PhD dissertation

A Dynamic General Equilibrium Analysis of Jordan's Trade Liberalisation

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1 Introduction

This dissertation aims at assessing the effects on the Jordanian economy of the preferential trade liberalisation process undertaken by Jordan with the European Union (EU). The Association Agreement (AA) between Jordan and the EU was signed in 1997 and entered into force in 2002. It eliminates progressively tariffs on most industrial goods imported by Jordan from the EU. Custom duties on agricultural products and processed agricultural goods are gradually and only partially eliminated. After the 12-year transition period in which import duties are reduced, the Agreement aims eventually at creating a free-trade area for most industrial products between the EU and Jordan.

The reduction of tariff rates on EU imports into Jordan is expected to result in positive effects for the Jordanian economy. Lower import duties leads to lower import prices of investment and consumption goods, that in turn brings about a positive impact on consumer welfare. On the other hand, trade liberalisation reduces government revenue. The magnitude of the adverse effects will be influenced by the measures taken by the Jordanian government to counteract the effects of revenue loss. Ideally, import duty reduction ought to be accompanied by an appropriate and parallel process of complementary economic reforms, such as reduction in government spending, modernisation of the tax system and broadening of the tax base in order to offset the loss in custom duties. Therefore, together with the economic effects of trade liberalisation on Jordan, this work aims also at drawing implications for domestic policy responses accompanying the trade liberalisation process.

In order to assess the impacts of the Association Agreement with the EU on the Jordanian economy, a dynamic computable general equilibrium (CGE) model is specified and then calibrated to the Jordanian economy. This methodology allows to capture fully the chain of events in the domestic economy, their interactions and their dynamic effects when a policy option is implemented. Particular emphasis is placed on the effects on consumer welfare. Using a dynamic CGE model, the impacts of gradually decreasing and eventually eliminating tariff barriers in Jordan for most EU industrial goods are assessed. However, given the need for domestic reforms parallel to the trade liberalisation process, the impacts of preferential trade liberalisation are assessed along with policy choices aiming at counterbalancing the negative effects of trade liberalisation on government revenue.

Computable general equilibrium models rely on social accounting matrices (SAMs) to capture national income, production and input-output information, and aim at simulating and evaluating economic policies. The use of CGE models for policy analysis has become widespread for a wide range of applications for both developed and developing economies (de Melo, 1988). An applied CGE model should have the following essential characteristics: (i) consumers' endowments of production factors, (ii) consumers' preferences and demand functions for commodities, (iii) production technology available to firms, and (iv) set of equilibrium conditions (Shoven, 1983). Equilibrium in the model is characterised by a set of prices and output levels in each industry such that, for all commodities, market demand and supply are equal. Demand functions are homogeneous of degree zero and profits are linearly homogeneous in prices. Therefore the absolute price level has no impact on the equilibrium outcome and only relative prices are of any significance in the model. Market demands are the sum of individual household demands, and they satisfy the Walras' law (Shoven and Whalley, 1984). In dynamic models, household behaviour is determined by the maximisation of the discounted lifetime utility. The instantaneous utility function is defined over the domain of the consumption goods in the economy and in some models it includes also leisure (Pereira and Shoven, 1988).

A complete equilibrium dataset for a single year must then be assembled. On the assumption that the data represent an equilibrium of the economy, functional parameters, such as share and shift parameters, are calibrated, i.e. they are estimated in such a way that the model solution reproduces the initial dataset, called benchmark equilibrium. However, some parameters, namely the elasticities, are taken exogenously from the existing literature. Calibration in a dynamic context requires additionally the model to be parameterised to yield an intertemporal balanced growth path when the base policy is maintained. Exogenous shocks are then implemented in the model, in order to compute a counterfactual equilibrium determined by the new policy regime. The impact of the policy change is then assessed by comparison between counterfactual and benchmark equilibria (Shoven and Whalley, 1992).

In analysing a wide range of policy issues, the general equilibrium approach has a main advantage over the partial equilibrium one, namely the possibility of capturing fully the chain of events and their interactions. In order to analyse the detailed effects of import tariff reduction, the chain of events taking place when tariffs are cut should be examined (Bandara, 1991). A tariff rate reduction affects demand patterns. The relative prices of imports and domestic goods change and imports increase. This has an effect on the allocation of resources within the tariff-reducing country. Consequently, changes in import tariffs can not be considered separately, since their repercussions are spread throughout the economy, through channels that affect production, consumption and investment decisions. Moreover, given that trade liberalisation is not implemented in isolation, but it requires combination with other appropriate policies, its economic effects should be computed together with those brought about by the associated policies.

To my knowlege, there are two studies on Jordan's trade liberalisation using CGE models. D. Lucke (2001) implemented a static model to assess the fiscal effects on Jordan of the Association Agreement with the EU, and to address the issue of fiscal responses aiming at counteracting the loss in government revenue. Hosoe (2001) used a static model to analyse the impacts of the implementation of the Uruguay Round and the free trade arrangement with the EU on Jordanian welfare. He finds positive welfare effects brought about by the Uruguay Round and an additional welfare gain due to the EU-Jordan prefential trade agreement.

The model implemented in the first part of the analysis is a neoclassical dynamic computable general equilibrium (CGE) model, in which one representative household maximises her future discounted utility by choosing optimal consumption and investment paths. In the domestic economy full employment and perfect competition are assumed. Imperfect substitution between domestic and foreign goods characterises international trade flows. Jordan is assumed to be a small economy, i.e. it is a price-taker in the international markets. The model is calibrated to 1998 dataset.

Simulation results of the process of preferential trade liberalisation undertaken by Jordan show that the Association Agreement with the EU raises consumers welfare in Jordan and has positive impacts on all macroeconomic variables in the long-run. However, in the short-run private consumption is negatively affected by trade liberalisation, and this may raise concerns about political feasibility of the process of opening up domestic trade.

Trade liberalisation processes undertaken by many developing countries over the past years have been accompanied by widespread concerns that opening up domestic trade in developing countries will affect negatively the poor and it will deteriorate the distribution of income. Whereas most economists agree on the fact that open economies perform better than closed ones, and open policies provide a significant contribution to economic development and growth, many commentators fear that, both in the short and in the long-run, trade liberalisation might be harmful for poorer agents in the economy (Oxfam International, 2003 and 2005). In fact, it might well be, as argued by Aisbett (2005), that people's interpretation of the available evidence of the impacts of trade liberalisation on poverty is strongly influenced by their values and by their beliefs about the process of globalisation.

Winters et al. (2004) survey the empirical work on trade liberalisation and poverty. They point out that there is plenty of evidence that trade liberalisation affects each household groups, and that the ability of households to respond to trade liberalisation impacts differs across households groups. The theory suggests that trade liberalisation might alleviate poverty in the long-run and on average, and the empirical evidence supports this view. However, they also warn that this view does not assert that trade policy is always among the most important determinants of poverty reduction or that the effects of trade liberalisation are always beneficial to the poor. Instead trade liberalisation implies necessarily some distributional changes and, at least in the shortrun, it may reduce the welfare of some individuals and some of these may be poor. Winters et al. (2004) also point out that, given the variety of factors that have to be taken into account, it will hardly be surprising that there are no general comparative static results about the impact of trade liberalisation on poverty. However, in a WTO special study, Winters (1999) concludes that trade liberalisation generally contributes strongly to poverty alleviation. He also recognises that most reforms might create some losers, even in the long-run, and that some reforms could have temporarily a negative impact on poverty.

The model with one representative household, described above, is then extended to include heterogeneous consumers. Individual households' tax rates, wage rates, initial endowments of assets, transfers from government and abroad and individual preferences are calibrated from data from a 2002 household survey. Introducing heterogeneous households into a standard neoclassical dynamic CGE model allows to address the issue of how trade liberalisation affects different households.

In the context of general equilibrium modelling several studies have been conducted to assess aspects of income distribution (see Reimer, 2002 for a survey). However, the approach used in this dissertation is the first one analysing income distribution in a dynamic general equilibrium framework with utility maximising agents as used by Ramsey (1928), Cass (1965) and Koopmans (1965). Theoretical contributions analyse the effects of implementing heterogeneous consumers into a neoclassical framework (Chatterjee, 1994 and Caselli and Ventura, 2000). However, the restrictions on the utility maximising agents imposed by this strand of literature are not fulfilled in this model and would be neglected by the available survey data for Jordan. Specifically, they assume the same rate of discount for all household groups, whereas in the multi-household model implemented in this dissertation the categories of households are characterised by different rates of time preference, which are calibrated from the dataset. Therefore, this approach can be regarded as novel.

As one would expect, effects of trade liberalisation on Jordan are different across individual households, and in some simulations one household group even experiences a welfare loss. Therefore trade liberalisation is not always Pareto improving for Jordan. In addition effects on welfare and income distribution are opposite. While on the one hand welfare gains are slightly larger for low-income households, on the other hand the gap in income between rich and poor increases, especially in the long run. The results are driven by the fact that capital stock of high-income households increases much more in the long run due to exploitation of investment incentives. Moreover, poor households use their amount of capital assets to smooth consumption. The remaining findings confirms the analysis suggested by the model with one representative household on the aggregate level.

Both models are programmed in the mathematical software Gauss and are solved with the relaxation algorithm proposed by Trimborn et al. (2006).

The dissertation is structured as follows. Chapter 2 describes the Association Agreement between Jordan and the EU and deals with the update of the inputoutput table for Jordan. In chapter 3, the effects of preferential trade liberalisation on the Jordanian economy are analysed by means of a standard trade CGE model, in which one representative consumer chooses optimal consumption and investment path so as to maximise future discounted utility. The model is calibrated to 1998 data. In chapter 4, the model is extended to include six representative households, in order to assess the welfare impact of trade liberalisation on each household class. As mentioned above, households represent different income groups with different consumption and time preferences, levels of wealth, income, tax rates, and government transfers. The dataset is based on the 2002 social accounting matrix (SAM) for Jordan, in which households data are taken from the 2002 Jordanian Household Survey. For convenience, in the dissertation the one representative consumer model is denoted as standard trade model, while the model with six household classes is called poverty model. Chapter 5 draws the main conclusions. The appendices provide equations and glossaries of both the standard trade and poverty models, and tables and details about the I-O table update.

2 Institutional framework and dataset

2.1 The EU-Jordan Association Agreement

The economic relations between Jordan and the European Union (EU) are governed by the Euro-Mediterranean Partnership, which is implemented through the EU-Jordan Association Agreement (AA) and the regional dimension of the Barcelona Process. The EU-Jordan Association Agreement is part of the bilateral track of the Euro-Mediterranean Partnership. The aims of the Partnership are to provide a framework for the political dialogue, to establish progressive liberalisation of trade in goods, services and capital, to improve living and employment conditions, to promote regional cooperation and economic and political stability, and to foster the development of economic and social relations between the parties. The final aim of the Association Agreement is the creation of a free trade area for most industrial products between the EU and Jordan over a period of 12 years, in conformity with the provisions of the General Agreement on Tariffs and Trade (GATT).

The Euro-Mediterranean Partnership was launched at the Euro-Mediterranean Conference between the European Union and its originally 12 Mediterranean Partners¹, and governs the policy of the EU towards the Mediterranean region. The Euro-Mediterranean Conference was held in Barcelona in 1995, and marked the starting point of the Euro-Mediterranean Partnership, a wide framework of political, economic and social relations between the Member States of the Euro-Mediterranean Partners of the Middle East and North Africa (MENA) region. The Euro-Mediterranean Partnership comprises two complementary tracks, the bilateral and the regional agenda. The framework for the bilateral agenda is the Association Agreement. The regional agenda is implemented through a number of regional working groups on a range of policy issues including trade, customs cooperation, and industrial cooperation.

The latest EU enlargement, on 1st May 2004, has brought two Mediterranean Partners (Cyprus and Malta) into the European Union, while adding a total of 10 to the number of Member States. The Euro-Mediterranean Partnership thus comprises 35 members, 25 EU Member States and 10 Mediterranean Partners (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia and Turkey).

¹The 12 original partners are: Israel, Morocco, Algeria, Tunisia, Egypt, Jordan, the Palestinian Authority, Lebanon, Syria, Turkey, Cyprus and Malta.

Libya has observer status since 1999.

Before the start of the Euro-Mediterranean Partnership, relations between the EU and the countries in the MENA region were ruled by the Cooperation Agreements dating from the 1970s. Under the 1977 Cooperation Agreement Jordan were granted duty-free access to the EU markets for most industrial products and preferential access for agricultural commodities. The Cooperation Agreement was unlimited in duration, and it was not reciprocal. In 1979 the Agreement allowed Jordan exports to enter the EU market free of quantitative restrictions.

The Euro-Mediterranean Association Agreement (AA) between Jordan and the European Union was signed in November 1997. It entered into force on May 1st, 2002, and replaced the 1977 Cooperation Agreement. The Association Agreement allows imports into the EU of Jordanian products free of custom duties and free of quantitative restrictions, with the exclusion of agricultural goods and processed agricultural products. Custom duties and charges on imports into Jordan of EU products are progressively abolished, and duties on agricultural products are gradually and partially eliminated. The Agreement aims eventually at creating a free-trade area for most industrial goods between the EU and Jordan within 12 years by its entry into force.

Table 2.1 shows the time schedule of reduction of custom duty rates on EU imports to Jordan, provided by the Association Agreement (Chapters 1 and 2 of Title II, Annex II and Lists A and B of Annex III). Chapter 1 and Lists A and B of Annex III of the Agreement apply to most industrial goods, while Chapter 2 and Annex II deal with agricultural goods and processed agricultural products. The left column in table 2.1 shows the time period, in each other column the percentage of the baseyear import tariff rates charged in the relevant period are shown for four different groups of goods listed in the Association Agreement. The group of commodities in the second column of the table, i.e. products listed in Annex II, includes agricultural products and processed agricultural products. For these goods reduction of import tariff rates starts four years after the entry into force of the AA, and is only partial. The other groups of goods comprise the remaining industrial products, for which trade liberalisation is complete.

