regions. Higher losses in terms of trade on tradables and lower increases in allocative efficiency in the EU-15 result in an EV loss of -€ 199 m whilst the AC-12 records an EV gain of € 25 m. These changes in welfare correspond to a minor loss of utility per capita of -0.001 % in the EU-15 and to an increase of 0,004 % in the AC-12.

As expected, for the remaining non-member regions (ROW) included in this analysis, *scenario-1* has very small welfare effects (results in a welfare gain of € 795 m for ROW). This is because Turkey is a 'small country' on global trading markets.

Under the *scenarios 2.1* and *2.2* migration from Turkey results in significant aggregate EV welfare losses in Turkey of -€ 5016 m and -€ 481 m respectively. These losses stem from relative population falls compared to the baseline and *scenario-1* which appear in the 'other effects' category in Table 5.18[61]. Lower market prices in the EU-15, as a result of the expansion of sectors, lead to falls in import prices in Turkey resulting in an improvement in Turkey's terms of trade on tradables. Interestingly, the EV (aggregate) welfare losses are outweighed by the exodus of the labour (and subsequent population decrease). As a result, per capita utility in Turkey rises by 1,445 % (*S-2.1*) and 1,515 % (*S-2.2*).

In the EU-15, migratory flows from Turkey, under the *scenarios 2.1* and *2.2*, lead to long tun estimated welfare gains of € 158432 m and € 128121 m respectively, relative to the baseline. These estimates are equivalent to 0,462 % and 0,240 % increases in utility per capita respectively. Clearly, the marginal value product of migrating Turkish labour is higher (i.e., greater sectoral production) in the EU-15 resulting in a Pareto per capita utility gain in both Turkey and the EU-15. (In Germany, where 76 % of Turkish migratory labour is projected to locate, per capita utility increases by *2,031 %* and *1,091 %* (see appendix VI) under *scenarios 2.1* and *2.2* respectively. The effects of *scenarios 2.1* and *2.2* on welfare results are different reflecting production changes in Turkey (see Table 5.9) and in the EU-15 (see Table 5.14). For example, higher production levels under *scenario 2.1* results in higher utility per capita in the EU-15 compared with *scenario 2.2*.

The overall welfare changes for the AC-12 and ROW remains very small under the *scenarios 2.1* and *2.2* as it is assumed that migration flows of labour in these scenarios do not go to the AC-12 countries or to ROW. These scenarios result in slight welfare gains for the AC-12 and ROW originating from improvements in terms of trade on tradables due to lower import prices for the EU-15 products.

[61] Changes in EV is calculated as the per capita income multiplied by the population change.

5.5 CONCLUSIONS

The potential long run economic impacts of Turkey's accession to the EU on Turkish and EU agricultural sectors are analyzed in this chapter with the aid of the GTAP model. To improve the quality of our long-term estimates, a baseline scenario including projections to the year 2025 and likely policy changes (i.e., Doha Round shocks) is employed. The baseline scenario is then compared with two alternative accession scenarios.

The sectoral results for Turkey suggest that it is relatively competitive in the agro-food sectors, where all scenarios implemented lead to increases in production levels of most agro-food sectors compared to the baseline. These increases for all agro-food sectors are between *5,3%* to *6,9%*. The increases in agro-food sectors are accompanied with concurrent falls in non-agricultural (i.e., manufacturing and services) sectors as a result of the reallocation of resources from these sectors to agricultural sectors. Across the scenarios examined, the largest increases in Turkish agro-food sectors occur in meat processing (86% to 88,1%), other meat processing (56,8% to 60,7%) and vegetable oils and fats (41,7% to 44,7%) sectors. Under *scenarios 2.1* and *2.2* where a migration flow of 2.7 million Turkish people is included, the production in all sectors falls relative to *scenario-1* due to lower productive capacity and income in Turkey. Increases in factor prices and higher production in the destination countries (EU-15) of the immigrants lead to falls in Turkish manufacturing output (between -4,3% to -4,5%) and exports (between -4,7% to -4,8%) and an increase in the sectoral trade deficit (between -€ 3,6 bn to -€ 3,8 bn) compared with the baseline.

Under the accession scenario without migration (*scenario-1*), Turkey's aggregate trade balance increases slightly (€ 83 m) relative to the baseline despite improving aggregate agricultural trade balance (€ 2688 m). On the other hand, the deterioration in the sectoral trade balance of the manufacturing sector under the scenarios involving migration from Turkey results in a declining aggregate trade balance of between -€ 238 m to -€ 260 m relative to the baseline.

In the case of the EU, the likely impacts of the accession of Turkey remain relatively small. The accession of Turkey without free movement of labour leads to production falls in most agricultural sectors in the EU-15 and the AC-12 while the non-agricultural sectors expand. Under the accession with migration scenarios, due to higher labour supply, production in all sectors (in particular in non-agricultural sectors) increases in the EU-15 compared with the accession without migration. The production level remains unchanged in the AC-12 as assumed migration flows in these scenarios do not include migrants to the AC-12 countries.

In terms of welfare, simulation results suggest that accession to the EU without free movement of labour results in a welfare gain of € 754 m in Turkey while the accession scenarios with migration yield in welfare losses between -€ 4811 m to -€ 5016 m due to lower Turkish population compared to the baseline. Despite overall welfare declines after migration, utility per capita rises by 1,445 % to 1,515 % as the equivalent variation (real income) losses are smaller than the outflow of people from Turkey. Accordingly, we predict that despite contractions in economic real income growth in Turkey, on average people should be better off even after migration. Estimates in the literature (see section 2.5.2 in chapter II) range between $ 300 m to € 28200 m. In this context, our estimate for the accession without migration would appear at the lower end of the estimates in the literature. The main reason of this is the implementation of different scenario assumptions in each study. For example, higher welfare gain estimates are found in Lejour et al. (2004) where, full membership of Turkey includes policy shocks in addition to the standard characterisation used in this chapter (i.e., the elimination of bilateral tariffs and implementation of common external tariff). Indeed, they assume that Turkey's accession to the EU may increase trade for different reasons such as the elimination of administrative barriers, reduction of technical barriers, improvements in Turkish institutions etc. and they incorporate non-trade barriers to the model in order to measure the effects of the potential trade increases estimated by them. Thus, their model generates higher trade increases then our model which results higher estimates of welfare[62]. On the other hand, estimates done by the studies which implemented similar assumptions as *scenario-1* used in this study are comparable with our results. In this context, Zahariadis (2005) estimated a welfare gain of € 480 m (under scenario E2), Sulamaa and Widgrén (2007) found gains of

[62] Note that they use a different model (Worldscan model) although they use GTAP database v6. Moreover, in our study we isolate the impacts of the Doha round resulting in lower trade increases.

welfare between $ 300 m (under perfect competition assumption) to $ 700 m (under imperfect competition assumption) and Acar et al. (2007)[63] suggested a welfare gain of $ 49.1 m (under simulation-1.1a) in Turkey. Our estimate compared to these studies is slightly higher than theirs due to the baseline assumptions employed in this study in particular the elimination of agricultural domestic support results in higher estimates. Lejour et al. (2004) also focus on the effects of free movement of labour after the accession of Turkey as mentioned in chapter two (section 2.5.2). They estimated increases in GDP per capita between 0,9% to 1,4% in Turkey which are comparable with our results of changes in utility per capita shown above (as they do not provide overall welfare results for their migration scenarios here we can not compare our findings with theirs).

The results from the European perspective suggest that accession of Turkey without migration will have very minor effects on welfare in the EU-27 whilst migration from Turkey will affect welfare positively. Under all accession scenarios applied in this study lead to falls market prices which would be beneficial for EU consumers. In the case of the Turkish accession without free movement of labour, the EU-15 records an EV loss of - € 199 m (-0,001 % loss of utility per capita) whilst the AC-12 records an EV gain of € 25 m (0,004 % gain of utility per capita). Thus, it can be said that the Turkish accession would not have very important economic impacts for an EU where the CAP is eliminated. These results are also comparable with the studies mentioned above. Zahariadis (2005) estimated a welfare loss of - $ 119.3 m in the EU-25 (under scenario E2), whilst Acar et al. (2007) found a welfare gain of $ 0.1 m (under simulation-1.1a) in the EU-15. On the other hand, the Turkish accession with migratory outflows from Turkey to the EU results in significant welfare gains in the EU-15 (utility per capita increases by 0,240 % and 0,462 %). Following this result, it can be commented that in the EU of the year 2025 where tight labour markets and skill constraints will exist, it would be an opportunity cost for the EU to try to limit immigration from new member states. It should however be noted that we are assuming that all immigrants are employed in the EU and that no 'welfare shopping' behaviour occurs. Moreover, in a comparative static characterisation, we can only examine a 'before' and 'after' image of what has occurred in the economy. In other words, the model has nothing to say about the 'adjustment' process from one equilibrium to another, where considerable 'frictional employment' and related structural adjustments in the economy should not be underestimated.

[63] This is a preliminary study.

CHAPTER VI

CONCLUSIONS

CHAPTER VI

CONCLUSIONS

6.1 BACKGROUND

Shortly after the creation of the European Economic Community (later the European Union), Turkey made its first formal application to join the community in 1959 which resulted with the Association Agreement known as Ankara Agreement in 1963. In April 1987, Turkey submitted its application for full membership into the European Community. Due to internal political change in the European Union (EU), the European Commission did not respond to this until 1990, rejecting the option of immediate accession negotiations. Following this, in January 1996 Turkey and the EU established a Customs Union (CU). As a result of this agreement, Turkey and the EU have mutually abolished all quotas and tariffs on imports of industrial goods. Interestingly, agricultural products were not included in this agreement, although a significant part of agricultural trade takes place under preferential agreements.

In December 1999, at the Helsinki European Council meeting, the EU recognised Turkey officially as a candidate for accession on an equal footing with other potential candidates. The European Council began accession negotiations with Turkey on October 3, 2005, having determined that Turkey fulfilled the Copenhagen political criteria. This decision provoked some uncertainties in both sides. Some of these uncertainties are political (e.g., the fulfillment of the political criteria, geographical location, free movement of labour, religion difference etc.) in nature and some are economic, the latter of which form the basis of this study.

As a potential accession member, Turkey has a sizeable economic output. Indeed, in 2005 Turkish GDP was (290,5 EUR billion) nearly 2,6 % of the EU-25 level and 51,7 % of the accession countries (AC)-10. However, Turkey is significantly poorer than the EU average, with an income per

capita of 6500 EUR (in purchasing power parity (PPS)) compared with the average EU-25 level of 23500 EUR. On the other hand, income per capita is comparable to the recent acceded states of Bulgaria and Romania. Turkey has registered higher growth rates in more recent years than Bulgaria, Romania and the EU-25 but also shows instability in its economic growth due to economic crises which took place in different years, which has not been observed in other considered countries.

Agriculture is an important part of the Turkish economy, accounting for an important share of GDP (11,5 %) and employment (34 %). These figures remain much higher than in the EU-25. Furthermore, with the exception of Romania, in no other EU state does agriculture have such an important role.

The EU is an important trade partner of Turkey in particular in agricultural products. The EU-25 accounts for approximately 52 % of Turkey's total agricultural exports and 30,5 % of total agricultural imports. Thus, further integration of Turkey with the EU would imply changes in production in Turkey and considerable trade diversion flows between the EU and the rest of the world. Given that the current CU agreement between Turkey and the EU does not include agricultural products, the possible impacts of the abolition of trade barriers between Turkey and the EU in agriculture under the full membership scenario have importance for the policy makers on both sides.

In this context, this study investigated the potential economic effects of Turkey's accession to the EU employing a multiregional computable general equilibrium (CGE) framework. The CGE modelling approach was specifically chosen since it represents a powerful analytical tool for assessing the impact of bilateral, regional and multilateral reform scenarios, as well as market integration scenarios (i.e., EU enlargement). Indeed, this modelling approach has played a particularly important role in assessing likely impacts of EU enlargement and CAP integration over the last ten years or so.

The fundamental CGE framework used for this study is based on the Global Trade Analysis Project (GTAP) CGE model of the world economy and the latest GTAP database version 6 (base year 2001). The GTAP database covers 57 sectors and 87 regions. In order to focus on issues of interest and to keep the model within manageable computational limits, the data is aggregated into 13

regions/countries and 21 sectors including 18 agricultural sectors. With its detailed input-output trade and final demand accounts as well as detailed support and protection data across numerous regions and sectors, it is the most up to date and comprehensive global trade database of its type. Moreover, its usage in the relevant literature on EU enlargement is also worthy of note.

To assess the likely implications of the Turkish accession to the EU, a status quo (baseline) scenario where Turkey remains outside of the EU in 2025 was analysed next to two alternative accession scenarios. The baseline scenario included projections to the year 2025 and some foreseeable policy change (i.e., Doha Round shocks characterised by reductions in import tariffs and elimination of all export subsidies; elimination of domestic agricultural support in all regions). Under the first accession scenario (*scenario-1*) Turkey accedes to the EU without free movement of labour (migration). In the second accession scenario (this scenario is divided into two simulations according to the assumptions used on the composition of the migrants) the impacts of migration flows from Turkey due to accession was addressed by including forecasts of potential migration flows as additional policy shocks. Under both accession scenarios, all tariffs between the EU and Turkey were abolished and Turkey was given the same level of protection against third countries as in the EU in order to mimic the EU common external tariff (CET).

6.2 STRUCTURE OF STUDY

Following the introductory chapter, Chapter II provided a brief history of the EU-Turkish relationship accompanied with some arguments on Turkish membership found in the literature. A general description of Turkish economy was provided with comparisons to the EU and accession countries. The agricultural situation in Turkey with comparisons to the situation in the EU was also examined by providing information on land usage, agricultural holdings, production, trade and agricultural support policies (a subsection is dedicated to the Common Agricultural Policies (CAP) of the EU). The chapter reviewed the literature of recent CGE studies on EU enlargement, focusing in

particular on the impacts of Turkish accession. These studies were compared in terms of model characteristics, policy questions, experimental design and their resulting implications.

Chapter III gave a summary of the key issues in CGE model design and implementation. The chapter began with a discussion of the properties of 'convenient' functions often used in CGE modeling. Other issues such as representation and solution methods, calibration, nesting and closure were also discussed. The chapter also presented a simple stylised CGE model example.

Chapter IV provided information about the theory behind the GTAP model and its database. The accounting relationships within the database, which are key to the model framework, were explained in this chapter by tracking value flows from production and sales to intermediate and final demands. The chapter also described the equations that characterise behavioural patterns of producers and consumers within the economy. Inclusion of the GTAP parameters and sets data and further issues pertaining to GTAP data construction and reconciliation procedures were also discussed in this chapter.

Chapter V presented the experimental design and result. The explanation of the rationale behind the chosen sectoral and regional aggregation and a quantitative description of the scenarios were also included in this chapter. In this chapter the results were split into two sections. First section discussed sectoral effects for various regions of the model with special attention paid to Turkey and the EU-15. The second section provided estimates of the potential macroeconomic effects (i.e, welfare effects) from the Turkish accession.

In addition, this study provided six appendices. In Appendix I, the techniques that are used to solve CGE models, such as Johansen approach, multi-step solution methods and extrapolation, in more detail were described. Appendix II and III included theoretical restrictions for the choice of the functional forms in CGE models. Appendix IV provided codes (for the GEMPACK software) for the stylised model used in the chapter. Appendices V and VI provided some simulation results for all 10 chosen regions (except Turkey) related with the changes in production and welfare.

6.3 MAIN RESULTS

Summarising the model results, Turkey appears to be relatively competitive in the agro-food sectors where all scenarios implemented lead to increases in production levels of most agricultural sectors compared to the baseline. These increases for the entire agro-food sector are between 5,3 % to 6,9 %. The increases in agro-food sectors are accompanied with concurrent falls in non-agricultural (i.e., manufacturing and services) sectors as a result of a reallocation of resources from these sectors to agriculture. Across the scenarios examined, the largest increases in Turkish agro-food sectors occur in meat processing (86% to 88,1%), other meat processing (56,8% to 60,7%) and vegetable oils and fats (41,7% to 44,7%) sectors. Under migration scenarios (*scenario 2.1* and *2.2*) the production in all sectors falls relative to the accession scenario without migration (*scenario-1*) due to lower productive capacity and income in Turkey. Increases in factor price in Turkey and higher production in the destination countries (EU-15) of the immigrants lead to falls in Turkish manufacturing output (between -4,3% to -4,5%) and exports (between -4,5% to -4,8%) and an increase in the sectoral trade deficit (between -€ 3,6 bn to -€ 3,8 bn) compared with the baseline. Again in comparison with the baseline 'primary' agricultural production falls between -0,4 % to -0,7 % under the second scenario.

The likely impacts of Turkey's accession on the EU remain relatively small. The accession of Turkey without free movement of labour leads to production falls in most EU agricultural sectors in the EU-15 and the AC-12 compared with the baseline, while the non-agricultural sectors expand. Under the case of accession with migration scenarios, due to higher labour supply, production in all sectors (in particular in non-agricultural sectors) increases in the EU-15 compared with the accession without migration whilst the production level remains unchanged in the AC-12 as assumed migration flows in these scenarios do not include migrants to the AC-12 countries.

In terms of welfare, simulation results suggest that accession to the EU without free movement of labour results in a welfare gain of € 754 m in Turkey while the accession scenarios with migration yield welfare losses of between -€ 4811 m to -€ 5016 m due to lower Turkish population compared to the baseline. Despite overall welfare declines after migration, utility per capita rises by 1,445 % to

1,515 % as the equivalent variation (real income) losses are smaller than the outflow of people from Turkey. Accordingly, it is predicted that despite contractions in economic real income growth in Turkey, on average people in Turkey are better off even after migration.

From the European perspective, the result show that accession of Turkey without migration will have very minor effects on welfare in the EU whilst migration from Turkey will affect welfare positively. All accession scenarios applied in this study lead to falls in market prices, which would be beneficial for EU consumers. In the case of Turkish accession without free movement of labour, the EU-15 records an EV small loss of - € 199 m (-0,004 % loss of utility per capita) whilst the AC-12 records minor EV gain of € 125 m (0,004 % gain of utility per capita). Thus, it can be said that the Turkish accession would not have very important economic impacts for an EU where the CAP is eliminated. These results are comparable with other studies. Zahariadis (2005) estimates a welfare loss of - $ 119.3 m in the EU-25 (under scenario E2), whilst Acar et al. (2007) found a small welfare gain of $ 0.1 m (under simulation-1.1a) in the EU-15. On the other hand, the Turkish accession with migratory outflows from Turkey to the EU results in significant welfare gains in the EU-15 (utility per capita increases by 0,240 % and 0,462 %). These results also support the arguments made by Littoz-Monnet and Penas (2004) and Hughes (2004) which suggest that Turkish migration could have a positive economic impacts on the EU since the EU has an aging demographic profile. Following this, it can be commented that if the EU maintains a long run policy of restricting migratory flows, this will carry an opportunity cost in terms of real income and per capita income growth.

To sum up, there are two main conclusions that can be drawn. The first one is that, Turkey has a relatively a higher competitiveness level in agro-food sectors in a world where all of the trade distorting support policies (i.e., output-intermediate input subsidies and land-capital based payments) are eliminated. Secondly, our results suggest that migration from Turkey could be beneficial for the EU. Accordingly, perhaps the EU should revise its transition period policy for immigrants from new member states in the case of Turkish accession in order to increase its labour supply. It should however be noted that in our migration scenarios it is assumed that all immigrants are employed in the EU and that no 'welfare shopping' behaviour occurs. Moreover, since the model provides a comparative static characterisation, it has nothing to say about 'adjustment' process from one equilibrium to another,

where considerable 'frictional employment' and related structural adjustments in the economy should not be underestimated.

6.4 LIMITATIONS AND FURTHER WORK

Some important aspects of the CGE modelling should be underlined in order to understand the model results obtained in this study. CGE models are not forecasting models. They are counter-factual simulation models constructed to answer 'what if' types of questions. Thus, changes in variables are meaningful in that they highlight useful trends, but these values should not be considered as definitive.