The establishment and the promotion of cross-border cooperation with the Mediterranean Partners will also be an important element of future regional integration. Jordan is already at the core of the main integration process in the region. It is a member of the Mediterranean Arab Free Trade Area, the so-called "Agadir" agreement, that was signed in May 2001 with Egypt, Morocco and Tunisia. Jordan has also signed bilateral FTAs with several countries in the MENA region, and is a member of the Great Arab Free Trade Area (GAFTA), with other 13 countries who are members of the Arab League. After joining the World Trade Organization (WTO) in April 2000, as a step towards even broader trade liberalisation Jordan signed free trade agreements with the United States in October 2000, and with the European Free Trade Association (EFTA) in June 2001.

period	Annex II	List A Annex III	List B Annex III	remaining
entry into force of the AA	100%	80%	100%	0%
one year after	100%	60%	100%	0%
two years after	100%	40%	100%	0%
three years after	100%	20%	100%	0%
four years after	90%	0%	90%	0%
five years after	80%	0%	80%	0%
six years after	70%	0%	70%	0%
seven years after	60%	0%	60%	0%
eight years after	50%	0%	50%	0%
nine years after	50%	0%	40%	0%
ten years after	50%	0%	30%	0%
11 years after	50%	0%	20%	0%
12 years after	50%	0%	0%	0%

Table 2.1. Tariff reduction schedule of the AA.

Trade liberalisation in the form of a preferential trade agreement with the EU is expected to provide benefits to Jordan in terms of lower import prices of investment and consumption goods that bring about higher consumer welfare. The economic impact of trade liberalisation can be separated into two types, static and dynamic. The static impact is due to the induced reallocation of existing resources, the dynamic impact takes into account the effect of opening up trade on the rate of capital accumulation (Hoekman and Djankov, 1997). Therefore a key role in such a process is played by investment demand, that is potentially important to the dynamic behaviour of output over the long-run (Francois et al., 1997 and Baldwin, 1993). On the other hand, trade liberalisation reduces government revenue, due to decreasing import tariff duties. Such an impact is likely to be particularly strong for Jordan, where government revenue relies heavily on custom duties.² The magnitude of the

²Import duties from EU trade in Jordan in the period 1994-96 averaged 12% of total tax revenue and 2% of GDP, total import duties averaged more than one-third of total tax revenue and about 6% of GDP (Abed, 1998).

adverse effects on government revenue will be influenced by the measures taken by the Jordanian government to counteract the effects of revenue loss. As pointed out in chapter 1, trade liberalisation should be accompanied by an appropriate and parallel process of economic reforms, such as reduction in government spending, modernisation of the tax system and broadening of the tax base in order to offset the loss in custom duties. As measures of fiscal reform, the Jordanian government has harmonised the General Sales Tax (GST) rates on domestic and imported goods, has replaced the GST, introduced in 1994, by a Value Added Tax (VAT) in 2000, and has undertaken an income tax reform in 2001.

2.2 Update of the input-output table

Jordan's economy is currently undergoing a rapid process of trade liberalisation and market-oriented economic reform. As mentioned above, the general sales tax (GST) has been replaced by a value-added tax (VAT), privatisation of state enterprises gained momentum and Qualifying Industrial Zones established in economic cooperation with Israel have proved very successful. In the past few years, Jordan accessed the WTO and signed free trade agreements, among others, with the European Union and the USA, which provide for a stepwise reduction of import tariff rates.

Scientific analysis aimed at assessing the impact of various policy reforms has largely relied on the use of computable general equilibrium (CGE) models, given that sufficiently long and reliable time series for econometric analysis are not available. Unfortunately, even for CGE analysis major impediments exist. One of the major obstacles is given by the fact that no recent input-output (I-O) table for the Jordanian economy is available. Such a table is essential in organising the available data for a particular base year in the social accounting matrix (SAM) which is of basic importance for CGE modelling.

The most recent input-output table for Jordan dates back to 1987. The matrix is therefore rather old and might not adequately reflect the structural changes which took place in the Jordanian economy since the beginning of the reform period in the mid-1990s. And even worse, the classification used in the 1987 I-O table is incompatible with the system of national accounts (NA) currently used, as the NA system was substantially revised in 1992. While the sectoral nomenclature of the data before and after the revision is similar, an uncritical identification of sectors with similar labels is, in fact, inappropriate since the differences in the definitions are non-negligible.

Updating the 1987 I-O table is a task with huge data requirements. Many of the data necessary for the update are in reality not available, and therefore estimates must be used. In order to update the 1987 I-O table the biproportionate RAS method (Bacharach, 1970, Bulmer-Thomas, 1982) is implemented. This method can be used to update an old input-output table if at least the row sums and the column sums of the I-O table are known.

The RAS method

The vectors and matrices of the model are initially defined. The column vector y is the sectoral supply in the domestic economy, i.e. domestic sales plus imports, where y_i is supply of sector i = 1, ..., n

$$y = \begin{bmatrix} y_1 \\ \cdot \\ \cdot \\ y_n \end{bmatrix}$$
(1)

x is the column vector of sectoral output, which is a composite of domestic sales and exports, where x_i is output of sector i

$$x = \begin{bmatrix} x_1 \\ \vdots \\ \vdots \\ x_n \end{bmatrix}$$
(2)

The square matrix Q is the input-output table of intermediate consumption goods

$$Q = \begin{bmatrix} q_{1,1} & . & . & q_{1,n} \\ . & . & . & . \\ . & . & . & . \\ q_{n,1} & . & . & q_{n,n} \end{bmatrix}$$
(3)

where $q_{i,j}$ is the spending of sector j for intermediate input good i, for i, j = 1, 2, ..., n.

The square matrix A is the table of input-output Leontief coefficients (Leontief, 1966):

$$A = \begin{bmatrix} a_{1,1} & . & . & a_{1,n} \\ . & . & . & . \\ . & . & . & . \\ a_{n,1} & . & . & a_{n,n} \end{bmatrix}$$
(4)

where each coefficient $a_{i,j}$ is the spending of sector j for the intermediate good produced by sector i divided through by output of sector j, for i, j = 1, 2, ..., n

$$a_{i,j} = \frac{q_{i,j}}{x_j} \tag{5}$$

The equilibrium between sectoral supply and demand in the domestic economy is therefore given by the identity

$$y = Ax + z \tag{6}$$

where z is the column vector of sectoral spending for final goods, i.e. the sum of private consumption, government consumption and investment.

Then r is defined as the column vector of total intermediates produced by each sector, i.e. the row sums of the matrix Q

$$r = Q\iota \tag{7}$$

where ι is a vector of ones. This vector may be thought of and may be defined as total intermediate supply.

Similarly, let c be the column vector of total intermediate consumption of each sector, i.e. the column sums of Q:

$$c = \iota' Q \tag{8}$$

This vector may be thought of as total intermediate demand.

The matrix Q is known for one base year only, 1987 in this particular application. Denote this matrix by \tilde{Q} . For all subsequent years matrix Q is unknown, but it is assumed that the vectors r and c are known. The RAS or biproportional method (Bacharach, 1970, Bulmer-Thomas, 1982) consists in adjusting the rows and the columns of the existing matrix \tilde{Q} , such that the entries in the adjusted matrix will add up to the row and column totals relative of the update year. For this purpose, the RAS method assumes that each entry in the updated matrix Q is biproportional to the known initial matrix \tilde{Q} , i.e. that there are weights w_i and z_j for the typical element $\tilde{q}_{i,j}$ such that

$$q_{i,j} = w_i \tilde{q}_{i,j} z_j \tag{9}$$

Clearly, the weights must be chosen subject to the restriction that the row and column sums of the adjusted matrix equal the known marginal totals

$$\sum_{j} q_{i,j} = r_i, \ i = 1, .., n$$

$$\sum_{i} q_{i,j} = c_j, \ j = 1, .., n$$
(10)

The problem can be solved using an iterative algorithm. The algorithm is written in GAUSS by Bernd Lucke. This however, assumes data availability to which the next section now turns.

Data

For the base year 1987 data provided by the Department of Statistics (DOS) of Jordan include the input-output table along with data on the sectoral spending for intermediate consumption goods, sectoral data on output, exports and imports. The input-output table Q is a square matrix - i.e. the number of activities is the same as the number of commodities - and includes 51 economic activities.

For subsequent years (1988-2001) data on intermediate consumption, gross output, imports and exports are available. These data are published within the revised system of national accounts and are thus inconsistent with the sectoral classification used in the 1987 I-O table. Revised national accounts data for 1987, i. e. data conforming with the new classification are also available. Unfortunately, this is not the case for the I-O table.

In order to minimise errors incurred by the change in the classification the activities are aggregated to just nine sectors producing goods. Further, the lack of disaggregated data for imports and exports of services implied that all eight service sectors had also to be aggregated. This is certainly a drawback, particularly for a country such as Jordan, where the service sector plays a very important role in the economy and a more detailed disaggregation for services would be appropriate. Therefore, the updated I-O matrices end up with 10 sectors, as shown in Table 2.2.

No.	Economic activity
1	Agriculture, hunting, forestry, and fishing
2	Mining and quarrying
3.1	Manufactures of food, beverage and tobacco
3.2	Manufactures of textiles, apparels, and leather product
3.3	Manufactures of wood, paper, printing
3.4	Manufactures of petrolum and chemicals
3.5	Manufactures of rubber and other non metallic mineral
3.6	Manufactures of basic metals and fabricated metal execpt machinery and equipment
3.7	Other manufactures
4-9	Services

Table 2.2. DOS classification with aggregated services.

Unfortunately, both for 1987 and all subsequent years, the revised data are not suitable to easy application of the RAS method. Three main problems were encountered.

The first problem is that variables are often evaluated at different prices, e.g. intermediate consumption at producer prices and output at basic prices. To adjust the data, all variables are thus evaluated at producer prices. Basic price is the price received by the producer from the purchaser for a unit of good or service, minus any taxes payable and plus any subsidies receivable on that unit. Producer price is the value received by the producer for a unit of product, minus any deductible tax (such as VAT) charged on the purchaser, but it includes non-deductible taxes and subsidies. This requires the transformation of sectoral output evaluated at basic prices into sectoral output at producer prices by applying the relevant net tax rate on the basic-price output level.

A second problem faced with the data concerns the different classifications of internationally traded goods that make figures for imports and exports of goods incompatible with the rest of the data. The classification used by the DOS in the original input-output table is similar but not identical to the Harmonized System (H.S.), which is a classification including only goods. Available external trade statistics for goods are provided under the Brussels Tariff Nomenclature (B.T.N.) classification for the period 1987-1993 and under the H.S. from 1994 onwards. Thus correspondences must be used to convert external trade data from B.T.N. and H.S. into the appropriate DOS classification. Some of these correspondences had to be constructed particularly for this purpose. The appendix provides details about the concordances used.

The third problem is certainly the major one. As explained above, application of the RAS method requires the use of data across production sectors on total output (x), domestic supply (y), and supply and demand of intermediate goods (r and c). Whereas vectors x, y and c are known for all years, the vector of intermediate goods supply r is known only for the base-year, i.e. 1987. The vector r needs therefore to be derived for the remaining years. Note that data on final uses across production sectors are not available either, so that it is impossible to compute r as the residual from output minus final uses. Instead, the strategy used here consists in estimating r by using sectoral data on supply and by adjusting it to make total demand for intermediate goods in the economy equal to intermediate goods total supply.

Scalars, vectors and matrices referring to the original 1987 data are denoted with \sim and time indices are omitted in order to keep notation simple.

Define s_i as the ratio of \tilde{r}_i , total intermediate input supply of sector *i* in 1987, to \tilde{y}_i , supply of sector *i* in 1987:

$$s_i = \frac{\tilde{r}_i}{\tilde{y}_i} \tag{11}$$

Collect these intermediate production shares in the vector s:

$$s = \begin{bmatrix} s_1 \\ \cdot \\ \cdot \\ s_n \end{bmatrix}$$
(12)

The vector s is used to obtain estimates of r for each year, on the assumption that each r_i is proportional to the respective y_i . The variable y is referred to as domestic supply, not output. The reason for this is given by the fact that entries $q_{i,j}$'s in the matrix Q are domestic sales - including imports and excluding exports. Moreover, the elements of r must be adjusted to make total supply of intermediates equal to total demand in the intermediate goods market, i.e. $\sum_i r_i = \sum_i c_i$.

The estimate of r_i for each year is therefore given by:

$$r_i = s_i y_i \frac{\sum_j c_j}{\sum_j s_j y_j} \tag{13}$$

Since the revised 1987 data differ quite substantially from the original figures, the first step consists in updating the 1987 I-O table to the new classification. This enables to check how strongly the change in the accounting system affects the Leontief coefficients. In order to distinguish between the Leontief coefficients of the original

1987 input-output table and Leontief coefficients of the updated 1987 table (based on revised data), the former are denoted as 19870 and the latter as 1987r. Table 2.3 below shows the original 1987 Leontief coefficients, i.e. the input-output coefficients computed by making use of the original 1987 dataset on intermediate consumption and gross output. By comparison, Table 2.4 shows the 1987r Leontief coefficients obtained from applying the RAS method.

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1	0,067	0,000	0,215	0,000	0,000	0,000	0,000	0,002	0,001	0,003
2	0,000	0,118	0,000	0,000	0,000	0,048	0,041	0,002	0,004	0,005
3.1	0,167	0,000	0,122	0,007	0,003	0,001	0,001	0,001	0,000	0,008
3.2	0,000	0,000	0,000	0,499	0,003	0,000	0,000	0,001	0,001	0,001
3.3	0,000	0,002	0,013	0,006	0,222	0,011	0,018	0,008	0,004	0,007
3.4	0,031	0,112	0,016	0,016	0,050	0,144	0,192	0,035	0,035	0,076
3.5	0,010	0,002	0,012	0,010	0,002	0,007	0,056	0,014	0,206	0,050
3.6	0,002	0,031	0,024	0,014	0,023	0,014	0,022	0,177	0,084	0,045
3.7	0,011	0,050	0,004	0,016	0,014	0,003	0,006	0,021	0,294	0,038
4-9	0,148	0,160	0,200	0,102	0,101	0,040	0,150	0,087	0,250	0,178
	Ta	ble 2 .	3. Or	iginal	1987	Leon	tief co	efficie	ents	

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	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	49
1	0,082	0,000	0,212	0,000	0,000	0,000	0,000	0,003	0,001	0,003
2	0,000	0,100	0,000	0,000	0,000	0,068	0,037	0,004	0,002	0,004
3.1	0,196	0,000	0,115	0,004	0,004	0,002	0,001	0,001	0,000	0,007
3.2	0,000	0,000	0,001	0,487	0,006	0,001	0,000	0,002	0,001	0,002
3.3	0,000	0,002	0,012	0,003	0,310	0,015	0,016	0,013	0,002	0,006
3.4	0,040	0,101	0,017	0,011	0,077	0,216	0,185	0,062	0,024	0,067
3.5	0,015	0,003	0,014	0,007	0,003	0,013	0,063	0,029	0,159	0,050
3.6	0,003	0,029	0,025	0,009	0,037	0,021	0,022	0,323	0,057	0,040
3.7	0,016	0,053	0,005	0,012	0,025	0,005	0,007	0,044	0,229	0,039
4-9	0,204	0,158	0,223	0,074	0,170	0,065	0,158	0,169	0,182	0,170

Table 2.4. Estimated 1987 Leontief coefficients.

Results and Conclusions

Using the RAS algorithm for all subsequent years from 1988 to 2001 allows to analyse how the input-output coefficients change between the base-year 19870 and over the period 1987r-2001.

In the analysis of the Leontief coefficients, it is sensible to focus on those coefficients that are in some sense "important". While many different approaches - all of them somehow arbitrary - to choose the level of "importance" are available, two reasonable criteria seem to be:

(i) to select those coefficients $a_{i,j}$, whose value is "large" in at least one period, where "large" values are those equal to or larger than 0.1;

(ii) to take those coefficients $a_{i,j}$, whose associated spending for intermediate inputs $q_{i,j}$ is "large" in at least one period, where now "large" values are defined those equal to or larger than 10% of total spending of sector j for intermediate consumption goods c_j in this period.

Clearly, the criterion defined in (i) identifies a subset of the coefficients identified by criterion (ii), since (i) postulates that the value of a certain intermediate be more than 10% of total output value, while (ii) merely postulates that it be more than 10% of total intermediate consumption expenses of the particular sector.

Table 2.5 shows the mean values and the standard deviations (in brackets) of all Leontief coefficients, computed over the period 1987r-2001. The coefficients whose value is larger than 0.1 for at least one observation are shown in bold. According to such criterion, there are 23 "large" coefficients. Figures in italics show the coefficients whose intermediate consumption entry is larger than 10% of total sectoral spending for intermediates for at least one observation. Under criterion (ii), the group of "large" coefficients includes the same 23 coefficients selected under criterion (i), together with additional 9 coefficients.

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
	0.094	0.000	0.219	0.000	0.000	0.000	0.001	0.004	0.001	0.003
1	(0.015)	(0.000)	(0.039)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
	0.000	0.080	0.000	0.000	0.000	0.076	0.031	0.003	0.002	0.003
2	(0.000)	(0.013)	(0.000)	(0.000)	(0.000)	(0.011)	(0.005)	(0.001)	(0.000)	(0.001)
	0.277	0.000	0.145	0.007	0.006	0.004	0.001	0.002	0.000	0.009
3.1	(0.054)	(0.000)	(0.017)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
	0.000	0.000	0.001	0.474	0.006	0.001	0.000	0.002	0.001	0.002
3.2	(0.000)	(0.000)	(0.000)	(0.059)	(0.002)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
	0.000	0.002	0.013	0.005	0.350	0.025	0.019	0.015	0.002	0.007
3.3	(0.000)	(0.000)	(0.001)	(0.002)	(0.022)	(0.005)	(0.002)	(0.002)	(0.000)	(0.001)
	0.045	0.112	0.017	0.014	0.082	0.336	0.213	0.066	0.021	0.068
3.4	(0.011)	(0.012)	(0.003)	(0.007)	(0.009)	(0.050)	(0.019)	(0.004)	(0.002)	(0.005)
	0.022	0.004	0.017	0.013	0.005	0.024	0.089	0.038	0.179	0.064
3.5	(0.006)	(0.001)	(0.004)	(0.007)	(0.001)	(0.005)	(0.014)	(0.005)	(0.022)	(0.008)
	0.004	0.033	0.026	0.013	0.040	0.034	0.025	0.348	0.053	0.042
3.6	(0.001)	(0.004)	(0.004)	(0.006)	(0.005)	(0.006)	(0.003)	(0.030)	(0.005)	(0.006)
	0.024	0.074	0.007	0.021	0.034	0.011	0.010	0.058	0.263	0.051
3.7	(0.007)	(0.012)	(0.001)	(0.011)	(0.006)	(0.002)	(0.002)	(0.008)	(0.030)	(0.007)
	0.206	0.157	0.202	0.086	0.160	0.091	0.161	0.160	0.148	0.156
4-9	(0.028)	(0.020)	(0.027)	(0.034)	(0.016)	(0.012)	(0.012)	(0.020)	(0.018)	(0.018)

Table 2.5. Means and standard deviations of the coefficients

As can be seen, most of the "large" coefficients lie along the main diagonal and on the bottom row. This means that most of intermediate trade involves several activities that buy intermediate inputs from themselves - i.e. intra-sectoral trade between the same sector plays an important role - and sectors that buy intermediate goods from the services sectors. More importantly, the standard deviations of all "large" coefficients are "small", suggesting that the RAS procedure computed fairly similar coefficients for all the years. This may be interpreted as an indication that the approximations used to assemble the appropriate data and the update method in general may have worked quite well, since, despite large swings in particular importexport data, similar estimates have been obtained for all of the years.

In order to find out if and how much Leontief coefficients have changed over time, the "large" coefficients are regressed on a constant and time trend:

$$a_{i,j} = \alpha + \beta t \tag{14}$$

Table 2.6 shows the sign of time trends of "large" coefficients, whose estimate of β is significant. By looking at selected graphs depicted in appendix 1, the general impression is that trend-induced changes in Leontief coefficients are slow and far from dramatic. With few exceptions, time trends of Leontief coefficients are positive for intermediates produced by non-service sectors and negative for intermediates produced by service sectors.

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1			neg							
2										
3.1	pos		pos							
3.2				neg						
3.3										
3.4		pos			pos	pos	pos			
3.5							pos		pos	pos
3.6										
3.7		pos	pos						pos	
4-9	pos			pos	neg		neg	neg	neg	neg

Table 2.6. Time trends of the Leontief coefficient estimates.

Trending Leontief coefficients can, in principle, either reflect technological change or changes in market structure. Technological change is different to measure, hence one could try to explore the hypothesis that changes in Leontief coefficients are mostly due to changes in market structure. For this purpose, data on the number of firms in each sector are checked since an increase in a Leontief coefficient might be due to a decrease in vertical integration and thus an increase in the number of firms in a specific sector. Time-series data for the period 1990-1998 are available for sectors 2 to 3.7, whereas they are only partially available for sector 4-9, and not available at all for sector 1. The complete dataset is shown in the appendix. After excluding sector 1 because of lack of data and including dummies for the missing figures in sector 4-9, the number of firms in each sector is regressed against a constant and time. The number of firms shows significantly positive time trend over the 1990-98 period for all sectors. This can be taken as an evidence supporting the view that vertical integration has decreased, and that competition has increased, particularly in the manufacturing sectors.

Regressing the Leontief coefficients against a constant and the number of firms is supposed to yield some informative and suggestive result. However, only 11 Leontief coefficients depend significantly on the number of enterprises, as shown in table 2.7.

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1										
2						neg				
3.1			neg							
3.2										
3.3										
3.4					pos		pos	pos		
3.5							pos		pos	pos
3.6										
3.7										
4-9	pos						pos		pos	

Table 2.7. Effects of number of firms on Leontief coefficients.

3 The Standard Trade Model

General equilibrium modelling approach for policy analysis has become widespread for both developed and developing economies. In developing countries, CGE models are commonly used for a wide range of policy issues. The policy applications range from long-run development strategies on growth and resource allocation, to tax and trade policy reforms. As pointed out by de Melo (1988), the issue of foreign trade policy has occupied a center place in most of the applications. Even in the applications that do not focus on foreign trade, the way foreign trade is modelled plays a fundamental role in determining the outcome of policy simulations.

Over the past decades, the interest generated by computable general equilibrium (CGE) modelling in applications to developing countries can be explained by many factors. Firstly, the CGE modelling approach is appropriate when analysing policy changes and external shocks that affect the whole economy. Secondly, construction of CGE models has been facilitated by the development in many developing countries of relevant and statistical data bases, such as social accounting matrices (SAMs). Finally, the computational constraints on the implementation of CGE models have been removed by advances in numerical solution techniques (Bandara, 1991).

Many general equilibrium studies have assessed the economic impacts of tariff reform and domestic complementary policies in developing countries. Harrison et al. (1996) assess the impacts on Turkey of a custom union arrangement with the EU. Regional integration with the EU is found to raise welfare in Turkey between 1% and 1.5%, depending on the complementary policies adopted by the Turkish government. By using a standard static general equilibrium, Hoekman and Konan (1999) investigate the effects of the free trade agreement between Egypt and the EU on Egypt's welfare. They find large gains in welfare conditional on eliminating regulatory barriers and red tape. In a static general equilibrium model for Syria, B. Lucke (2001) studies different scenarios of preferential trade liberalisation with the EU, and focuses on the effects of tariff reform on government budget. The study finds that government revenue losses caused by reduction in the EU import duties are fairly large, but still manageable. Go (1994) uses a model in a parsimonious and dynamic framework to examine intertemporal effects of external shocks and adjustment policies in the Philippines, and concludes that complementary measures, consisting of domestic tax reform, are needed. Devarajan and Go (1998) present a similar model, and analyse the

response of the Philippinian economy to a terms-of-trade shock, tariff liberalisation and fiscal policy changes. Harrison et al. (1997), using a multiregional model, find that the implementation of the Uruguay Round has a negative impact on welfare in countries of the MENA region.

Previous studies by Hosoe (2001) and D. Lucke (2001) on Jordan's trade liberalisation implemented static models with homogenous agents and focused on aggregate welfare and fiscal effects. Hosoe (2001) investigates the impacts of two trade policy scenarios for Jordan, the Uruguay Round implementation and the establishment of a free trade area with the EU, by using a static model based on Devarajan et al. (1990). Simulation of the Uruguay Round shows that its implementation would increase Jordan's welfare by 0.28%. The EU-Jordan FTA scenario would further increase Jordan's welfare by 0.16%. The work by D. Lucke (2001) focuses on fiscal effects of the EU-Jordanian Association Agreement, and discusses fiscal responses aiming at overcoming the loss in government revenue, such as simplifying and harmonising tax rates, and broadening the tax base. However, these models do not account for intertemporal effects due to capital accumulation.

The model implemented in this chapter is a neo-classical open-economy singlecountry intertemporal model, it builds on previous work done by Feraboli et al. (2003), which is based on the dynamic framework developed by Devarajan and Go (1998). Discounted lifetime utility of the representative consumer is maximised by choosing optimal consumption and investment paths. In the domestic economy there are ten production sectors, nine of which producing goods and one producing services. Production sectors will be denoted by the subscript i. Perfect competition and full employment are assumed in all sectors. Firms use intermediate inputs and value added output to produce final output with a Leontief production technology. Value added output is in turn a constant elasticity of substituion (CES) composite of primary inputs, capital and labour. Production factors are assumed to be perfectly mobile across sectors. International trade flows are characterised by imperfect substitution between domestic and foreign goods. Final sectoral output Q is allocated across domestic sales D and exports E through a constant elasticity of transformation (CET) function. Total sectoral absorption X is an Armington (1969) composite of domestic good D and imported good M. It is differentiated among four uses: private consumption C, government consumption G, intermediate input q, investment I. The parameters in the Armington functions are the same for all uses, as well as prices.

The domestic country is assumed to be a price-taker in the international markets, that is world prices of imports and exports are exogenously determined.

The model is implemented by means of the mathematical software Gauss and by employing the relaxation algorithm proposed by Trimborn (2006).

3.1 Consumers

The representative consumer chooses consumption and new capital so as to maximise her discounted lifetime utility, subject to the budget constraint, the motion equation of capital, the equality between savings and investment, and the given initial capital stock. The optimisation problem is given by:

$$\max \int_{0}^{\infty} u\left(C_{t}\right) e^{-\rho t} dt \tag{15}$$

subject to

$$\dot{K} = I - \delta K = \frac{YD - P^CC}{P^I} - \delta K \tag{16}$$

$$K\left(0\right) = K_0 \tag{17}$$

where C, YD, K are aggregate consumption, disposable income and capital of the representative household, respectively, I is aggregate investment, P^C is the composite consumption price, P^I is the composite price of investment. The household discounts future utility with discount rate ρ , which is calibrated from the data. The depreciation rate of capital, δ , is also calibrated from the data.