In this study the dynamic aspect of the adjustment mechanisms in simulations is not covered since the standard GTAP model is a comparative-static representation. In static CGE models, the process of adjustment to the new equilibrium in the period considered is not explicitly represented. By contrast, dynamic CGE models explicitly trace each variable through time which makes them more realistic. This is particularly relevant to savings/investment behaviour where investment decisions based on adaptive expectations can be captured resulting in capital accumulation effects. This additional source of welfare change impact dramatically on the model results.

Additionally, the standard GTAP model used in this study incorporates perfectly competitive market structures with constant returns to scale. Indeed, a review of CGE models employing a perfectly competitive market structure reveals that the welfare estimates are typically smaller than the imperfectly competitive equivalents (e.g., Harris (1984), Devarajan and Rodrik (1989) and Norman (1990)). This can be explained by reductions in the number of firms and increases in the scale of the firm's operations, resulting in efficiency gains thanks to increasing returns. Notwithstanding, the realistic use of this modeling extension is tempered by the availability of relevant industry concentration data to correctly characterise interfirm rivalry in the food processing sectors.

Another drawback of the study is the experimental design. More specifically, uncertainties surrounding Turkey's potential membership makes it difficult to establish most appropriate scenarios for Turkish accession. These uncertainties are; the absence of an established time-table for the accession and the potential pre-accession options and requirements together with the support which will be provided by the EU. It is essential to know when and how Turkey will integrate into the Common Agricultural Policy (CAP) especially for a study which investigates the possible impacts of the accession on agricultural sectors. Finally, future international trade agreements that can be established in WTO meetings could have an impact on the implementation of the enlargement. The absence of a time-table for the accession also makes it difficult to implement migration scenarios since estimations on migration flows in the literature vary depending on the accession date and the uncertainty surrounding the conditions for the free movement of labour in the case of Turkish accession.

In addition, a problem of the database with respect to Turkey is an important point which should be mentioned. Acar et al. (2007) note that the subsequent financial crisis which occurred in Turkey in 2001 will have had a significant impact on the structure of the economy. Consequently, the 1996 input-output data provided by the Turkish Statistical Institute which are currently used in version 6 of the GTAP database may not adequately reflect the actual state and structure of the Turkish economy. Thus, a useful exercise for future policy research on Turkey would involve a revision of the Turkish entry in the GTAP data.

Finally, in this study, it is assumed that CAP pillar 1 support had disappeared prior to Turkish accession. However, a future endeavour of this type could examine the extent to which accession of Turkey into the CAP could impact on the EU-27 (in terms of accession costs) and Turkish agriculture, which would require an explicit characterisation of the CAP (i.e., budget, quotas, set aside etc.). At the current time it is unclear to what extent the CAP will be reformed after 2013, whilst there is no concrete timetable on Turkish accession. Despite this, access to quantitative estimates of Turkish accession costs would at least provide a perspective to policy maker, both within the EU and Turkey, on the potential budgetary, and therefore political, implications of reconciling a 'large' agricultural producer such as Turkey, with CAP reform.

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APPENDIX I

THE JOHANSEN APPROACH

APPENDIX I: THE JOHANSEN APPROACH

AI.1 One-Step Johansen Approach

This appendix offers useful information about Johansen approach, multi-step solution and extrapolation (the issues which are discussed in section 3.3) by giving a simple example which is adapted from Dixon et al. (1992) p73.

In this appendix a class of general equilibrium models is considered in which equilibrium is a vector, V, of length n satisfying a system of equations

$$F(V) = 0 \qquad \text{(AI.1)}$$

where F is a vector function of length m. It is assumed that F is differentiable and the number of variables, n, is more than number of equations m. For simplicity a system will be assumed to explain this approach which consists of two equations and three variables which has the form:

$$V_1^2V_3 - 1 = 0 \quad \text{and} \quad V_1+V_2-2 = 0 \qquad \text{(AI.2)}$$

where V_3 is an exogenous variable and V_1 and V_2 are endogenous variables of the system. The endogenous variables can be expressed as:

$$V_1 = V_3^{-1/2} \quad \text{and} \quad V_2 = 2-V_3^{-1/2} \qquad \text{(AI.3)}$$

With a solution system like (AI.2) which is in levels form, there would be no difficulty to evaluate the effects on the endogenous variables of shifts in the exogenous variable. For example, assume that initially we have

$$V^I = (V^I_1, V^I_2 , V^I_3) = (1,1,1) \qquad \text{(AI.4)}$$

a situation which satisfies (AI.1). Assuming an increase in V_3 from 1 to 1.1 in (AI.3) the new values for V_1 and V_2 are 0.9535 and 1.0465. Thus, a 10 percent increase in V_3 induces a 4.65 percent reduction in V_1 and a 4.65 increase in V_2.

After solving the system in levels form, now the same system will be solved in linearised form which is solved by the Johansen approach. To obtain a linearised form, a differential form is derived from (AI.1):

$$A(V)v = 0 \qquad \text{(AI.5)}$$

where A(V) is an m*n matrix whose components are functions of V. The n * 1 vector is usually interpreted as showing percentage changes or changes in the logarithms of the variables V. (AI.5) can be shown by using the example system (AI.2):

$$\begin{bmatrix} 2V_1V_3 & 0 & V_1^2 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} dV_1 \\ dV_2 \\ dV_3 \end{bmatrix} = 0 \qquad \text{(AI.6)}$$

In (AI.6) v is interpreted as the vector of changes, and it can be transformed into[64]

$$\begin{bmatrix} 2 & 0 & 1 \\ V_1/2 & V_2/2 & 0 \end{bmatrix} \begin{bmatrix} 100(dV_1)/V_1 \\ 100(dV_2)/V_2 \\ 100(dV_3)/V_3 \end{bmatrix} = 0 \qquad \text{(AI.7)}$$

[64] The equation (AI.7) is derived by dividing the first part of the equation (AI.6) by $V_1^2V_3$ and the second part by 2.

If the (dV_i/V_i)s in (AI.7) are replaced by $(d\ln V_i)$s then, on dividing all equations by 100 gives the system below in which v is the vector of changes in the logarithms of V:

$$\begin{bmatrix} 2 & 0 & 1 \\ V_1/2 & V_2/2 & 0 \end{bmatrix} \begin{bmatrix} d\ln V_1 \\ d\ln V_2 \\ d\ln V_3 \end{bmatrix} = 0 \qquad \text{(AI.8)}$$

In computations of how endogenous variables will change in response to given changes in the exogenous variables, A(V) is evaluated at $V = V^I$. Then (AI.5) can be rewritten as:

$$A_\alpha(V^I)v_\alpha + A_\beta(V^I)v_\beta = 0 \qquad \text{(AI.9)}$$

where v_α is the m * 1 subvector of endogenous components of v, v_β is the (n – m) * 1 subvector of exogenous components and $A_\alpha(V^I)$ and $A_\beta(V^I)$ are suitable submatrices of $A(V^I)$. By rearranging (AI.9) in terms of v_α gives:

$$v_\alpha = -A_\alpha^{-1}(V^I)A_\beta(V^I)v_\beta \qquad \text{(AI.10)}$$

or more compactly

$$v_\alpha = B(V^I)\, v_\beta \qquad \text{(AI.11)}$$

where $B(V^I)$ is defined at the right hand side of the (AI.10). Calculations (AI.9) – (AI.11) can be shown following the same mathematical procedure as in equations (AI.6) – (AI.8). With $V = V^I = (1,1,1)$, (AI.6) becomes

$$\begin{bmatrix} 2 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} dV_1 \\ dV_2 \\ dV_3 \end{bmatrix} = 0 \qquad \text{(AI.12)}$$

By choosing variable 3 as exogenous variable then (AI.12) can be rewritten as:

$$\begin{bmatrix} 2 & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} dV_1 \\ dV_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} dV_3 = 0 \qquad \text{(AI.13)}$$

That is:

$$\begin{bmatrix} dV_1 \\ dV_2 \end{bmatrix} = -\begin{bmatrix} 2 & 0 \\ 1 & 1 \end{bmatrix}^{-1}\begin{bmatrix} 1 \\ 0 \end{bmatrix} dV_3 \qquad \text{(AI.14)}$$

Hence:

$$\begin{bmatrix} dV_1 \\ dV_2 \end{bmatrix} = \begin{bmatrix} -0.5 \\ 0.5 \end{bmatrix} dV_3 \qquad \text{(AI.15)}$$

It is reassuring to note from (AI.3) that $V_3 = 1$

$$\left[\frac{\partial V_1}{\partial V_3}\right] = -\frac{1}{2}(V_3)^{-3/2} = -0.5 \qquad \text{and} \qquad \left[\frac{\partial V_2}{\partial V_3}\right] = \frac{1}{2}(V_3)^{-3/2} = 0.5$$

According to this, it can be easily seen that the derivates of the endogenous variables with respect to the exogenous variable at V^I is correctly exposed on the right hand side of (AI.15). Applying the same condition ($V = V^I$) for (AI.7) or (AI.8) gives:

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = -\begin{bmatrix} 2 & 0 \\ 0.5 & 0.5 \end{bmatrix}^{-1}\begin{bmatrix} 1 \\ 0 \end{bmatrix} v_3$$

that is, $$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} -0.5 \\ 0.5 \end{bmatrix} v_3 \qquad \text{(AI.16)}$$

By using (AI.3) the result can be checked

$$\eta_{1,3} = -\frac{1}{2}(V_3)^{-\frac{1}{2}} / V_1 \qquad \text{and} \qquad \eta_{2,3} = \frac{1}{2}(V_3)^{-\frac{1}{2}} / V_2$$

where $\eta_{1,3}$ and $\eta_{2,3}$ are elasticities of variables 1 and 2 with respect to variable 3. With $V = V^1$, gives $\eta_{1,3} = -0.5$ and $\eta_{2,3} = -0.5$, which confirms the result (AI.16).

To see if the Johansen approach is satisfactory for computing the effects on the endogenous variables of small changes in the exogenous variables a small experiment can be conducted. For example, by using (AI.16), if a 10 percent increase occurs in V_3 it will cause 5 percent reduction in V_1 and a 5 percent increase in V_2. This result is close to the result which was found earlier by substituting into (AI.3).