Disposable income of the representative household is given by

$$YD = (1 - t^{Y}) \left[wL + (1 - t^{K}) rK + TR + erFREM \right]$$
(18)

where L is the fixed labour supply, w is the wage rate, t^{Y} is the income tax rate, t^{K} is the capital rent tax rate, r is the rate of return to capital, TR is government transfer to households, FREM are foreign remittances, expressed in foreign currency, and er is the exogenous exchange rate, which is chosen as numeraire.

The instantaneous utility function is given by the constant relative risk aversion (CRRA) utility function:

$$u\left(C\right) = \ln C \tag{19}$$

which implies an elasticity of substitution between consumption at any two points in time equal to 1.

Solving the above dynamic optimisation problem yields the Euler equation

$$\frac{\dot{C}}{C} = \frac{\left(1 - t^{Y}\right)\left(1 - t^{K}\right)r}{P^{I}} - \rho - \delta \tag{20}$$

Equations (16) and (20) characterise the dynamics of the model.

Household aggregate consumption is a Cobb-Douglas composite of consumption sectoral goods

$$C = \Omega^C \prod_{i=1}^{N} c_i^{\theta_i^C}; \ \Omega^C > 0; \ 0 < \theta_i^C < 1$$
(21)

where c_i is private consumption of good produced by sector i, N = 10 is the number of sectors in the Jordanian economy, Ω^C is the shift parameter and θ_i^C is the share parameter of good i in the Cobb-Douglas consumption function.

Solving the static problem

$$\max_{c_i} \ \Omega^C \prod_{i=1}^N c_i^{\theta_i^C} \tag{22}$$

subject to the constraint

$$P^C C = \sum_{i=1}^N P_i^X c_i \tag{23}$$

yields the functions of demand for consumption good produced by sector i

$$c_i = \theta_i^C \frac{P^C C}{P_i^X} \tag{24}$$

where c_i is private consumption demand for the good produced by sector i, P^C is the private consumption price index and P_i^X is the price of the final good produced by sector i.

Household consumption of each good and service c_i 's are in turn composites of domestic and import goods, modelled through the Armington (1969) assumption of constant elasticity of substitution (CES) between domestically-produced consumption good cd_i and imported consumption good cm_i . The representative household chooses the optimal level of each domestic and import good and service for a given value of total consumption, by taking the Armington specification as constraint of the costminimisation static problem:

$$\min_{cm_i,cd_i} P_i^C c_i = P_i^M cm_i + P_i^D \left(1 + vat_i^D\right) cd_i$$
(25)

subject to

$$c_{i} = \Phi_{i} \left[\varepsilon_{i} \left(cm_{i} \right)^{\frac{\gamma_{i}-1}{\gamma_{i}}} + \left(1 - \varepsilon_{i} \right) \left(cd_{i} \right)^{\frac{\gamma_{i}-1}{\gamma_{i}}} \right]^{\frac{\gamma_{i}}{\gamma_{i}-1}}$$

$$0 < \varepsilon_{i} < 1; \ \gamma_{i} > 0, \ \gamma_{i} \neq 1$$

$$(26)$$

where P_i^M is the composite import price, inclusive of all taxes and import duties, P_i^D is the price of the domestic good (net of taxes), and vat_i^D is the VAT rate that applies to domestic goods; γ_i is the elasticity of substitution between domestic goods and imports, Φ_i is the shift parameter, ε_i is the imports share parameter, and the subscript *i* is the index for sectors.

The demand functions for imports and domestic goods resulting from the minimisation problem given by (25) subject to constraint (26) are given by

$$cm_i = (\Phi_i)^{(\gamma_i - 1)} c_i \left(\frac{\varepsilon_i P_i^X}{P_i^M}\right)^{\gamma_i}$$
(27)

and

$$cd_{i} = \left(\Phi_{i}\right)^{(\gamma_{i}-1)} c_{i} \left[\frac{\left(1-\varepsilon_{i}\right) P_{i}^{X}}{\left(1+vat_{i}^{D}\right) P_{i}^{D}}\right]^{\gamma_{i}}$$
(28)

Aggregate imports of consumption goods are then disaggregated across imports from the EU and from the rest of the world, through a Cobb-Douglas specification.³ The optimisation problem for the households applies to each sectoral production and is given by:

$$\min_{\{cm_i^j\}} P_i^M cm_i = \sum_j PM_i^j cm_i^j \tag{29}$$

s.t.
$$cm_i = \Phi_i^M \prod_j \left(cm_i^j \right)^{\varepsilon_i^j}; \sum_j \varepsilon_i^j = 1$$
 (30)

³Imports can be disaggregated across several different regions or countries (e.g. Arab countries, EFTA countries, USA), but for the purpose of this work, the basic disaggregation between the EU and the rest of world is considered.

where cm_i^j is households consumption of foreign good *i* imported from region *j*, PM_i^j is the price of good *i* imported from region *j* inclusive of all taxes, Φ_i^M is the shift parameter, and ε_i^j is the share parameter of imports of good *i* from region *j*, with each $\varepsilon_i^j \ge 0$. The elasticity of substitution between imports is therefore constant and equal to one, being the Cobb-Douglas specification a particular case of CES function.

The solution to the above minimisation problem yields the demand functions for imports disaggregated across foreign regions:

$$cm_{i}^{j} = \varepsilon_{i}^{j} \frac{P_{i}^{M} cm_{i}}{PM_{i}^{j}}; i = 1, 2, ..., N; j = EU, RW$$
 (31)

The domestic prices of imported goods are determined exogenously, since they depend on the fixed world price of imports, PW_i^M , the import tariff rate, tm_i^j , the VAT rate on imported goods, vat_i^M , and the exchange rate er:

$$PM_i^j = erPW_i^M \left(1 + tm_i^j\right) \left(1 + vat_i^M\right); \, j = EU, RW$$
(32)

3.2 Firms

On the supply side, constant returns to scale and perfect competition are assumed. Sectoral output in the domestic economy Q_i is determined by a two-stage production technology, which exhibits at the top tier a Leontief fixed-proportions specification between intermediate input $q_{j,i}$ produced by sector j and used in the production process of sector i, and value-added output VA_i :

$$Q_{i} = \min\left\{\frac{VA_{i}}{a_{0,i}}, \frac{q_{j,i}}{a_{j,i}}, \dots\right\}$$
(33)

where $a_{0,i}$ is the fixed requirements of valued-added output VA_i , and $a_{j,i}$ is the fixed requirements of intermediate input $q_{j,i}$ for production of aggregate output Q_i .

At the second tier, intermediate input $q_{j,i}$ is an Armington CES composite of domestic and foreign intermediate consumption goods, $qd_{j,i}$ and $qm_{j,i}$. Total import of intermediate goods is in turn a Cobb-Douglas composite of intermediate input regional imports.

Value-added production in each sector i is determined by a technology characterised by a constant elasticity of substitution between the two primary inputs, capital and labour, which are perfectly mobile across sectors:

$$VA_{i} = A_{i} \left[\alpha_{i} LD_{i}^{\frac{\sigma_{i}-1}{\sigma_{i}}} + (1 - \alpha_{i}) KD_{i}^{\frac{\sigma_{i}-1}{\sigma_{i}}} \right]^{\frac{\sigma_{i}}{\sigma_{i}-1}}$$

$$0 < \alpha_{i} < 1; \ \sigma_{i} > 0; \ \sigma_{i} \neq 1$$

$$(34)$$

where LD_i and KD_i are sector *i*'s demand for labour and capital respectively, A_i is a time-invariant technological parameter, α_i is the labour share parameter and σ_i is the constant elasticity of substitution between labour and capital.

At the value-added production stage, subject to the above technology constraint (34), firms minimise production costs, given by

$$P_i^{VA}VA_i = wLD_i + rKD_i \tag{35}$$

where P_i^{VA} is the value-added price, w is the nominal wage rate and r is the nominal rate of return to capital.

Cost-minimisation subject to the technology constraint yields the demands for labour and capital

$$LD_{i} = (A_{i})^{(\sigma_{i}-1)} VA_{i} \left(\frac{\alpha_{i} P_{i}^{VA}}{w}\right)^{\sigma_{i}}$$
(36)

$$KD_i = (A_i)^{(\sigma_i - 1)} VA_i \left[\frac{(1 - \alpha_i) P_i^{VA}}{r}\right]^{\sigma_i}$$
(37)

Sectoral production Q_i can be sold on the domestic market or abroad. Exports and domestic sales are modelled according to a constant elasticity of transformation (CET) function, that represents the constraint for the producer maximising total sales:

$$\max_{E_i, D_i^S} P_i^Q Q_i = P_i^E E_i + P_i^D D_i$$
(38)

s.t.
$$Q_i = \chi_i \left[\theta_i E_i^{\frac{1+\Psi_i}{\Psi_i}} + (1-\theta_i) D_i^{\frac{1+\Psi_i}{\Psi_i}} \right]^{\frac{\Psi_i}{1+\Psi_i}}$$
 (39)

where Q_i is total sectoral domestic production, E_i is exports, D_i is domestic supply, P_i^Q is producer output price (i.e. net of taxes), P_i^E is producer exports price (which turns to be equal to the world price of exports PW_i^E , given the absence of export subsidy), P_i^D is producer domestic sales price (i.e. net of VAT), θ_i is the export share parameter, χ_i is the shift parameter, and Ψ_i is the elasticity of transformation between domestic good and export good, with $0 < \theta_i < 1$, $\chi_i > 0$ and $\Psi_i > 0$.

Solving the above maximisation problem yields the following supply functions of domestically-sold and exported goods

$$D_i = \frac{Q_i}{\left(\chi_i\right)^{\left(1+\Psi_i\right)} \left(P_i^Q\right)^{\Psi_i}} \left(\frac{P_i^D}{1-\lambda_i}\right)^{\Psi_i} \tag{40}$$

$$E_{i} = \frac{Q_{i}}{\left(\chi_{i}\right)^{\left(1+\Psi_{i}\right)} \left(P_{i}^{Q}\right)^{\Psi_{i}}} \left(\frac{P_{i}^{E}}{\lambda_{i}}\right)^{\Psi_{i}}$$
(41)

Total exports are allocated across the EU and the rest of the world by means of the optimisation problem, in which, as above, a constant elasticity of transformation (CET) specification is adopted:

$$\max_{\{E_i^j\}} P_i^E E_i = \sum_j P E_i^j E_i^j \tag{42}$$

s.t.
$$E_i = \chi_i^E \left[\sum_j \theta_i^j \left(E_i^j \right)^{\frac{1+\psi_i^E}{\psi_i^E}} \right]^{\frac{\psi_i^E}{1+\psi_i^E}}; \sum_j \theta_i^j = 1 \text{ for } j = EU, RW$$
 (43)

where total sectoral exports E_i is a composite of regional exports E_i^{EU} and E_i^{RW} , PE_i^j are producer export prices (all of them equal to the fixed world price of exports, PW_i^E), $\chi_i^E > 0$ is the shift parameter, θ_i^j is the share parameter of exports to region $j = EU, RW, \ \psi_i^E$ is the elasticity of transformation between exports, with $\psi_i^E > 0$, and PE_i^j is the producer price of exports to region j.

The supply functions of exports to each foreign region j produced by sector i are given by

$$E_{i}^{j} = \frac{E_{i}}{\left(P_{i}^{E}\right)^{\Psi_{i}^{E}}\left(\chi_{i}^{E}\right)^{\left(1+\Psi_{i}^{E}\right)}} \left(\frac{PE_{i}^{j}}{\lambda_{i}^{j}}\right)^{\Psi_{E}}; i = 1, 2, ..., N; j = EU, RW$$
(44)

Prices of the export good, produced by sector i and exported to region j are equal to exogenous and fixed world export prices times the exchange rate:

$$PE_i^j = erPW_i^E; \, j = EU, RW \tag{45}$$

Aggregate investment I is a Cobb-Douglas composite of sectoral investment goods, inv_i . Each sectoral investment good inv_i is characterised by a CES Armington specification between investment domestic goods $invd_i$ and total imports $invm_i$, and by a Cobb-Douglas function for disaggregated imports. Given that functional parameters and prices are the same for all kinds of uses, optimal investment is determined in the same fashion as (25)-(31).

3.3 Government

The government consumes an exogenous amount of goods, raises taxes and tariffs, provides a transfer to consumers, and runs a balanced budget. Although at first sight the assumption of balanced budget might look unrealistic, it is actually appropriate and roughly consistent with government fiscal balance data for Jordan provided by the IMF.⁴

Aggregate government consumption G is a Cobb-Douglas composite of sectoral goods g_i . In turn, each government sectoral consumption is determined by a CES Armington specification between domestically-produced goods gd_i and imports gm_i in the same way as in (25)-(31). Government revenue is generated from the Value Added Tax (VAT), that applies with different rates to domestic and imported goods (*vatd* and *vatm*), the tax on capital rent (t^K), the income tax (t^Y), import duties, that apply with different rates to the EU and the rest of the world (tm), and foreign grants, FRG, expressed in foreign currency. The expenditure is given by transfer to household TR, and consumption of good G.

The government budget is therefore given by

$$VAT^{D} + VAT^{M} + TY + TK + TM + erFRG = TR + G$$

$$\tag{46}$$

where VAT^{D} is revenue of VAT on domestic goods, VAT^{M} is revenue of VAT on imports, TY is income tax revenue, TK is revenue of tax on capital rent, and TM is import tariff revenue.

⁴The IMF reported the Jordan's government fiscal balance in percent of GDP to equal -4.9 in 2002, -1.0 in 2003 and -1.7 in 2004 (see IMF, 2006).

3.4 Market clearing

The equilibrium on the factors markets requires aggregate endowment of labour be equal to aggregate labour demand and aggregate capital stock be equal to aggregate demand for capital

$$L = \sum_{j=1}^{N} LD_j \tag{47}$$

$$K = \sum_{j=1}^{N} KD_j \tag{48}$$

where L is labour supply (fixed), K is aggregate capital stock, and LD_j and KD_j are demands for labour and capital of production sector j.

The equilibrium in the domestic good markets is given by

$$X_{i} = \sum_{j=1}^{N} q_{i,j} + c_{i} + inv_{i} + g_{i}$$
(49)

where X_i is total sectoral absorption, $\sum_{j=1}^{N} q_{j,i}$ is total intermediate inputs production, c_i is private consumption, inv_i is investment demand, and g_i is government consumption, in sector i.

The equilibrium in the balance of payments is given by

$$\sum_{i=1}^{N} PW_{i}^{M}M_{i} = \sum_{i=1}^{N} PW_{i}^{E}E_{i} + FREM + FGR$$
(50)

where M_i and E_i are, respectively, total imports and total exports of sector i, PW_i^M and PW_i^E are the exogenous world prices of, respectively, imports and exports of sector i, FGR is foreign grant to the Jordanian government, and FREM are foreign remittances to households.

3.5 Data and calibration

The dataset is based on the Social Accounting Matrix (SAM) for Jordan constructed by D. Lucke (2001). The SAM is based on 1998 data, and includes the 1987 inputoutput coefficient matrix updated to 1998. The SAM has nine sectors producing goods and one sector producing services. The model described in the above section has been initially applied in a simplified version with only two production sectors, producing respectively goods and services. Later, as shown in the set of simulations below, the size of the model has been enlarged to include the original 1998 SAM with ten sectors, listed in Table 3.1.

The base-year dataset is assumed to reflect a stationary steady state economy. Parameters are then calibrated in order to obtain a solution reproducing the benchmark equilibrium.

No.	Economic activity
1	Agriculture, hunting, forestry and fishing
2	Mining and quarrying
3.1	Manufactures of food, beverage and tobacco
3.2	Manufactures of textiles, apparels and leather product
3.3	Manufactures of wood, paper and printing
3.4	Manufactures of petroleum and chemicals
3.5	Manufactures of rubber and other non-metallic minerals
3.6	Manufactures of basic metals and fabricated metal except machinery and equipment
3.7	Other manufactures
4-9	Services

Table 3.1. Production sectors.

The world prices of export PW_i^E and import PW_i^M are exogenously fixed to one. Real variables are then derived from the base-year nominal variables provided in the SAM. Elasticity values are taken from existing literature, as Table 3.2 shows.

Elasticity	Value	Source
Substitution between domestic goods and imports	0.6	Devarajan et al. (1999)
Transformation between domestic goods and exports	1.5	Devarajan et al. (1997)
Transformation between regional exports	3	Martin (2000); Lucke B. (2001)
Substitution between labour and capital	0.9	Devarajan and Go (1998)

Table 3.2. Elasticity values.

The assumption of steady state allows to calibrate the dynamic parameters δ and ρ . From the capital accumulation equation (16) and from the stationary steady-state condition $K_t = K_{ss}$, it follows that the depreciation rate of capital is:

$$\delta = \frac{I_{ss}}{K_{ss}} \tag{51}$$

where the subscript ss indicates steady state.

The steady-state intertemporal condition for private consumption, given by the Euler equation (20), allows then to calibrate the consumers' discount rate as:

$$\rho = \left(1 - t^Y\right) \left(1 - t^K\right) \frac{r_{ss}}{P_{ss}^I} - \delta \tag{52}$$

The steady-state conditions apply also as terminal conditions.

3.6 Simulations

The basic feature of each scenario, exogenous and common to all simulations, is given by the gradual reduction of tariff rates on EU-import goods, provided by the EU-Jordan Agreement, and described in table 3.3. For agricultural goods and industrial goods containing agricultural components the import duty reduction is only partial, whereas it is complete for the remaining industrial goods.

	Agriculture	Mining	Food	Textile	Paper	Chemicals	Minerals	Metals	Others
Entry into force of the AA	100%	60%	100%	60%	60%	60%	60%	60%	60%
One year after	100%	53%	100%	53%	53%	53%	53%	53%	53%
Two years after	100%	47%	100%	47%	47%	47%	47%	47%	47%
Three years after	100%	40%	100%	40%	40%	40%	40%	40%	40%
Four years after	90%	30%	90%	30%	30%	30%	30%	30%	30%
Five years after	80%	27%	80%	27%	27%	27%	27%	27%	27%
Six years after	70%	23%	70%	23%	23%	23%	23%	23%	23%
Seven years after	60%	20%	60%	20%	20%	20%	20%	20%	20%
Eight years after	50%	17%	50%	17%	17%	17%	17%	17%	17%
Nine years after	50%	13%	50%	13%	13%	13%	13%	13%	13%
Ten years after	50%	10%	50%	10%	10%	10%	10%	10%	10%
11 years after	50%	7%	50%	7%	7%	7%	7%	7%	7%
12 years after	50%	0%	50%	0%	0%	0%	0%	0%	0%

Table 3.3. Import tariff reduction schedule (percent of the base-year tariffs).

The immediate effect of a reduction in custom duties on imports of a specific trade partner can be seen by considering the first-order conditions for the Armington specification between imports and domestically-produced goods:⁵

$$\frac{cm}{cd} = \left[\frac{\varepsilon P^D}{\left(1 - \varepsilon\right) P^M}\right]^{\gamma} \tag{53}$$

and the first-order conditions for the Cobb-Douglas regional imports:

$$\frac{cm^{EU}}{cm^{RW}} = \frac{\varepsilon^{EU} P M^{RW}}{\varepsilon^{RW} P M^{EU}} \tag{54}$$

⁵For convenience, the subscript denoting the production sector has been dropped.

Prices of regional imports are defined as:

$$PM^{j} = erPW^{M}\left(1 + tm^{j}\right)\left(1 + vat^{M}\right)$$

$$\tag{55}$$

where tm^{j} is the tariff rate on goods imported from region j and vat^{M} is the VAT rate applied to imports.

From (55), a decrease in tm^{EU} will clearly reduce PM^{EU} . From (54) it follows that, ceteris paribus, regional import demand cm^{j} is decreasing in the regional import price PM^{j} . Moreover, since P^{M} is a composite of PM^{EU} and PM^{EU} , a fall in one regional import prices will decrease P^{M} . Therefore, a reduction in the tariff rate on EU import will determine a fall in the EU imports price and in the composite imports price, and a rise in EU imports.

The gradual reduction of the import duty rate decreases prices of imported goods. Domestic prices will also decrease. The fall in domestic prices boosts directly demand, investment might go up and output is expected to increase in the long-run. The loss in government revenue due to the import duty reduction might be partially offset by the expansion in the tax base in the longer run. However, the government must compensate the fall in revenue by undertaking counteracting fiscal measures, such as an increase in the domestic tax rates or a reduction in spending. Therefore the simulation of the AA is accompanied by a parallel change in the domestic policy. Moreover, some intersectoral impact is expected. The sector in which tariff reduction is complete is likely to attract more resources in the long-run, although it might suffer from a short-run negative impact due to the move from protectionism to free trade.

The impact on welfare might be in principle ambiguous. On the one hand, lower domestic prices increase consumption and hence households' welfare. On the other hand, the reduction in government revenue due to cutting import duty rates forces the government to implement painful fiscal measures, such as increase in domestic tax rates or reduction in transfer to households. This will negatively affect disposable income of households, who must ceteris paribus reduce consumption. Such an impact on welfare is therefore negative. The overall impact on households' consumption and welfare depends therefore on the magnitude of the effects of lower consumption prices and lower disposable income. However, the simulations results show that under all scenarios of trade liberalisation welfare rises. Table 3.4 lists the scenarios and summarises the welfare effects.

Scenario	Policy variables	Welfare change %
1	Government transfer	0,06
2	Income tax rate	0,03
3	Government consumption	0,16
4	Government transfer; VAT 10% increase	0,03
5	Government consumption; VAT 10% increase	0,07

Table 3.4. Scenarios and welfare changes.

All scenarios are characterised by two-policy simulations. Trade policy is determined exogenously, it is established by the Association Agreement with the EU and is common to all scenarios, while the responses of domestic policy are a mix of endogenous and exogenous options. In scenario 1, government transfer to households is the endogenous policy variable. In scenario 2, the reform of the domestic income taxation is the government endogenous policy choice. In the third scenario, the endogenous policy choice is government consumption. In scenarios 4 and 5, respectively government transfer and government consumption are endogenous, while an additional exogenous policy response is put into effect in both scenarios, namely an increase by 10% in the VAT rates.

Scenario 1: Association Agreement and endogenous government transfer

As pointed out above, the reduction of the import duty rates on EU imports will immediately decrease the prices of imported goods. This will cause, ceteris paribus, a fall of final internal prices, which are a composite of prices of imports and domestically-produced commodities. As figure 3.1 shows, composite prices of private consumption (PC), government consumption (PG) and investment (PI) fall relatively to their benchmark levels, which have been initialised to one, and approach the new steady-state level from above.

Alongside the exogenous import duties reduction, the endogenous policy variable playing a role in the simulation is government transfer to households. Clearly, given the fall in government revenue, transfer to households is expected to decrease. As shown in figure 3.2, during the gradual reduction of the EU import tariff rates, the drop in government revenue forces the government to cut transfer to households, which falls relatively to the benchmark value equal to one, has a decreasing trend until the 13th year, increases very slightly and finally approaches the steady state from below.



Figure 3.1. Prices under scenario 1.

The path of transfer in the initial 15 years shows ups and downs. This rather unexpected time path characterises also the trend of government revenue, shown in figure 3.3. This is due to the fact that, whereas time is continuous, the import tariff reduction is a discrete-time process, i.e. it takes place at a specific point in time. This causes a discrete adjustment in government revenue, that fluctuates around the trend. The behaviour of government revenue in turn affects the path of transfer to households.



Figure 3.2. Government transfer to households under scenario 1.

The implementation of this two-policy simulation has two impacts on the revenue of government: (i) an immediate and direct effect brought about by the reduction in import duties, that lowers government revenue; (ii) the expected effect of increased internal demand, determining a larger domestic tax base, that raises government revenue.

The outcome depends on the magnitudes of the above two effects. Altogether the first effect is larger, as both government revenue and transfer to households are, for all time periods, below their benchmark values. However, along the transition to the new steady state, it might well be that in some periods the second effect is larger than the first one, and thereby government revenue and transfer increase relatively to the previous time period. In fact, after the negative trend in the initial periods, government revenue increases slightly and approaches the steady-state level from below.



Figure 3.3. Government revenue under scenario 1.

One of the most important and most relevant results of the simulation concerns the impact on private real consumption, since welfare of households depends on consumption. As figure 3.4 shows, private consumption reaches in the long-run a higher level than the initial benchmark value. However, although the impact on welfare is positive, consumption initially falls relatively to the benchmark level, afterwards it keeps increasing in all periods, and it is below the benchmark value until the 8th year after the entry into force of the AA. The implication of this analysis suggests that consumers must give up some current consumption in order to achieve higher future consumption.

This clearly raises the question concerning the political feasibility of the trade liberalisation process undertaken by the Jordanian government.


Figure 3.4. Private consumption under scenario 1.

Whereas opening up domestic trade leads unambiguously to an increase in welfare, the government willingness to follow consistently a trade liberalisation policy might be harmed, given the "political price" to be paid in terms of short-run decrease in private consumption.

Capital and investment are in all periods above their benchmark levels. The fall in domestic prices pushes up internal demand, which, in turn, boosts new capital formation. As shown by figures 3.5 and 3.6, capital keeps increasing and reaches the new long-run equilibrium value from below, whereas investment follows a different pattern. Aggregate investment is much above the benchmark value in the initial periods, then it falls slowly, and finally reaches from above the new steady state, which is higher than the initial level.



Figure 3.5. Capital stock in scenario 1.



Figure 3.6. Investment in scenario 1.

Trade liberalisation is expected to have also sectoral effects. The formerly protected sectors might experience a long-run increase in output, due to a shift of resources from other sectors. However, they may be negatively affected in the very short-run, due to increased foreign competition.



Figure 3.7. Sectoral outputs under scenario 1.

Nevertheless, simulation results support the view that trade liberalisation brings about positive effects also in the short-run, and penalises sectors in which trade openness is incomplete, i.e. agriculture and food sectors, in terms of slowdown in the very short-run and lower long-run equilibrium levels.

Figure 3.7 shows how outputs of all good sectors are affected by opening up domestic trade. The agriculture and food sectors, in which trade liberalisation begins

four years after the entry into force of the Association Agreement and in which tariff rates are only partially reduced, experience initially a slowdown in production, and the lowest percentage increases in the final steady-state values. Sectors in which trade liberalisation is complete and faster avoid the short-run negative impact on output and achieve higher long-run equilibrium levels.

Table 3.5 lists the output level for each sector at the period when the Association Agreement enters into force, i.e. when the first shock occurs, and the steady-state values in the long-run equilibrium. From both figure 3.7 and table 3.5 it can be seen that agriculture and food sectors are those that benefit least from trade liberalisation, and are actually harmed in the short-run. The same conclusion on sectoral outputs effects can be drawn by analysing results of the remaining scenarios.

Sector	first shock	final steady state
Agriculture	0,9796	1,0201
Mining	1,0035	1,0500
Food	0,9801	1,0196
Textile	1,0313	1,1751
Paper	1,0210	1,0400
Chemicals	1,0032	1,0565
Minerals	0,9981	1,0249
Metals	1,0149	1,0347
Others	1,0467	1,1367
Services	0,9992	1,0138

Table 3.5. Sectoral outputs.