AI.2 A simple example of a multi-step Johansen approach

In this subsection of the appendix I, a simple example of a multi-step solution of Johansen model is provided. Before the example in Figure AI.1 a diagram for a multi-step solution of a Johansen model is provided to summarise the procedure. To start a multi-step computation for a stylised Johansen model (box 1) the provided input-output data is read (parameter estimates also can be read in case that they are provided). In the initial stage modeller should set the closure, the shocks, the number of steps (denoted by s) to be used and the counter, r, which tracks how many steps have been completed. The mathematics starts in box 2 with evaluating the A matrix using the initial input-output data. In box 3, the shocks to be applied to the exogenous variables are computed. Then, these shocks are used to compute changes in the endogenous variables in box 4. After the completion of the task in box 4, if r + 1 is less than s, then r is increased by 1 (box 5) and with updating the input-output data (box 6) the next step starts. The computations continue as explained above until r +1 is equal to s. Then, the s-step estimates of the values reached by the endogenous variables after the shocks (box 7) are computed.

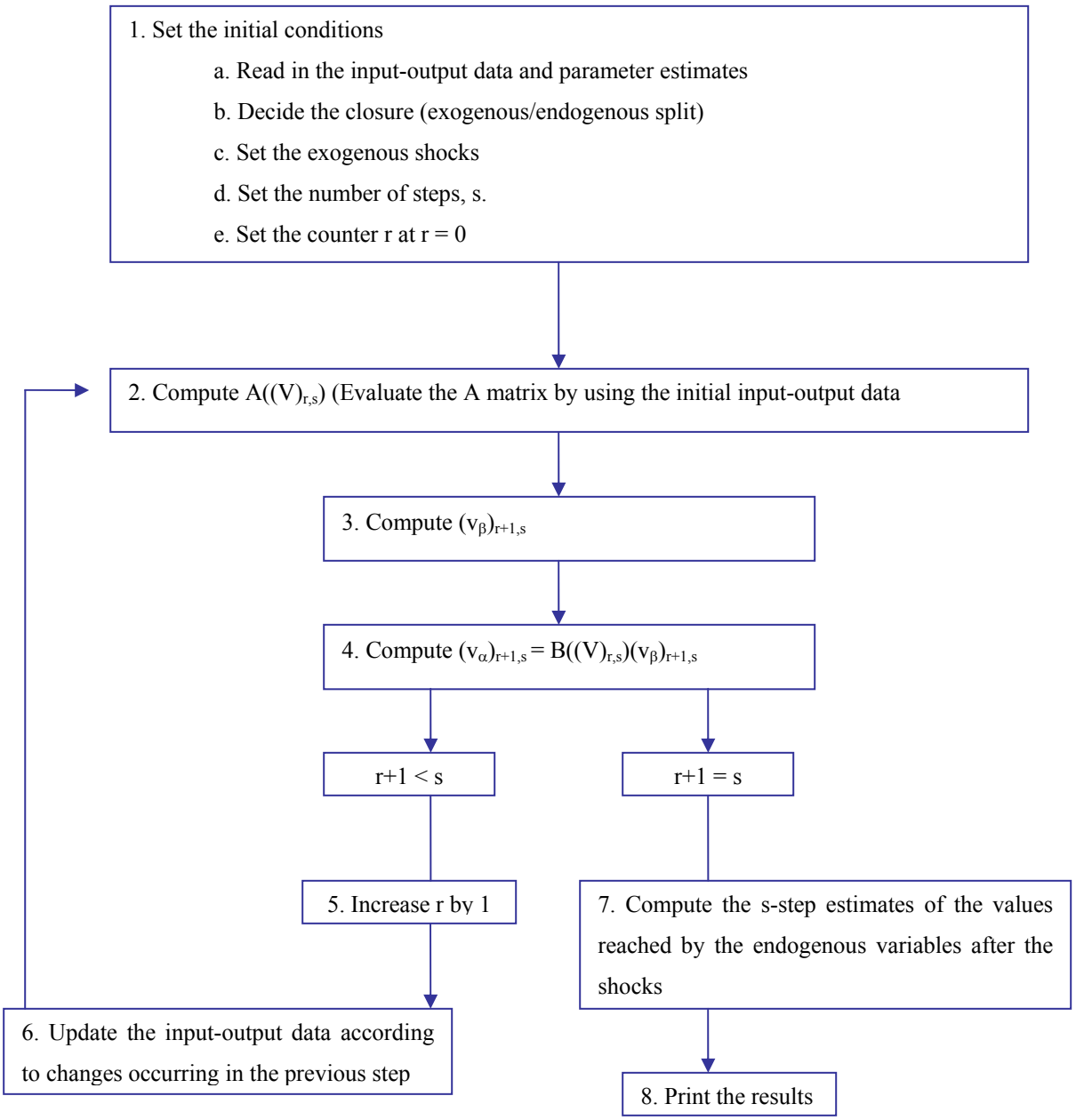

Figure AI.1 Stages for a multi-step solution of a Johansen model (Dixon et al., 1992)

Using the same system which is used at AI.1 estimations of the values of V_1 and V_2 will be done after a 100 percent increase in V_3 by using one-step, 2-step, 4-step, 8-step and different ways of extrapolation computations. Initial values for the variables will be 0.5 for V_1, 1.5 for V_2 and 4 for V_3.

In this example we have

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = B(V)v_3 \qquad \text{(AI.17)}$$

where

$$B(V) = -\begin{bmatrix} 2 & 0 \\ V_1/2 & V_2/2 \end{bmatrix}\begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -0.5 \\ 0.5V_1/V_2 \end{bmatrix} \qquad \text{(AI.18)}$$

Here the v_is are interpreted as percentage changes. In the first step of the two-step procedure:

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{1,2} = B(V^I)50 = \begin{bmatrix} -25 \\ 8.\underline{3} \end{bmatrix}$$

which shows the estimate of the percentage effects on V_1 and V_2 of changing V_3 from 4 to 6. After this step new values are:

$$(V)_{1,2} = (0.375,\ 1.625,\ 6)$$

where $(V)_{r,s}$ is the value of V at the end of the rth step of an s-step procedure. In the second step of the two-step procedure:

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{2,2} = B((V)_{1,2})33.\underline{3} = \begin{bmatrix} -16.\underline{6} \\ 6.25 \end{bmatrix}$$

which shows the estimate of the percentage effects on V_1 and V_2 of changing V_3 from 6 to 8. Thus, the final estimate of V in the two-step procedure is:

$$(V)_{2,2} = (0.3125,\ 1.726,\ 8) \qquad \text{(AI.19)}$$

Hence, a 100 percent increase in V_3 cause a 37.5 percent reduction in V_1 and nearly 15 percent increase in V_2.

Below the calculations for four-step procedure is given:

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{1,4} = \begin{bmatrix} -12.5 \\ 4.1\underline{6} \end{bmatrix} \quad \text{leading to } (V)_{1,4} = (0.4375,\ \ 1.5625,\ \ 5)$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{2,4} = \begin{bmatrix} -10 \\ 2.8 \end{bmatrix} \quad \text{leading to } (V)_{2,4} = (0.39375,\ \ 1.60625,\ \ 6)$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{3,4} = \begin{bmatrix} -8.\underline{3} \\ 2.0428 \end{bmatrix} \quad \text{leading to } (V)_{3,4} = (0.3609,\ \ 1.639,\ \ 7)$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}_{4,4} = \begin{bmatrix} -7.1429 \\ 1.5728 \end{bmatrix} \quad \text{leading to } (V)_{4,4} = (0.3351,\ \ 1.6647,\ \ 8)$$

According to the results of four-step procedure, a 100 percent increase in V_3 cause a 32.98 percent reduction in V_1 and nearly 10.98 percent increase in V_2.

As it was mentioned before another way of increasing accuracy is to use an extrapolation procedure. To explain this the result for variable i from a procedure with a step size h is denoted by $V_i(h)$ (For example, from Table AI.1 $V_1(1/8) = 0.3446$). here two assumptions, the first one is:

$$\lim_{h \to 0} V_i(h) = V_i^T \qquad \text{(AI.20)}$$

where V_i^T, i = 1,2, is the true value for variable i after increasing V_3 to 8. V_1^T and V_2^T can be derived from (AI.1.) and are shown in the last row of Table AI.1 as 0.3535 and 1.6464. This assumption says that the n-procedure converges to the true solution as n becomes large. The second assumption is that $V_i(h)$ can be expressed as:

$$V_i(h) = \sum_{r=0}^{\infty} a_{ir} h^r \quad , \text{i} = 1,2 \qquad \text{(AI.21)}$$

over the relevant range for h. This assumption relies on the idea that continuous functions can be approximated arbitrarily closely by polynomials of sufficiently high degree. These two (AI.20) and (AI.21) together imply that,

$$V_i^T = a_{i0} \quad , \text{i} = 1,2 \qquad \text{(AI.22)}$$

Now supposing that $V_i(h)$ can be approximated by

$$V_i(h) = a_{i0} + a_{i1} h \quad , \text{i} = 1,2 \qquad \text{(AI.23)}$$

where the higher order terms in (AI.21) can be ignored in the relevant range for h is assumed. The approximations which are done with (AI.23) can permit researcher to achieve appropriate accuracy with multi-step Johansen computations using less number of steps. For example, only using the estimations of one-step computation and two-step computation it can be possible to evaluate $V_i(1)$ and $V_i(1/2)$. Then according to (AI.23), V_i^T can be estimated by solving it for a_{i0} in the equations

$$V_i(1) = a_{i0} + a_{i1}$$
$$V_i(1/2) = a_{i0} + a_{i1}/2$$

Then, V_i^T can be estimated by extrapolation from one using next equation:

$$V_i^T = 2V_i(1/2) - V_i(1) \quad , \text{i} = 1,2 \qquad \text{(AI.24)}$$

The results of applying this equation are given in Table AI.1. To estimate V_i^T by extrapolation from one, two and four step solutions first (AI.23) should be replaced by an improved approximation:

$$V_i(h) = a_{i0} + a_{i1}h + a_{i2}h^2 \qquad \text{(AI.25)}$$

Then, after computing $V_i(h)$, $V_i(h/2)$ and $V_i(h/4)$, the next system of equation should be solved for a_{i0}:

$$\begin{aligned} V_i(h) &= a_{i0} + a_{i1}h + a_{i2}h^2 \\ V_i(h/2) &= a_{i0} + (a_{i1}/2)h + (a_{i2}/4)h^2 \\ V_i(h/4) &= a_{i0} + (a_{i1}/4)h + (a_{i2}/16)h^2 \end{aligned} \qquad \text{(AI.26)}$$