Scenario 2: Association Agreement and endogenous income tax rate

Under this scenario the income tax rate is the endogenous policy variable used by the Jordanian government to counteract the fall in revenue. Given the immediate decrease in government revenue, the endogenous income tax rate is expected to be set above the benchmark value of of 0.072, to keep increasing during the 12-year transition period towards the free-trade area, and finally to stabilise or perhaps slightly fall, given the possibly larger domestic tax base.

In the simulation the "optimal" income tax rate moves to a value around 0.08 in the initial periods, it increases steadily, after 12 years it decreases very slighly, and it approaches from above the new steady-state rate of 0.089, as shown in figure 3.8. Although this is a simplification, since in reality the income tax rates are six, the simulation provides a clear and expected insight for fiscal policy reform.



Figure 3.8. Optimal income tax rate.

Qualitative results for all macroeconomic variables are the same like under the other scenarios. Figure 3.9 shows the time path of capital, which is very similar under all scenarios. Given the fall in domestic prices, investment demand goes up, capital stock rises over time and approaches the new steady-state level from below. It has to be noticed that the new steady-state level of capital is 1.02, which is lower than the steady-state value of 1.05 under scenarios 1 and 3. This difference is probably due to the distortionary effect introduced by the endogenous income tax rate. The higher income tax rate has a negative effect on consumers' income, and it also creates a distortion in the optimal choices of consumers. In this simulation therefore, optimal investment choice might be negatively affected by the endogenous income tax rate, which is not present in the other scenarios, since t^Y is constant there. Due to such distortion, ceteris paribus, capital grows less than under the other scenarios, and reaches a lower long-run equilibrium value.



Figure 3.9. Capital stock under scenario 2.

Scenario 3: Association Agreement and endogenous government consumption

In this simulation, macroeconomic variables follow a path which is qualitatively the same as in scenarios 1 and 2. Quantitavely, it has to be noticed that the increase in welfare is larger than under the other two scenarios, due to a faster and higher growth in private consumption, as shown in figure 3.10.

It is in fact no surprise to find that welfare increase under scenario 3 is larger than under the other two simulations. In the previous two scenarios the policy choice implemented by the government reduces household income. Therefore, ceteris paribus, private consumption and utility will also fall. The reduction in government consumption, instead, does not reduce welfare, because government spending plays no role in utility of consumers. However, the credibility of such result might be questioned, given that the government is likely to face a problem of feasibility in cutting consumption.



Figure 3.10. Private consumption in scenario 3.

Under scenarios 1 and 2, households' consumption reaches the benchmark value of 1 between 6 and 7 years after the start of the tariff reform, and ends with long-run equilibrium levels which are 1.01 in scenario 3 and 1.02 in scenario 1. Without the negative impact on income due to lower government transfer and higher income tax rate, consumption under scenario 3 reaches the benchmark level after 2 years and ends with a new steday-state value very close to 1.04.

The endogenous policy variable, i.e. government consumption, is expected to fall relatively to the benchmark value of one, to keep falling given the government budget constraint, and perhaps increase slightly in the long-run, when the negative short-run effect of trade liberalisation on government revenue is compensated by the positive effect brough about by the larger domestic tax base.



Figure 3.11. Endogenous government consumption.

Figure 3.11 depicts the dynamic path of endogenously-determined government consumption, that lies always below the benchmark level, falls in the initial periods, follows an increasing trend after 12 years, and finally approaches the new steady state from below.

Scenario 4: Association Agreement, endogenous government transfer and exogenous VAT rates increase

This scenario implements an exogenous increase in the VAT rates by 10% together with the endogenisation of government transfer to households, like in scenario 1. One would expect a positive impact on household welfare, brought about by trade liberalisation. Moreover, the increase in welfare is expected to be smaller than under scenario 1, given that the reduction of distortionary import tariffs is accompanied by distortionary side-effects brought about by the exogenous increase in the VAT rates. The results are consistent with expectations. Welfare rises by 0.03%, whereas under scenario 1 the increase was 0.06%. Consumption follows a slightly different path from the one under scenario 1. As figure 3.12 shows, private consumption initially falls below the benchmark value, but the initial decrease relative to the benchmark level is smaller than the drop under scenario 1.

Private consumption rises afterwards, it reaches the benchmark level after 10 years, and then approaches the final steady-state value from below. After normalising the benchmark level to 1, the long-run equilibrium value of consumption is 1.012, smaller than the long-run consumption under scenario 1, which is equal to 1.021. As pointed out above, this can be explained by the effects due to the VAT rates increase.



Figure 3.12. Consumption under scenario 4.

There are two impacts on the consumption price index brought about by exogenous policy choices. The reduction in import duties determines a decline in domestic prices, which raises demand. On the other hand, the increase in the VAT rates brings about a rise in prices, which has a negative impact on consumption. The consumption price index has quite a different behaviour than the one observed under scenario 1, as figure 3.13 shows.



Figure 3.13. Consumption price index under scenario 4.

Whereas previously the consumption price was below the benchmark value for all periods, under scenario 4, it increases slightly in the initial periods, it drops along the transition period, and then it approaches the long-run value from above. The final steady-state price is 0.992, higher than the long-run price under scenario 1, which was 0.982.

The exogenous increase in the VAT rates, compared with scenario 1, reduces aggregate demand and hence also investment demand. This determines therefore a lower growth rate of the capital stock, which reaches the long-run equilibrium level of 1.032, as shown in figure 3.14, whereas under scenario 1 this was 1.05.



Figure 3.14. Capital stock under scenario 4.

Finally, it is worthwhile to note that, whereas under scenario 1, the burden of the fall in government revenue was borne only by transfer to households, under scenario 4 the increase in the VAT rates determines, ceteris paribus, higher values of government transfer. As shown in figure 3.15, transfer to households is above the benchmark value in the initial three years and falls steadily afterwards. The long-run equilibrium value is 0.87, fairly above the steady-state value under scenario 1, equal to 0.74.



Figure 3.15. Government transfer to households under scenario 4.

Scenario 5: Association Agreement, endogenous government consumption and exogenous VAT rates increase

In this scenario the simulation performed in scenario 3 is extended, by adding an exogenous ten-percent increase in the VAT rates to the endogenous change in government consumption. Like in scenario 4, domestic prices are affected through two exogenous channels. The gradual reduction in import tariff rates leads to lower prices in the domestic economy, which boosts internal demand. On the other hand, the increase in the VAT rates increases domestic prices and hence affects negatively domestic demand. As a result, the consumption price index is at the very beginning of the time-horizon above the benchmark value when preferential trade liberalisation and the VAT rate increase take place, as it is shown in figure 3.16. The price index falls thereafter, it reaches the benchmark level at the second year, and approaches the long-run equilibrium value, equal to 0.992, from above. As expected, the final steady-state consumption price is higher than under scenario 3, given the additional effect brought about by the increase in the VAT rates.

Like in the other scenarios, private consumption drops below the benchmark level, it rises steadily and approaches the final long-run equilibrium from below. The final steady-state level of private consumption is 1.021, far below the long-run consumption value determined by scenario 3. As a result, implementing the exogenous increase in the VAT rates has decreased the welfare gain under scenario 3 from 0.16% to 0.07%.



Figure 3.16. Consumption price index under scenario 5.

Comparing these simulation results with those of scenario 3, the exogenous increase in the VAT rates determines also higher government consumption, as one would expect. As figure 3.17 shows, government consumption is above its benchmark value in the first two periods, it then drops, overshoots and reaches the long-run equilibrium equal to 0.98, whereas it was 0.96 under scenario 3.



Figure 3.17. Government consumption under scenario 5.

3.7 Conclusions

In this chapter the bilateral trade liberalisation process undertaken by Jordan has been assessed by means of a dynamic CGE model, in which one representative consumer chooses consumption and new capital in order to maximise her discounted lifetime utility. The standard trade model is able to capture intertemporal effects on Jordan of opening up domestic trade, with particular emphasis on consumer welfare. The policy implications for the Jordanian economy of the PTA with the EU have also been analysed.

The main conclusions drawn from the set of two-policy simulations are therefore: (i) the Association Agreement with the EU brings about in Jordan positive long-run effects on all macroeconomic variables; (ii) the impact of trade liberalisation on welfare is positive under all scenarios; (iii) the government should counteract the negative impact of opening up domestic trade on government revenue by implementing fiscal policy reforms; (iv) trade liberalisation and government counteracting actions affect negatively private consumption in the short-run and raise concerns about political feasibility of the trade liberalisation process; and (v) sectors in which trade liberalisation is complete and faster benefit more than sectors in which import duties are only partially removed.

4 The Poverty Model

Trade liberalisation processes undertaken by many developing countries over the past years have raised many concerns that liberalisation of domestic trade in the developing countries will affect negatively the poor and it will increase the income gap between the rich and the poor. Given the lack of studies about effects of trade liberalisation on poverty and income distribution in Jordan, this dissertation aims at providing evidence that trade liberalisation has different impacts across different household classes. The process of opening up domestic trade might lead to unequal distribution of welfare gains, and might even make some specific groups worse off.

As mentioned in chapter 1, in the context of general equilibrium modelling several studies have been conducted to assess aspects of income distribution related to trade liberalisation (see Reimer, 2002 for a survey and Winters et al., 2004 for an overview). However, this is the first approach that analyses income distribution in an applied dynamic neoclassical general equilibrium framework in which heterogeneous households are assumed to have different discount rates.

In the general equilibrium analysis of poverty and distribution issues, there are mainly two approaches. One is to use a CGE model with one single representative consumer. The changes in commodity and factor prices generated by a trade liberalisation experiment are applied to household data to compute the impacts on poverty and income distribution. This approach has been followed, among others, by Ianchovichina et al. (2001), who simulate unilateral trade liberalisation in Mexico and estimate that, combining price and income changes, welfare increases for all households, with larger proportionate changes for poorer households, and by Hertel et al. (2001), who examine the effects of multilateral liberalisation on seven countries and find that liberalisation reduces poverty in four countries and increases it in three countries.

The second approach is to embed the household dissaggregation within the CGE model. As pointed out by Winters et al., this approach has the advantage of being internally consistent. Simulations help therefore to identify the household classes that are vulnerable even when trade liberalisation is beneficial on average. All studies find that trade liberalisation has different impacts on different household categories. Decaluwé et al. (1999) incorporate the analysis of income distribution and poverty into the social accounting matrix (SAM) and computable general equilibrium (CGE)

methodology in an archetype African economy, characterised by six different household categories. Bourguignon at el. (1991) carry out illustrative simulations of a stabilisation package for a representative economy, and find a large adverse impact on the distribution of income. Harrison et al. (2003) develop a multi-regional and multi-sectoral model to evaluate the trade policies options faced by Brazil, i.e. regional arrangements and multilateral trade liberalisation. Households are disaggregated across 20 groups, ten rural and ten urban, that are distinguished by income levels. The simulations suggest that most of the trade policies options result in an overall welfare gain to Brazil, and in larger gains to the poorest households. Cockburn (2001) applies a CGE model to study the impacts of Nepal's trade liberalisation on poverty and income ditribution. Poverty falls urban areas and increases in rural areas. Impacts are larger with higher income levels, leading therefore to an increase in income inequality. Löfgren (2001) studies the impact of alternative development strategies on growth and poverty in a dynamic model for Egypt. Households are disaggregated into six groups, according to their income, i.e. rich, middle and poor, and the area where they live, i.e. urban and rural. He finds positive impacts of price liberalisation on welfare of all household groups. However, the effects are smaller for the poor, and inequality increases. The same kind of household disaggregation is applied in a dynamic framework by Löfgren et al. (1999), who assess the effects of the Association Agreement with the EU on Morocco. Simulation results show that trade liberalisation has small aggregate effects, but disfavours the rural poor. However, trade liberalisation combined with complementary domestic policies lead to welfare increases for all household groups. Bautista et al. (1998) stress the importance of implementing fiscal adjustment measures that accompany the process of trade liberalisation, and conclude that failure to undertake complementary policies may explain why trade liberalisation efforts in many African countries did not contributed to egalitarian growth.

As mentioned in chapter 3, previous studies on Jordan's trade liberalisation by B. Lucke (2001) and Hosoe (2001) used static CGE models with one homogeneous household. To my knowledge, there is no work on Jordan's trade liberalisation based on a dynamic CGE model with heterogeneous households.

The Jordanian economy is modelled as a dynamic small open economy building on a model which is very similar to the one presented in the previous chapter. The main difference lies on the consumption side. Whereas in the standard trade model one representative household maximises her discounted lifetime utility, the poverty model captures household heterogeneity. The household disaggregation is embedded within the CGE model. In detail, households are disaggregated into six different classes ranked by their disposable income. Within each of six different household groups one typical consumer maximizes discounted intertemporal utility subject to a budget constraint. Households groups' individual tax rates, wage rates, initial endowments of assets, tranfers from the government and from abroad and consumption preferences are calibrated from data from a 2002 households survey. Moreover, different households' time preferences are also calibrated from survey data by assuming that consumption levels of all households are stationary in the long-run.

In the domestic economy there are nine production sectors, eight of which producing goods and one producing services. Aggregate private consumption, government consumption and aggregate investment are Cobb-Douglas composites of nine different sectoral outputs, which in turn are composites of domestically produced and imported goods modelled through the Armington (1969) specification. Firms in each of the nine production sectors use a Leontief production technology between intermediate goods and value added output, which is in turn a CES composite of capital and six different kinds of labour. Total output can be sold domestically or exported according to a CET specification. The government raises taxes and collects tariffs. Revenues are spent for a fixed amount of government consumption as well as transfers to households. The domestic economy is a price-taker on international markets. Perfect competition and full employment are assumed in all sectors. Production factors are perfectly mobile across sectors.

The model is implemented by means of the mathematical software Gauss and by employing the relaxation algorithm proposed by Trimborn (2006). This allows for simulation exercises regardless of the dimension of the state space. The simulation results indicate changes in per-capita level of welfare in Jordan between -0.03% and 0.21%, providing evidence that trade liberalisation has indeed different impacts across heterogeneous households. More precisely, low income households gain slightly more from trade liberalisation in terms of welfare, since they can overcome losses in government transfer by an increasing wage income due to aggregate capital accumulation. However, income inequality increases, since high income households can exploit the benefits of increased incentives for investment. This results in higher capital income and, therefore, a widening income gap. Remarkably, the behavior of aggregate variables is qualitatively consistent with the one-representative-household model.

4.1 Households

The problem of each infinitely-lived household i is to maximize discounted intertemporal utility

$$\int_0^\infty \log\left(C_i\right) e^{-\rho_i t} dt, \, i = 1, \dots, H \tag{56}$$

subject to

$$\dot{K}_i = SAV_i - \delta K_i = -\frac{YD_i - P_i^C C_i}{P^I} - \delta K_i$$
(57)

$$K_i(0) = K_{i,0} (58)$$

where C_i , SAV_i , YD_i , K_i are respectively consumption, saving, disposable income and capital asset of household i, δ is the capital depreciation rate, P_i^C is the consumption price index of household i, and P^I is the composite price of the investment good. The representative household in each class discounts future utility with discount rate ρ_i , which is specific to each household group.

Disposable income of each household class i is given by

$$YD_i = (1 - \tau_i)(w_iL_i + rK_i + Tr_i + erFT_i)$$

$$\tag{59}$$

where w_i , L_i , K_i , Tr_i and FT_i denote the individual wage rate, labour endowment, capital endowment, government and foreign transfers to each household group, respectively. The exchange rate er is the model numeraire. The interest rate r is identical for each household since capital is a homogenous good. Each household pays a different income tax τ_i .

The solution to the above dynamic maximisation problem yields the Euler equation

$$\frac{\dot{C}_i}{C_i} = \frac{\left(1 - \tau_i\right)r}{P^I} - \rho_i - \delta \tag{60}$$

Consumption of each household group is a Cobb-Douglas composite of sectoral consumption

$$C_{i} = \Omega_{i}^{C} \prod_{j=1}^{N} c_{i,j}^{\theta_{i,j}^{C}}, \, \Omega_{i}^{C} > 0, \, 0 < \theta_{i,j}^{C} < 1, \, i = 1, 2, ..., H, \, j = 1, 2, ..., N$$
(61)

where $c_{i,j}$ is household *i*'s consumption of good *j*, $\theta_{i,j}^C$ is the share parameter of good *j* and Ω_i^C is the shift parameter in the Cobb-Douglas consumption function of household *i*, H = 6 is the number of household groups and N = 9 is the number of production sectors in the Jordanian economy.

Each household i solves the static constrained maximisation problem

$$\max_{c_{i,j}} \ \Omega_i^C \prod_{j=1}^N c_{i,j}^{\theta_{i,j}^C} \quad \text{s.t.} \quad P_i^C C_i = \sum_{j=1}^N P_j^X c_{i,j}$$
(62)

which yields the household i's functions of demand for consumption good produced by sector j

$$c_{i,j} = \theta_{i,j}^C \frac{P_i^C C_i}{P_j^X} \tag{63}$$

where $c_{i,j}$ is consumption demand of household *i* for good *j*, and P_j^X is the price of the final good produced by sector *j*.

Aggregate government transfers to households are given by

$$TR = \sum_{i=1}^{H} Tr_i \tag{64}$$

while government transfers to each household class are fixed proportions of aggregate transfers:

$$Tr_i = \pi_i TR; \ 0 < \pi_i < 1; \ \sum_{i=1}^H \pi_i = 1$$
 (65)

where π_i is the fixed share of aggregate transfers paid to household group *i*.

4.2 Firms

Sectoral output in the domestic economy is determined by a two-stage production process, which exhibits at the top tier a Leontief (or fixed-proportions) specification between intermediate input and value-added output. Each representative firm of activity j produces total output according to the following production technology

$$Q_j = \min\left\{\frac{VA_j}{a_{VA,j}}, \frac{q_{1,j}}{a_{1,j}}, \dots, \frac{q_{9,j}}{a_{9,j}}\right\}; \ j = 1, \dots, N$$
(66)

where Q_j and VA_j are sectoral output and value added, respectively. $q_{i,j}$ is intermediate input produced by sector *i* and used in the production of activity *j*. Leontief coefficients are denoted by $a_{(\cdot)}$. N = 9 is the number of production sectors in the domestic economy.⁶ At the second tier, intermediate input $q_{i,j}$ is a CES composite of domestic and foreign intermediate consumption goods.

Value-added production is determined by a technology characterized by a constant elasticity of substitution between the primary inputs, capital KD and six different types of labour LD_i , appendant to each household class *i*:

$$VA_{j} = A_{j} \left[\sum_{i=1}^{H} \alpha_{i,j} LD_{i,j}^{\frac{\sigma_{j}-1}{\sigma_{j}}} + \left(1 - \sum_{i=1}^{H} \alpha_{i,j}\right) KD_{j}^{\frac{\sigma_{j}-1}{\sigma_{j}}} \right]^{\frac{\sigma_{j}}{\sigma_{j}-1}}$$

$$\alpha_{i,j} > 0; \ 0 < \sum_{j=1}^{H} \alpha_{i,j} < 1; \ \sigma_{j} > 0; \ \sigma_{j} \neq 1$$

$$(67)$$

where A_j is the time-invariant technological parameter, $\alpha_{i,j}$ is the share parameter of labour of type i, σ_j denotes the constant elasticity of substitution between primary inputs, and H = 6 is the number of households. At the value-added production stage, firms minimize production costs subject to the above technology constraint.

4.3 Government

The government consumes an exogenous amount of goods, raises taxes and tariffs and provides transfers to consumers. The government balance budget is assumed to be balanced. As noted already in the previous chapter, although at first sight the assumption might look unrealistic, it is actually appropriate and roughly consistent with government fiscal balance data for Jordan provided by the IMF.⁷

Aggregate government consumption G is a Cobb-Douglas composite of sectoral goods g_i . Government consumption of good i is determined by a CES Armington specification between domestically-produced goods and imports. Government revenue is generated from the Value Added Tax, on domestic goods VAT^D and on imports VAT^M , that apply with different rates, vat^D and vat^M , to domestic and imported goods, the income tax, TY, and import duties, TM, that apply with different rates to the EU and the rest of the world, tm^{EU} and tm^{RW} , and foreign grants, FRG,

⁶In the standard trade model the number of production sectors is N = 10.

⁷The IMF reported the Jordan's government fiscal balance in percent of GDP to equal -4.9 in 2002, -1.0 in 2003 and -1.7 in 2004 (see IMF, 2006).

which are exogenous and fixed. The expenditure is given by aggregate transfers to households TR, and aggregate and fixed consumption of goods and services, G.

The government budget is therefore given by

$$VAT^{D} + VAT^{M} + TY + TM + erFRG = TR + G$$

$$(68)$$

where on the left-hand side there are tax revenues, tariff revenue and foreign grants, and on the right-hand side there is total expenditure.

4.4 Market clearing

The equilibrium in the factors markets requires that for each type of labour aggregate endowment of labour is equal to aggregate labour demand and that aggregate capital stock is equal to aggregate demand for capital

$$L_i = \sum_{j=1}^N LD_{i,j} \tag{69}$$

$$\sum_{i=1}^{H} K_i = \sum_{j=1}^{N} KD_j$$
(70)

where L_i and K_i are labour and capital supplied by household *i*, and N = 9 is the number of production sectors in the domestic economy.

The equilibrium condition in each good market j is given by

$$X_{j} = \sum_{i=1}^{N} q_{j,i} + \sum_{h=1}^{H} c_{h,j} + inv_{j} + g_{j}$$
(71)

where X_j is total absorption in sector j, $\sum_{i=1}^{N} q_{j,i}$ is total intermediate inputs production, $\sum_{h=1}^{H} c_{h,j}$ is total demand of private consumption, inv_j is investment demand and g_j is government consumption, in sector j.

The equilibrium in the balance of payments is given by

$$\sum_{j=1}^{N} PW_{j}^{M}M_{j} = \sum_{j=1}^{N} PW_{j}^{E}E_{j} + \sum_{i=1}^{H} FT_{i} + FGR$$
(72)

where M_j and E_j are, respectively, imports and exports of sector j, PW_j^M and PW_j^E are the exogenous world prices of, respectively, imports and exports of sector j, and FGR is the foreign grant donated to the Jordanian government.

4.5 Data and calibration procedure

The calibration procedure is based on the Social Accounting Matrix (SAM) for Jordan constructed for the year 2002.⁸ The model's parameters are calibrated such that the SAM represents a solution of the model where all variables are stationary, except asset accumulation of individual households. The reason is that the fractions of savings and assets are not the same across households and therefore the assumption of stationarity for individual accumulation would violate the SAM.

Household survey data allow disaggregation into six different groups of households, ranked by their income levels. Each group differs with respect to labour income, capital income, transfer from government and from abroad, income-tax payments, savings as well as total consumption and its composition. Within the calibration process this results in different exogenous variables for each group of households as well as different parameters. It has to be noticed that according to Jordan's new tax system there is no distinction between labour and capital income taxation. Households are taxed with a progressive, general income tax. This results in different net interest rates and therefore each household faces different incentives for saving. Time preference rates are calibrated such that they exactly offset this effect in the long run.⁹ In addition, individual households' preferences are reflected in different consumption baskets according to the consumption pattern of each household in the benchmark year.

Figure 4.1 shows the levels of per capita income of the six households classes. For convenience and throughout the chapter, the poorest household class is denoted as HH1, and the richest household group as HH6. Total per capita income of the richest household group (HH6) has been normalised to one. The picture provides information on the income gap between rich and poor household groups. It provides also some insight about the income composition, which differs across household classes.

⁸The SAM was constructed by Feraboli and Kolev.

⁹Precisely this means that all households' consumption grows with the same rate in the long run since otherwise some would vanish asymptotically.



The income composition of each household group, together with the size, is reported in table 4.1.

Class	Individuals	Labour	Capital	Gov. Transfer	Foreign remit.
HH1	81184	48%	27%	14%	11%
HH2	583420	58%	24%	10%	8%
HH3	970240	58%	27%	8%	7%
HH4	1251301	52%	32%	9%	7%
HH5	1224470	45%	39%	8%	8%
HH6	939704	30%	57%	6%	7%

Table 4.1. Size and income composition of the household groups.

In figure 4.2 the income composition of the six household groups is shown graphically. As expected, poor households rely on labour income and government transfer more strongly than rich consumers do, while rich household have a much larger share of capital income in their total income than the poorer.¹⁰

¹⁰The share of capital income in total income of the two poorest household classes is unexpectedly high. The suspect is that this is in reality self-emplyoment labour income which has been reported wrongly. However, this does not affect the main simulation results, given that poor households have still lower capital income shares than rich households.



Elasticities of substitution are obtained again from the existing literature (Devarajan et al., 1997 and 1999, Devarajan and Go, 1998, Martin, 2000 and B. Lucke, 2001). Once these parameters have been fixed, the remaining parameters are calibrated from the SAM on the assumption that the base-year dataset reflects a stationary steady state economy.

The model is programmed in Gauss and solved with the relaxation procedure as proposed by Trimborn et al. (2006). Very importantly, the relaxation procedure can simulate transitional dynamics on multidimensional stable manifolds. This means that an increase in the dimension of the model, especially in the state space, does not cause any conceptual problems.

4.6 Simulations

As illustrated in chapter 3 the economic effects of the EU-Jordan Association Agreement can be summarized by a gradual reduction of tariff rates on EU imports in Jordan according to the time schedule shown in table 4.1. Since the data available for the calibration procedure represent the Jordan economy of the year 2002 this is the benchmark year. In the simulations tariff rates are then gradually reduced in the subsequent years.

Like in the trade model, each scenario has two components: (i) the prefential trade liberalisation implemented through the Association Agreement, and (ii) the domestic policy responses accompanying the trade liberalisation process. Table 4.2 shows the schedule of tariff reduction over the 12-year transition period. Tariff liberalisation is partial for agricultural goods and industrial goods with agricultural components. The reduction in the tariff rates on EU imports is complete for the remaining manufacture goods.

	Agriculture	Mining	Food	Textile	Paper	Chemicals	Minerals	Others
Entry into force of the AA	100%	60%	100%	60%	60%	60%	60%	60%
One year after	100%	53%	100%	53%	53%	53%	53%	53%
Two years after	100%	47%	100%	47%	47%	47%	47%	47%
Three years after	100%	40%	100%	40%	40%	40%	40%	40%
Four years after	90%	30%	90%	30%	30%	30%	30%	30%
Five years after	80%	27%	80%	27%	27%	27%	27%	27%
Six years after	70%	23%	70%	23%	23%	23%	23%	23%
Seven years after	60%	20%	60%	20%	20%	20%	20%	20%
Eight years after	50%	17%	50%	17%	17%	17%	17%	17%
Nine years after	50%	13%	50%	13%	13%	13%	13%	13%
Ten years after	50%	10%	50%	10%	10%	10%	10%	10%
11 years after	50%	7%	50%	7%	7%	7%	7%	7%
12 years after	50%	0%	50%	0%	0%	0%	0%	0%

Table 4.2. Import tariff reduction schedule (percent of the base-year tariffs).

While the implementation of the AA is a feature common to all scenarios, the government responses are specific to each simulation. Since the government revenue is expected to decrease, counteracting fiscal measures by the government must be taken into account. In scenario 1 this is a reduction in aggregate government transfers to households. Precisely total transfers from government granted to households are endogenous whereas the share that each household receives is fixed. This assumption guarantees that the reduction of distortionary tariffs is not accompanied by distorionary side-effects due to additional taxation. In scenario 2, aggregate government transfers are endogenous and additionally it is investigated how a ten-percent increase in all VAT rates affects the economy. In scenario 3, aggregate government transfers are endogenous, and an exogenous change in the transfer shares to the households is simulated, i.e. a change in the values of the parameters π_i 's, in order to yield a more equal distribution of welfare gain across the households groups. In the fourth simulation experiment, government consumption is the endogenous variable.