To obtain the solution for a_{i0} first equation should be multiplied by -1, the second one by 6 and the last one by -8 and the resulting equations should be added which gives:

$$-V_i(h) + 6V_i(h/2) - 8V_i(h/4) = -3a_{i0}$$

and this will give the extrapolation equation:

$$V_i^T = (8/3)V_i(h/4) - 2V_i(h/2) + (1/3)V_i(h) \qquad \text{(AI.27)}$$

Applying this equation gives the results shown in Table AI.1. And when $V_i(h)$, $V_i(h/2)$, $V_i(h/4)$ and $V_i(h/8)$ are available the approximation can be improved to:

$$V_i(h) = a_{i0} + a_{i1}h + a_{i2}h^2 + a_{i3}h^3 \qquad \text{(AI.28)}$$

And following the same method which has been used to obtain (AI.27) from (AI.24) it can be derived the extrapolation equation for extrapolating from one, two, four and eight step solutions:

$$V_i^T = (64/21)V_i(h/8) - (56/21)V_i(h/4) + (14/21)V_i(h/2) - (1/21)V_i(h) \qquad \text{(AI.29)}$$

The results of the application of this equation are also given in Table AI.1.

Endogenous Variables	V_1	V_2
Initial Values	0.5	1.5
Estimated values after n increase in V_3 from 4 to 8		
1-step computation	0.25	1.75
2-step computation	0.3125	1.726
4-step computation	0.3351	1.6647
8-step computation	0.3446	1.6560
1,2 step extrapolation [a]	0.375	1.702
1,2,4 step extrapolation [b]	0.3519	1.5705
1,2,4,8 step extrapolation [c]	0.3530	1.6749
Truth [d]	0.3535	1.6464

[a] Computed according to (AI.24)
[b] Computed according to (AI.27)
[c] Computed according to (AI.29)
[d] Computed using (AI.3)

Table AI.1 Solution for V_1 and V_2 when V_3 is moved from 4 to 8

To conclude this appendix, as it can be observed from the results using more step numbers and extrapolation increases the accuracy of the estimations which are done according to the Johansen approach.

APPENDIX II

STRICT AND QUASI CONCAVITY

APPENDIX II: STRICT AND QUASI CONCAVITY

Following Beattie and Taylor (1985), *strict concavity* can be shown diagrammatically:

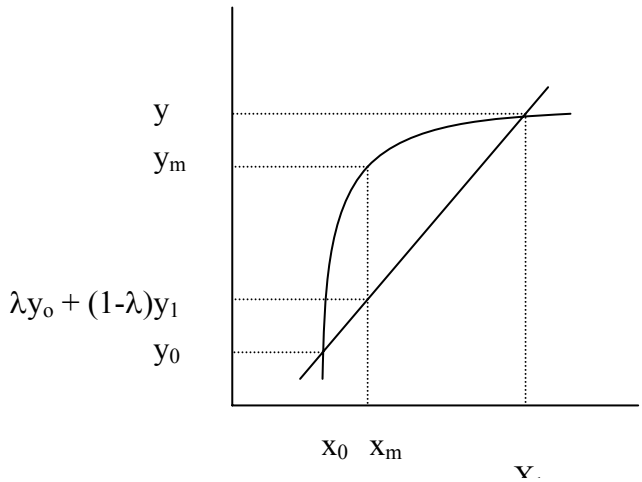

Figure AII.1 Strict concavity

where x_m is a weighted average ($0<\lambda<1$) of x_0 and x_1:

$$x_m = \lambda x_0 + (1-\lambda)x_1$$

Strict concavity implies that y_m must always be *greater* than a weighted value of y from a linear line connecting two points x_0 and x_1 in the domain. Thus, in the figure, the value of y corresponding to an arbitrary value x_m is:

$$\lambda y_0 + (1-\lambda)y_1$$

where

$$y_m > \lambda y_0 + (1-\lambda)y_1$$

Strict quasi-concavity states that all values of y_m will always be above the minimum value of the function in the domain. Algebraically:

$$y_m > \min(y_0, y_1)$$

Thus, if the minimum value of the function was y_0, then a strictly quasi-concave function would be represented as:

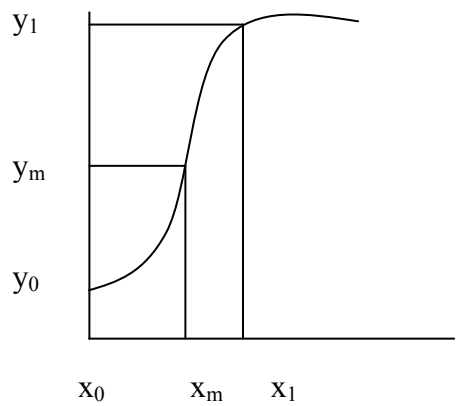

Figure AII.2 Strictly quasi-concave function

where the value of y_m will never fall below the minimum value (in this case y_0), although the shape of the curve does not have to be everywhere concave (for example between x_0 and x_1). Strict quasi-concavity is a more general form of concavity which is inclusive of strict concavity (i.e. all strict quasi-concave functions are strictly concave but not the other way round).

For CD and CES, the restrictions for both forms of concavity are:

	Strict Concavity	Strict quasi-concavity
$Y = AX_1^{\alpha} X_2^{\beta}$	$0 < \alpha < 1$	$\alpha > 0$
	$0 < \beta < 1$	$\beta > 0$
	$0 < (\alpha+\beta) < 1$	$A > 0$
	$A > 0$	
$Y = A[\delta_1 X_1^{-\rho} + (1-\delta_1) X_2^{-\rho}]^{-\frac{v}{\rho}}$	$0 < \delta_1 < 1$	$0 < \delta_1 < 1$
	$A > 0$	$A > 0$
	$\rho > -1$	$\rho > -1$
	$0 < v \leq 1$	$v > 0$

Under constant returns to scale, Cobb-Douglas parameters $\alpha+\beta$ must sum to one, which effectively rules out strict concavity.

APPENDIX III

STAGES OF PRODUCTION

APPENDIX III: STAGES OF PRODUCTION

Under neo-classical assumptions of diminishing marginal returns (short run) and returns to scale (long run) a production function (total product (TP) curve) may exhibit an 's' shape which in turn has implications for marginal (MP) and average product (AP) curves. Schematically, the three stages are represented:

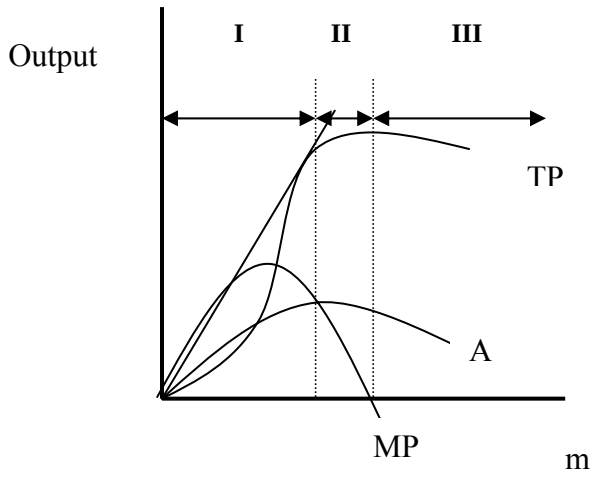

Figure AIII.1 Stages of production (Beattie and Taylor, 1985)

where in the short-run 'm' is a single input and in the long-run, 'm' would be a proportional change in all inputs. Thus, stage I is characterised by increases in average productivity up to the point where MP cuts the AP curve at the highest point. Stage II is where MP is positive but everywhere below the AP curve. Stage III characterises negative productivity (i.e., MP is negative). Clearly, it is not sensible for rational producers to be in the third stage of production. Under profit maximising criteria in perfectly competitive input and output markets, equating Marginal Value Product ($MVP = MP*P_{output}$) with the Marginal Factor Cost (MFC = Average Factor Cost (AFC)) in stage I, will lead to losses where AFC is everywhere above Average Value Product ($AVP = AP*P_{output}$). Hence, according to the theory, stage II (MP<AP) is the only rational range within which to produce.

APPENDIX IV

GEMPACK CODES FOR THE STYLISED MODEL

APPENDIX IV: GEMPACK CODES FOR THE STYLISED MODEL

```
File       INFILE  # Raw data #;

! Set for comparing COM and IND data !
SET IND # Industries #
(manu, svces);
SET COM # Commodities #
(manu, svces);
Subset IND is subset of COM;
       COM is subset of IND;

!46 variables, 7 exogenous: 38 equations and endogenous variables !
VARIABLE (all,j,IND)
l(j)  # labour demands #;
VARIABLE (all,j,IND)
k(j)  # capital demands #;
VARIABLE (all,j,IND)
xl(j)  # labour supply #;
!VARIABLE (all,j,IND)
xk(j)  # capital supply #;!
!VARIABLE (all,j,IND)
r(j) # capital rental #;!
VARIABLE (orig_level=1.0)
r # capital rental #;
VARIABLE (orig_level=1.0)(all,j,IND)
w(j) # wage rate #;
!VARIABLE
rcomp # composite capital rental #;!
VARIABLE
wcomp # composite wage rate #;
VARIABLE (all,j,IND)
x(j)  # industry supply #;
VARIABLE (all,j,IND)
c(j)  # private demand for industry output #;
VARIABLE (all,j,IND)
g(j)  # public demand for industry output #;
VARIABLE
y  # private consumer income #;
VARIABLE
pexp  # private consumer expenditure #;
VARIABLE (orig_level=1.0)(all,j,IND)
p(j)  # basic price in each industry #;
VARIABLE (orig_level=1.0)(all,j,IND)
q(j)  # purchaser's price in each industry  #;
VARIABLE (orig_level=1.0)(all,j,IND)
tc(j)  # commodity tax on (private) final demands (exogenous)  #;
VARIABLE
lab  # total labour endowment (exogenous) #;
VARIABLE
cap  # total capital endowment (exogenous) #;
VARIABLE
t # total tax revenues to government #;
```

```
VARIABLE
govt # total government expenditures #;
VARIABLE (orig_level=1.0)(all,j,IND)
pw(j)  # world prices (exogenous)  #;
VARIABLE
f  # exchange rate (exogenous) #;
VARIABLE
expor  # exports #;
VARIABLE
impor  # imports #;
VARIABLE
bot  # balance of trade #;
VARIABLE (all,j,IND)
compii(j)  # composite intermediate inputs #;
VARIABLE (all,j,IND)
compva(j)  # composite value added #;
VARIABLE (all,j,IND)
iim(j)  # intermediate inputs #;
VARIABLE (all,j,IND)
iis(j)  # intermediate inputs #;
VARIABLE (all,j,IND)
pva(j)  # composite value added price #;
VARIABLE (all,j,IND)
pii(j)  # composite intermediate input price #;
VARIABLE
gdp  # produccion bruto interior #;


Coefficient (ge 0)(all,i,IND)
VL(i) # value of labour demands in industry #;
Read (all,i,IND)
VL(i) from file INFILE header "LAB";
Update (all,i,IND)
VL(i) = w(i) * l(i);
Coefficient (ge 0)
VLTOT # total value of labour demands #;
FORMULA
VLTOT = sum(i,IND,VL(i)) ;

Coefficient (ge 0)(all,i,IND)
VK(i) # value of capital demands in industry #;
Read (all,i,IND)
VK(i) from file INFILE header "CAP";
Update (all,i,IND)
VK(i) = r!(i)! * k(i);
Coefficient (ge 0)
VKTOT # total value of capital demands #;
FORMULA
VKTOT = sum(i,IND,VK(i)) ;

! Intermediate demands !
Coefficient (ge 0)(all,j,IND)
VMANU(j) # value of manufactured intermediate inputs by industry #;
Coefficient (ge 0)(all,j,IND)
```

```
VSERV(j) # value of services intermediate inputs by industry #;
Read (all,j,IND)
VMANU(j) from file INFILE header "VMAN";
Read (all,j,IND)
VSERV(j) from file INFILE header "VSER";

Update
VMANU("manu") = p("manu") * iim("manu") ;
Update
VMANU("svces") = p("manu") * iim("svces") ;
Update
VSERV("manu") = p("svces") * iis("manu") ;
Update
VSERV("svces") = p("svces") * iis("svces") ;


Coefficient (ge 0)
IMPORTS # value of (svces) imports #;
Read
IMPORTS from file INFILE header "IMP";
Update
IMPORTS = impor * p("svces") ;
! impor demands (1) !
EQUATION E_imports # import demands #
impor = c("svces")  ;
! assumed that imports are a fixed share of private household expenditure !

! compsite Leontief demands for value added and intermediate inputs !
EQUATION E_compii # composite intermediate inputs # (all,j,IND)
compii(j) = x(j) ;
EQUATION E_compva # composite intermediate inputs # (all,j,IND)
compva(j) = x(j) ;

! Factor demands and supplies (8)!
Coefficient (ge 0)(all,j,IND)
VADDED(j) # total value of factor demands in industry #;
FORMULA (initial) (all,j,IND)
VADDED(j) = VK(j) + VL(j) ;
Update (all,j,IND)
VADDED(j) = pva(j) * compva(j) ;
coefficient (all,j,IND)
    PVASHRK(j);
Formula (all,j,IND)
    PVASHRK(j) = VK(j) / VADDED(j);
coefficient (all,j,IND)
    PVASHRL(j);
Formula (all,j,IND)
    PVASHRL(j) = VL(j) / VADDED(j);
EQUATION E_pva # composite value added price # (all,j,IND)
pva(j) = PVASHRK(j) * r + PVASHRL(j) * w(j);

Coefficient (parameter)(all,j,IND)
SIGVA(j) # elasticity of substitution between factors #;
FORMULA (initial)
```

```
SIGVA("manu") = 2 ;
FORMULA (initial)
SIGVA("svces") = 1.5 ;

! CES demands for the factors of production !
EQUATION E_l1 # labour demands #
l("manu") = compva("manu") - SIGVA("manu") * [w("manu") - pva("manu")] ;

EQUATION E_l2 # labour demands #
l("svces") = compva("svces") - SIGVA("svces") * [w("svces") - pva("svces")] ;

EQUATION E_k1 # capital demands #
k("manu") = compva("manu") - SIGVA("manu") * [r!("manu")! - pva("manu")] ;

EQUATION E_k2 # capital demands #
k("svces") = compva("svces") - SIGVA("svces") * [r!("svces")! - pva("svces")] ;

! CET factor supply function !

Coefficient (parameter)(all,j,IND)
SIGCET(j) # (CET) constant elasticity of transformation between factors #;
FORMULA (initial)
SIGCET("manu") = -120 ;
FORMULA (initial)
SIGCET("svces") = -120 ;

EQUATION E_l11 # labour supply #
xl("manu") = lab + SIGCET("manu") * [wcomp - w("manu")] ;

EQUATION E_l22 # labour supply #
xl("svces") = lab + SIGCET("svces") * [wcomp - w("svces")] ;
!
EQUATION E_k11 # capital supply #
xk("manu") = cap + 0.11 * (rcomp - r("manu")) ;

EQUATION E_k22 # capital supply #
xk("svces") = cap + 0.05 * (rcomp - r("svces")) ;!

! factor market clearing equations (4) !
!
EQUATION E_kkk # capital market clearance # (all,i,IND)
xk(i) = k(i) ;!

EQUATION E_w # labour market clearance # (all,i,IND)
xl(i) = l(i) ;

coefficient (all,j,IND)
    REVSHRK(j);
Formula (all,j,IND)
    REVSHRK(j) = VK(j) / VKTOT;
coefficient (all,j,IND)
    REVSHRL(j);
Formula (all,j,IND)
    REVSHRL(j) = VL(j) / VLTOT;
```

```
! Composite factor price equations (2) !
!EQUATION E_rcomp # labour market clearance #
rcomp = sum(j,IND,REVSHRK(j) * r(j)) ;!

EQUATION E_wcomp # labour market clearance #
wcomp = sum(j,IND,REVSHRL(j) * w(j)) ;

EQUATION E_COMPR # capital factor market #
cap = REVSHRK("manu") * k ("manu") + REVSHRK("svces") * k ("svces");

! intermediate input demands !
Coefficient (ge 0)(all,j,IND)
VINTINP(j) # total value of intermediate demands by industry #;
FORMULA (initial)
VINTINP("manu") = VMANU("manu") + VSERV("manu") ;
FORMULA (initial)
VINTINP("svces") = VMANU("svces") + VSERV("svces") ;
Update
VINTINP("manu") = pii("manu") * compii("manu") ;
Update
VINTINP("svces") = pii("svces") * compii("svces") ;
coefficient (all,j,IND)
    PIISHRM(j);
Formula (all,j,IND)
    PIISHRM(j) = VMANU(j) / VINTINP(j);
coefficient (all,j,IND)
    PIISHRS(j);
Formula (all,j,IND)
    PIISHRS(j) = VSERV(j) / VINTINP(j);

EQUATION E_pii # composite value added price # (all,j,IND)
pii(j) = PIISHRM (j) * p("manu") + PIISHRS (j)* p("svces") ;


! intermediate input demands !
Coefficient (parameter)
SIGII # elasticity of substitution between intermediate inputs #;
FORMULA (initial)
SIGII = 0.87 ;

EQUATION E_ii1 # labour demands #
iim("manu") = compii("manu") - SIGII * [p("manu") - pii("manu")] ;

EQUATION E_ii2 # capital demands #
iis("manu") = compii("manu") - SIGII * [p("svces") - pii("manu")] ;

EQUATION E_ii3 # labour demands #
iim("svces") = compii("svces") - SIGII * [p("manu") - pii("svces")] ;

EQUATION E_ii4 # capital demands #
iis("svces") = compii("svces") - SIGII * [p("svces") - pii("svces")] ;

! final demands !
```

```
Coefficient (ge 0)(all,i,COM)
HHDEMANDB(i) # private household demands (basic prices) #;
Coefficient (ge 0)(all,i,COM)
GODEMANDB(i) # government demands (basic prices)#;
Coefficient (ge 0)(all,i,COM)
HHDEMANDP(i) # private household demands (purchaser's prices) #;

Read (all,j,COM)
HHDEMANDB(j) from file INFILE header "HHDB";
Read (all,j,COM)
GODEMANDB(j) from file INFILE header "GOVB";
Read (all,j,COM)
HHDEMANDP(j) from file INFILE header "HHDP";

UPDATE (all,i,COM)
HHDEMANDB(i) = p(i) * c(i) ;
UPDATE (all,i,COM)
GODEMANDB(i) = p(i) * g(i) ;
UPDATE (all,i,COM)
HHDEMANDP(i) = q(i) * c(i) ;

! Price linkages (1) !
EQUATION E_q # price linkage equation # (all,j,IND)
q(j) = p(j) + tc(j) ;

!Consumer demands (2) !
EQUATION E_c1 # consumer demands #
c("manu") = y - q("manu") ;
EQUATION E_c2 # consumer demands #
c("svces") = y - q("svces") ;

!public demands (2) !
EQUATION E_g1 # consumer demands #
g("manu") = t - p("manu") ;
EQUATION E_g2 # consumer demands #
g("svces") = t - p("svces") ;

Coefficient (ge 0)
TAXREV # commodity tax revenues to government #;
FORMULA
TAXREV = sum(i,COM,HHDEMANDP(i)) - sum(i,COM,HHDEMANDB(i));

! government income from taxes and expenditures on goods (2) !
coefficient (all,i,COM)
    TAXSHRP(i);
Formula (all,i,COM)
    TAXSHRP(i) = HHDEMANDP(i) / TAXREV;
coefficient (all,i,COM)
    TAXSHRB(i);
Formula (all,i,COM)
    TAXSHRB(i) = HHDEMANDB(i) / TAXREV;
coefficient (all,i,COM)
    TAXSHRG(i);
Formula (all,i,COM)
```

```
    TAXSHRG(i) = GODEMANDB(i) / TAXREV;
EQUATION E_t # tax revenue #
t = sum(i,COM,[TAXSHRP(i) * (q(i) + c(i))]) -
sum(i,COM,[TAXSHRB(i) * (p(i) + c(i))]) ;

EQUATION E_govt # government expenditures #
govt = sum(i,COM,[TAXSHRG(i) * (p(i) + g(i))]) ;

!
EQUATION E_COMPW # labour factor market #
VLTOT * lab = sum(i,IND,VL(i) * l(i)) ;!

! keep this out,so that we have a numeraire variable !
!EQUATION E_COMPR # capital factor market #
VKTOT * cap = sum(i,IND,VK(i) * k(i)) ;!

! Household income (1) !
Coefficient (ge 0)
INC # household gross income = household expenditure #;
FORMULA
INC = !sum(i,COM,HHDEMANDP(i))!
VK("manu") + VK("svces") + VL("manu") + VL("svces") ;
coefficient (all,i,COM)
    INCSHRK(i);
Formula (all,i,COM)
    INCSHRK(i) = VK(i) / INC;
coefficient (all,i,COM)
    INCSHRL(i);
Formula (all,i,COM)
    INCSHRL(i) = VL(i) / INC;
coefficient (all,i,COM)
    INCSHRE(i);
Formula (all,i,COM)
    INCSHRE(i) = HHDEMANDP(i) / INC;
EQUATION E_y # private household gross income #
y = sum(i,COM,[INCSHRK(i) * (r + k(i))]) +
sum(i,COM,[INCSHRL(i) * (w(i) + l(i))]) ;

EQUATION E_pexp # private household expenditure #
pexp = sum(i,COM,[INCSHRE(i) * (q(i) + c(i))])
!VK("manu") * [r("manu") + k("manu")] +
VK("svces") * [r("svces") + k("svces")] +
VL("manu") * [w("manu") + l("manu")] +
VL("svces") * [w("svces") + l("svces")] ! ;

! the commodity prices, p(j), are determined by the world price
linkage equations at the bottom of the Tablo !

Coefficient (ge 0)(all,i,IND)
VSALE(i) # value of domestic industry supplies #;
FORMULA
VSALE("manu") = VK("manu") + VL("manu") +
VMANU("manu") + VSERV("manu") ;
FORMULA
```

```
VSALE("svces") = VK("svces") + VL("svces") +
VMANU("svces") + VSERV("svces") + IMPORTS ;

Coefficient (ge 0)
EXPORTS # value of (svces) imports #;
Read
EXPORTS from file INFILE header "EXP";
Update
EXPORTS = expor * p("manu") ;
EQUATION E_exp # export demands #
EXPORTS * [expor + p("manu")] =
IMPORTS * [impor + p("svces")] ;


EQUATION E_x1 # value of commodity demands #
VSALE("manu") * [p("manu") + x("manu")] =
VMANU("manu") * [p("manu") + iim("manu")] +
VMANU("svces") * [p("manu") + iim("svces")] +
HHDEMANDB("manu") * [p("manu") + c("manu")] +
GODEMANDB("manu") * [p("manu") + g("manu")] +
EXPORTS * [p("manu") + expor] ;

EQUATION E_x2 # commodity demands #
VSALE("svces") * [p("svces") + x("svces")] =
VSERV("manu") * [p("svces") + iis("manu")] +
VSERV("svces") * [p("svces") + iis("svces")] +
HHDEMANDB("svces") * [p("svces") + c("svces")] +
GODEMANDB("svces") * [p("svces") + g("svces")] ;
! Here HHDEMANDB("svces") includes imports !


! trade equations (3 equations) !

EQUATION E_p1 # price linkage equation #
p("manu") = f + pw("manu") ;

EQUATION E_p2 # price linkage equation #
p("svces") = f + pw("svces") ;

! balance of payments starts at zero and should stay at zero
to ensure a GE solution !
EQUATION E_BT # balance of payments #
bot = [pw("manu") + expor] - [pw("svces") + impor] ;

! tasa de crecimiento en la economía !
Coefficient (ge 0)
GDPP # PBI #;
FORMULA
GDPP =
sum(i,COM,HHDEMANDB(i)) + sum(i,COM,GODEMANDB(i)) + EXPORTS  - IMPORTS  ;
coefficient (all,i,COM)
    GDPSHRB(i);
Formula (all,i,COM)
    GDPSHRB(i) = HHDEMANDB(i) / GDPP;
```

```
coefficient (all,i,COM)
    GDPSHRG(i);
Formula (all,i,COM)
    GDPSHRG(i) = GODEMANDB(i) / GDPP;
coefficient
    GDPSHRE;
Formula
    GDPSHRE = EXPORTS / GDPP;
coefficient
    GDPSHRI;
Formula
    GDPSHRI = IMPORTS / GDPP;
EQUATION E_gdp # PBI = C + G + X - M #
gdp = sum(i,COM,[GDPSHRB(i) * [p(i) + c(i)]]) +
sum(i,COM,[GDPSHRG(i) * [p(i) + g(i)]]) +
GDPSHRE * [expor + p("manu")] -
GDPSHRI * [impor + p("svces")] ;
```

APPENDIX V

CHANGES IN PRODUCTION

APPENDIX V: CHANGES IN PRODUCTION

	France					Germany					Greece				
Sectors	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)
Wheat	3451	77,2	0,1	0,4	0,2	2937	73,6	0,9	1,9	1,6	174	-13,9	0,3	0,8	0,6
Ograins	3224	13,3	+	0,6	0,4	3258	6,7	-0,1	2,6	2,1	241	9,2	0,6	1,5	1,4
VegFruitNuts	7676	71,8	+	0,4	0,3	4541	47,8	-	5,6	4,5	3945	45,8	0,1	1,1	0,9
Oilseeds	1038	53,6	-0,3	0,5	0,3	1139	84,5	-0,2	-0,2	-0,1	344	-18,2	-4,3	-2,8	-3,1
Sugar	771	12,8	-1,0	-0,6	-0,7	1145	-13,4	-9,7	-6,6	-7,2	43	20,8	-20,1	-19,3	-19,5
Plants	236	36,3	0,1	0,5	0,1	52	20,1	0,3	2,6	2,0	440	228,5	1,4	1,5	1,4
Ocrops	14630	50,4	-0,1	0,2	+	9352	67,0	-0,2	6,9	5,2	732	-29,4	+	2,0	1,5
Catshp	6511	17,2	-0,2	0,1	0,0	3128	-15,9	-0,6	4,0	3,1	1005	13,9	0,3	1,2	1,1
PigsPoultry	8385	33,8	-	0,3	0,2	8683	30,3	-0,3	4,0	3,2	778	50,6	2,4	3,2	3,1
RawMilk	7950	13,7	-	0,3	0,2	10853	-1,0	-	4,0	3,3	951	50,4	-0,4	0,6	0,5
Oagric	72	965,1	0,1	-0,4	-0,3	55	751,3	0,2	5,5	3,9	23	260,4	-	1,1	0,6
Meatpro	10960	42,4	-0,2	0,1	+	9972	3,0	-0,7	3,9	3,1	3096	59,3	0,4	1,1	1,0
Omeatpro	19782	49,6	-0,2	0,1	+	18366	41,7	-0,5	4,5	3,5	2641	84,2	2,4	3,2	3,1
Vegoilsfats	3324	17,9	-0,4	0,1	-0,1	23355	26,7	-0,1	3,3	2,8	960	17,5	-4,6	-3,5	-3,7
Dairy	22063	36,0	-	0,4	0,3	26358	17,9	-	3,7	3,0	2203	85,5	-0,5	0,5	0,4
Sugarpro	3723	28,8	-1,8	-1,4	-1,5	4946	6,4	-10,4	-7,5	-8,0	128	54,6	-16,7	-16,0	-16,1
Ofoodpro	46092	44,9	-	0,4	0,3	46537	35,4	0,1	3,2	2,7	2197	53,1	0,2	1,2	1,1
BevsTobac	21465	49,2	-	0,5	0,4	43693	34,4	0,1	2,9	2,5	3101	78,3	-0,1	0,6	0,6
RawMat	8791	87,8	-	+	+	16688	57,7	0,0	0,1	0,1	19403	52,8	0,0	0,1	+
Mnfcs	753311	56,9	0,0	0,2	0,1	1329114	27,8	+	6,7	5,2	49325	40,7	-	0,8	0,7
Svces	1632972	65,1	0,0	0,3	0,2	2362702	39,5	+	3,9	3,1	160929	98,5	+	0,6	0,6

Table AV.1 Changes[65] in production, France, Germany and Greece (Simulation results and own calculations)

+/- indicates less than + or -0,1 %

[65] The results for the baseline are presented as accumulated changes during the period 2001-2025 (second column), while accession scenarios are presented as percentage changes relative to the baseline (third, forth and fifth columns).

	Italy					Netherlands					Spain				
Sectors	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)
Wheat	1177	-2,5	0,4	0,5	0,5	125	-41,3	0,4	0,8	0,7	674	7,9	0,2	0,4	0,3
Ograins	1812	-8,8	+	0,1	0,1	94	-23,5	0,1	0,6	0,5	1188	13,9	0,1	-	+
VegFruitNuts	11281	28,2	0,1	0,2	0,2	3116	43,8	0,1	1,3	1,0	11308	62,6	0,0	0,1	0,1
Oilseeds	1816	-12,1	-7,2	-6,8	-6,8	4	-86,9	-0,1	0,8	0,7	1143	0,7	-1,6	-1,6	-1,6
Sugar	439	21,6	-0,8	-0,8	-0,7	310	24,1	-4,2	-2,8	-3,1	341	39,7	-1,6	-1,5	-1,5
Plants	28	471,8	0,1	0,1	0,1	1	-61,5	-0,4	+	0,0	189	95,9	0,3	-0,1	-
Ocrops	10441	25,2	-0,1	-0,2	-0,1	5646	109,5	+	0,5	0,4	3153	100,2	+	-0,5	-0,4
Catshp	3782	1,2	-0,2	-0,3	-0,2	1491	79,5	-0,7	0,3	0,1	2797	22,5	-0,1	-0,2	-0,1
PigsPoultry	6492	25,6	+	+	0,1	4420	152,5	-0,3	0,8	0,6	7393	67,2	0,1	-	_+
RawMilk	4700	0,2	-	-0,1	+	4069	32,7	-0,1	1,7	1,3	2236	34,3	-0,1	-0,1	-0,1
Oagric	477	214,1	0,8	0,7	0,7	7	94,7	0,4	2,2	1,6	285	707,1	0,2	0,1	0,1
Meatpro	11594	27,8	-0,2	-0,2	-0,2	3170	153,7	-1,0	0,3	+	6710	57,9	-0,1	-0,1	-0,1
Omeatpro	9188	32,9	-0,1	-0,1	-	5160	293,5	-0,5	0,7	0,4	11850	106,7	-0,1	-0,2	-0,2
Vegoilsfats	6387	18,3	-9,0	-8,6	-8,6	1909	105,5	-0,3	1,5	1,1	5621	38,2	-4,9	-4,8	-4,8
Dairy	14677	28,2	-	0,0	+	7840	68,4	-0,1	1,7	1,3	7090	74,2	-0,1	-0,1	-0,1
Sugarpro	1379	27,9	-2,9	-2,8	-2,8	765	45,9	-5,0	-3,6	-3,9	1081	50,3	-3,6	-3,6	-3,6
Ofoodpro	43949	33,0	-	0,1	0,1	20260	92,8	-0,1	1,2	0,9	24957	46,1	-	-	-
BevsTobac	19940	39,7	+	0,3	0,3	8674	75,8	-0,1	0,7	0,6	16889	72,0	0,0	0,2	0,1
RawMat	7430	74,1	0,0	+	+	7536	66,0	-	-	-	9386	63,6	0,0	0,0	0,0
Mnfcs	722720	51,4	0,1	-0,1	-	185112	64,7	+	1,0	0,8	298652	70,9	+	-0,3	-0,3
Svces	1268136	55,4	0,0	0,1	0,1	584844	84,4	+	0,8	0,7	736762	95,1	+	0,1	0,1

Table AV.2 Changes in production, Italy, Netherlands and Spain (Simulation results and own calculations)

+/- indicates less than + or -0,1 %

	United Kingdom					Rest of EU-15				
Sectors	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)
Wheat	1703	32,4	-	0,2	0,1	1228	34,1	0,3	0,5	0,4
Ograins	984	18,8	-	0,1	0,1	1999	18,5	-	0,2	0,2
VegFruitNuts	3536	46,4	0,1	0,1	0,1	5645	88,6	+	0,3	0,4
Oilseeds	459	32,0	-0,1	0,2	0,1	384	-5,7	-0,6	0,1	-0,1
Sugar	502	12,9	-0,4	-0,3	-0,3	855	13,2	-2,0	-1,7	-1,7
Plants	34	-98,4	0,6	0,0	0,0	240	-48,9	0,1	0,3	0,3
Ocrops	2012	102,7	0,3	-0,1	+	6658	123,8	-0,1	-0,4	-0,2
Catshp	3937	9,4	0,1	0,2	0,2	4102	-7,2	-0,6	-0,4	-0,4
PigsPoultry	5056	37,5	0,6	0,7	0,7	9478	56,5	-0,2	-0,1	-
RawMilk	5166	21,8	-	0,1	0,1	6996	23,6	-0,1	0,2	0,2
Oagric	133	1182,6	-0,2	-0,2	-0,2	152	1150,6	0,3	0,3	0,1
Meatpro	11755	50,1	-0,2	-0,1	-0,1	11633	17,6	-0,9	-0,7	-0,7
Omeatpro	20350	32,5	-0,1	-	-	21390	74,6	-0,5	-0,4	-0,3
Vegoilsfats	2301	56,8	-	0,2	0,2	5280	46,3	-0,3	0,0	+
Dairy	22311	47,0	-	0,1	0,1	20890	50,2	-0,1	0,2	0,2
Sugarpro	5016	38,4	-0,6	-0,4	-0,5	4907	38,6	-2,3	-2,0	-2,0
Ofoodpro	69282	47,3	-	0,1	0,1	45502	51,2	-	0,3	0,3
BevsTobac	24366	58,7	-0,1	0,1	0,1	21714	59,7	-	0,5	0,4
RawMat	26956	56,9	0,0	+	0,0	20791	81,0	0,0	+	+
Mnfcs	724046	52,6	-	-0,1	-0,1	787329	81,2	0,0	-	0,1
Svces	2036965	63,1	+	0,1	0,1	1463311	76,6	+	0,3	0,3

Table AV.3 Changes in production, United Kingdom and Rest of EU-15 (Simulation results and own calculations)

+/- indicates less than + or -0,1 %

	USA					Rest of World				
Sectors	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)	2001 (€ mil)	Baseline (%)	S-1 (%)	S-2.1 (%)	S-2.2 (%)
Wheat	7176	8,7	0,1	0,2	0,1	78788	43,2	0,1	+	+
Ograins	23377	35,8	0,1	0,1	0,1	70270	42,3	-	-	-
VegFruitNuts	29068	79,3	+	+	+	382883	44,3	-	-	-
Oilseeds	14261	81,4	-0,2	-0,1	-0,2	57280	25,0	-0,1	0,0	-0,1
Sugar	2570	30,0	-	-	-	30326	48,9	-	-0,1	-0,1
Plants	8154	98,8	0,1	-	0,0	31048	41,3	+	-0,1	-0,1
Ocrops	34080	65,8	-0,1	-0,2	-0,2	138123	26,7	0,1	0,0	0,0
Catshp	36112	58,7	-	-0,1	-	99254	53,5	-	-	-
PigsPoultry	39553	88,0	-	-	-	231867	65,5	-	-	-
RawMilk	27842	51,6	0,0	+	+	107837	71,6	-	-	-
Oagric	1118	4,8	+	-0,1	-0,1	126880	40,8	-	-	-
Meatpro	95542	91,0	-	-0,1	-	113656	63,8	-0,1	-0,1	-0,1
Omeatpro	78074	105,3	-	-0,1	-0,1	137481	54,4	-0,1	-0,1	-0,1
Vegoilsfats	20105	47,3	-0,1	-0,1	-	72820	60,0	-0,3	-0,3	-0,3
Dairy	94281	85,0	-	+	+	110638	74,6	-	-	-
Sugarpro	33596	64,6	-	-	-	74997	64,4	-0,1	-0,1	-0,1
Ofoodpro	331902	81,8	-	+	+	764834	57,4	-	-	-
BevsTobac	177986	83,8	0,0	+	+	351936	80,7	-	-	+
RawMat	151118	63,0	0,0	+	0,0	1013192	44,0	-	0,0	0,0
Mnfcs	4785203	74,6	0,0	-0,1	-0,1	8860502	71,1	+	-0,2	-0,2
Svces	14053547	83,7	0,0	+	+	14721270	109,3	0,0	+	+

Table AV.4 Changes in production, USA and Rest of World (Simulation results and own calculations)

+/- indicates less than + or -0,1 %

APPENDIX VI

CHANGES IN WELFARE

APPENDIX VI: CHANGES IN WELFARE

S-1		France	Germany	Greece	Italy	NL	Spain	UK	RoEU15	USA	ROW
Per capita utility (%)		0,000	0,006	0,006	0,000	-0,011	0,000	0,000	0,000	0,000	0,000
Equivalent variation	(€ m)	-22	75	16	-27	-91	-22	-56	-72	141	654
Of which:											
Allocative efficieny	(€ m)	2	162	13	7	-12	34	-8	-12	-29	255
ToT on tradables	(€ m)	-10	-92	0	-49	-58	-35	-35	-29	-22	148
ToT capital account	(€ m)	3	10	5	3	-1	-4	4	4	120	-140
Other effects	(€ m)	-20	-6	-2	-14	-21	-17	-17	-38	146	324
S-2.1		**France**	**Germany**	**Greece**	**Italy**	**NL**	**Spain**	**UK**	**RoEU15**	**USA**	**ROW**
Per capita utility (%)		-0,061	2,031	-0,045	0,042	0,243	0,031	0,037	-0,017	0,019	0,006
Equivalent variation	(€ m)	7250	133300	1344	735	6624	361	3260	5558	4118	2515
Of which:											
Allocative efficieny	(€ m)	675	42797	25	293	1525	-5	197	-20	387	-421
ToT on tradables	(€ m)	158	-11220	-187	273	-696	405	511	653	1135	7582
ToT capital account	(€ m)	43	757	-29	8	32	-21	-1	65	392	-1268
Other effects	(€ m)	6370	100961	1534	164	5762	-20	2555	4858	2203	-3430
S-2.2		**France**	**Germany**	**Greece**	**Italy**	**NL**	**Spain**	**UK**	**RoEU15**	**USA**	**ROW**
Per capita utility (%)		-0,140	1,091	-0,135	0,102	0,072	0,024	0,018	0,011	0,019	0,000
Equivalent variation	(€ m)	5239	105239	1133	1860	5316	288	2879	6166	3959	1263
Of which:											
Allocative efficieny	(€ m)	-378	28815	-14	948	874	1	126	382	370	-449
ToT on tradables	(€ m)	176	-8848	-185	114	-564	323	70	273	865	6059
ToT capital account	(€ m)	31	612	-28	12	25	-15	0	76	352	-1071
Other effects	(€ m)	5410	84658	1361	785	4986	-21	2386	5433	2406	-3114

Table AVI.1 Changes in welfare,France, Germany, Greece, Italy, Netherlands, Spain, United Kingdom Rest of EU-15, USA and Rest of World (Simulation results and own calculations)

+/- indicates less than + or -1 %