The immediate effect of reducing import rates on EU imports is a change in the relative prices in the domestic economy. The price of EU imports falls relatively to the price of imports from the rest of world. The composite import price will also decrease relative to the price of domestically-produced goods. The fall in the import prices increases incentives for investment, which in turn leads to faster capital accumulation. In the long-run equilibrium this leads to a higher value of aggregate capital stock. Output is also expected to increase in the long-run. The loss in government revenue due to reduction in import duties is partially offset by the expansion in the tax base in the long-run. In the short-run government transfers to households are expected to fall to compensate for the immediate drop in government revenue. Consumption is likely to increase in the long-run on aggregate and also for each household class, but in the short-run consumption of specific household groups or even aggregate consumption might fall.¹¹

The impact on welfare on individual household classes is therefore ambiguous. On the one hand, the long-run increase in consumption increases welfare. On the other hand, reduction in the government revenue brought about by trade liberalisation forces the government to cut transfers to households, at least in the short-run. This affects negatively disposable income of households, who are forced, ceteris paribus, to reduce consumption. This will clearly have an adverse impact on welfare. Moreover, whereas on the aggregate level consumption might increase also in the short-run, the benefits might be distributed unevenly across different households, and some specific household group can be worse off after the trade liberalisation takes place.

Table 4.3 summarises the impacts on the welfare under the four scenarios. The two-policy simulations result in welfare gains for most household classes, and in larger gains to the two poorest household groups than to the richest. The only household category that loses from trade liberalisation is the second-richest household group (HH5), that is better off only under scenario 3, in which an exogenous and arbitrary change in government transfers shares is implemented. Therefore, trade liberalisation is not always Pareto-improving since some households, i.e. group denoted HH5, are worse off under two scenarios, namely scenario 1 and 2.

Scenario	Policy variables	HH1	HH2	HH3	HH4	HH5	HH6
1	Government transfers	0,06	0,19	0,08	0,04	-0,03	0,06
2	Government transfers; VAT 10% increase	0,05	0,14	0,02	0,00	-0,07	0,03
3	Government transfers; change in Tr shares	0,06	0,03	0,08	0,04	0,01	0,06
4	4 Government consumption		0,21	0,10	0,07	0,00	0,08
Table 4.3. Scenarios and welfare changes.							

¹¹This is the case in the standard trade model analysis, considered in chapter 3.

Figure 4.3 provides a picture of the welfare results and the absolute size of each household group.



Figure 4.3. Welfare changes and sizes of household classes.

Inequality is measured with the Gini index of income (Gini, 1912), which is shown in figure 4.4. From the initial value of 0.2763, the Gini index follows different paths under the four scenarios. Under scenario 3, the Gini index increases immediately very sharply with trade liberalisation, and ends up with a value of 0.281, which is the highest Gini index in the long-run under all scenarios. Under scenarios 1 and 4, the Gini indeces follow a very similar pattern, with a small initial increase and a long-run value around 0.278. The index under scenario 2 follows a quite different path. It falls at the very beginning of the trade liberalisation process, but it rises immediately and approaches the long-run equilibrium from below, reaching the value of 0.281.

The reason for increasing Gini indeces is that households rely differently on various sources of income. Government transfers are reduced immediately when trade liberalisation begins and they are decreasing in the following years. This clearly affects relative strongly income of poor households. Furthemore, poor households use their amount of capital assets to smooth consumption, since they have to overcome temporary decreases in income.

Therefore, the immediate response of income to trade liberalisation is positive for the rich and negative for the poor. In addition, the increase in income is larger the richer the household is, which over time leads to a larger income gap between rich and poor households. Figure 4.8 will show graphically how income reacts to the shocks.



Figure 4.4. Gini index of income.

Scenario 1: Association Agreement and endogenous government transfers

In the first simulation experiment the Association Agreement is implemented and aggregate government transfers to households, TR, are endogenous. While aggregate transfers are endogenous, the shares of aggregate transfer received by each household group, π_i 's, are fixed. As pointed out above, the gradual reduction in the EU tariff rates induces a fall in the composite price of imported goods. This leads to an increase in the domestic demand for consumption and investment goods. The upward movement in investment results in an increase of aggregate capital stock and in higher production in the long-run. Figure 4.5 shows the consumption path of heterogeneous households. The three poorest household groups, i.e. HH1, HH2 and HH3, are immediately identifiable as "winners", since their consumption level is at all time above the benchmark value. Hence, regardless of their discount rate, they are expected to experience an increase in welfare, as already indicated by table 4.3. For the remaining household classes, the impact on welfare depends crucially on the rate at which they discount future consumption. Figure 4.5 explain how the welfare impact shown in table 4.3 are determined. The households denoted as HH4 and HH6 experience an

initial drop in consumption. However, consumption increases steadily and reaches the final equilibrium well above the benchmark value, suggesting that the dynamic effect of trade liberalisation on welfare of these two household classes is positive. The consumption path of the second-richest household group, HH5, is rather different. Consumption falls abruptly below the benchmark level, thereafter it grows slowly, and it ends with a long-run equilibrium value which is little above the benchmark level. This explains therefore where the welfare loss for HH5 comes from.



Figure 4.5. Consumption under scenario 1.

The dynamic path of aggregate transfers to households is shown in figure 4.6. As expected, endogenous aggregate transfers start below the benchmark level, and increase slightly. Thereafter they drop steadily, they overshoot and then approach the long-run equilibrium value from below. The ups and downs in the transfers time path can be explained as follows: whereas time is continuous, the import tariff reduction occurs in a discrete-time way; after the tariff reduction, government revenue adjusts over the continuous-time horizon until the next tariff reduction step occurs, and hence it fluctuates around the trend; in turn the time path of government revenue affects government transfers to households.¹²

Figure 4.7 shows the behaviour of government revenue during the process of trade liberalisation under scenario 1.

 $^{^{12}}$ The same phenomenon characterises the standard trade model, as shown in chapter 3.



Figure 4.6. Aggregate government transfer under scenario 1.



Figure 4.7. Government revenue under scenario 1.

Figure 4.8 depicts the response of income to trade liberalisation. This explains why the Gini index is increasing over time. As mentioned above, households rely differently on the four sources of income. Given the fall in government transfers, income of poor households is affected adversely. In order to enjoy higher consumption, poor households use their amount of capital assets. On the other hand, rich households can better exploit investment opportunities, i.e. they can accumulate more capital stock, and they are also weakly affected by the drop in transfers, compared to poor households. As a consequence, the income inequality increases over time.



Figure 4.8. Income under scenario 1.

Figure 4.9 shows how the capital stock of each specific household class is affected under scenario 1. The picture is consistent with the above results. The four richest households accumulate capital stock over time, whereas poor households deaccumulate capital in order to smooth consumption. The trade liberalisation leads therefore to a reallocation of capital assets which is adverse to the poor.



Figure 4.9. Capital stock under scenario 1.

Finally, the aggregate investment level is shown in figure 4.10. The fall in import prices due to the reduction in tariff provides strong incentives for investment. The level of aggregate investment starts well above the benchmark value, it decreases steadily and approaches the equilibrium level from above.



Figure 4.10. Investment under scenario 10.

Scenario 2: Association Agreement, endogenous government transfers and exogenous increase in the VAT rates

Under this scenario, further to endogenous transfers to households the government is assumed to undertake the fiscal measure of a ten-percent increase in the VAT rates to overcome losses in revenue. This leads to two main effects. Prices of consumption and investment goods increase relatively to scenario 1. This effect leads to a fall in demand, it reduces incentives for investment, and it is expected to have a negative impact on welfare. On the other hand, government revenue are expected to be higher than under scenario 1. Hence transfers to households are likely to increase relative to the previous scenario, since the fiscal burden is now taken by two policy instruments, i.e. transfers to households and VAT. As a result, this simulation is expected to yield smaller welfare gains and larger welfare losses than scenario 1. Moreover, larger transfers than under scenario 1 imply that poor households will benefit relatively to the rich from the additional fiscal measure. Therefore this scenario leads to a lower Gini index than under scenario 1. This can be seen in figure 4.4, which shows that scenario 2 results in the lowest Gini index in the long-run equilibrium. Moreover, under this scenario, income inequality decreases in the initial years of the trade liberalisation process.

Figure 4.11 shows the private consumption time path. The fall in import prices boosts consumption demand in the very short-run. As can be seen graphically, consumption of all household groups starts above the benchmark value, equal to one. A second positive effect on consumption is brought about by the high level of government transfers, which lie above the benchmark value, as shown in figure 4.12.



Figure 4.11. Consumption under scenario 2.

However, the increase in the VAT rates has a negative impact on aggregate demand. This reduces the incentives to invest, investment starts below the benchmark level, it increases sharply, it overshoots its long-run value and then it approaches the equilibrium level from above, as figure 4.13 shows. Consumption also falls sharply, and after seven years of the entry into force of the AA it increases slowly towards the long-run equilibrium value. Comparison between the consumption paths under scenario 1 and 2 explains the different impacts on welfare. Under scenario 2, the negative effect on demand brought about by the VAT increase results in lower longrun consumption levels for all households categories. This in turn leads to a adverse impact on welfare of all household groups.







Figure 4.13. Investment under scenario 2.

However, although the additional VAT increase affects negatively welfare compared with scenario 1, it reduces inequality. As argued above, higher transfer values than under scenario 1 imply a beneficial impact for those household groups who rely more heavily than other on government transfer. Therefore, the income gap between rich and poor is reduced compared to the result under scenario 1, as comparison between figures 4.8 and 4.14 suggests.



Figure 4.14. Income under scenario 2.

Scenario 3: Association Agreement, endogenous government transfers and exogenous changes in government transfer shares

This simulation addresses the issue of a more even distribution of welfare gains across household groups. Scenario 1 is therefore extended to include an exogenous component, i.e. the change in the shares of government transfers to households, π_i , in order to compensate losers in scenario 1.

Table 4.4 reports the shares of aggregate transfers that each household class receives in the benchmark equilibrium. Initial shares of transfer of each household in aggregate transfers have been calibrated from the dataset. Additionally, the table shows the transfer shares in scenario 3. The percent share of aggregate transfers received by HH5 has been increased by 2.5, and the proportion to HH2 has been decreased by the same amount. The remaning shares have not been changed. While the exogenous change in the π_i 's is clearly arbitrary, nevertheless it reflects the objective of a more equal distribution of welfare gains across different households.

	HH1	HH2	HH3	HH4	HH5	HH6
calibrated shares	1,04%	6,76%	11,08%	19,91%	26,97%	34,23%
shares in scenario 3	1,04%	4,26%	11,08%	19,91%	29,47%	34,23%
			•	C I		

Table 4.4. Changes in transfers share.

As indicated in table 4.3, the change in transfer shares results in a much lower welfare gain for HH2, whose welfare now increases only by 0,03% instead of 0.19%. The welfare loss for HH5 under scenario 1 turns now into a welfare gain by 0.01%.



Figure 4.15. Income under scenario 3.

The change in transfer shares results into an income benefit for HH5 and into an adverse effect to HH2's income, as can be seen by comparing results under scenario 3, shown in figure 4.15 with the outcome of scenario 1, in figure 4.8.



Figure 4.16. Consumption under scenario 3.

This change is reflected in the consumption paths of the two households affected by the policy change. The differences in terms of time path and long-equilibrium values can be seen by comparison of figure 4.16 with figure 4.5.

Scenario 4: Association Agreement and endogenous government consumption

In this simulation, the endogenous variable is government consumption. As already pointed out in chapter 3, trade liberalisation combined with endogenisation of government consumption is expected to bring about larger welfare changes than the remaining scenarios, given that government consumption does not enter the utility function. Therefore, the measure taken by the government does not affect private income. Households can fully exploit the benefits of trade liberalisation. In the longrun, the consumption levels of all household classes are higher than the respective long-run values under the remaining scenario, as figure 4.17 shows.



Figure 17. Consumption under scenario 4.

As shown in table 4.3, the welfare gains under scenario 4 are larger than those brought about by scenario 1. Moreover, the only household group that experiences a welfare loss under scenarios 1 and 2, i.e. HH5, is now unaffected. However, the credibility of this simulation result is clearly questionable, given the feasibility problem in implementing a reduction in government spending.

4.7 Conclusions

In this chapter the question of how preferential trade liberalisation affects different households has been investigated. The model implemented here is based on the standard trade model presented in chapter 3, augmented by introducing heterogeneous households. Each of the six household group differs with respect to income, initial endowments of assets, transfers from the government and from abroad, wage rate, income tax rate and individual preferences. Whereas several studies have implemented general equilibrium models to address poverty and income distribution issues in a dynamic framework, the approach used in this chapter introduces the fundamental assumption that different household classes are characterised by different discount rates, which are calibrated from the available data.

Aggregate results confirm the findings provided by the standard trade model in chapter 3. Specifically, import tariff reduction lowers domestic prices of imported goods, it boosts consumption and investment demand. In turn this leads to faster aggregate capital accumulation. Trade liberalisation reduces government revenue, due to foregone import duties. This requires domestic complementary policies aiming at counterbalancing the adverse impact on government revenue. Policy options considered here are the endogenous decrease in government transfers to households and government spending, and the exogenous increase in the VAT rates.

Effects of opening up domestic trade and implementing adjustment policies are different across household groups. Most simulations result in positive welfare effects. However, one specific household group, the second richest one, is worse off under two scenarios. Therefore trade liberalisation is not Pareto improving. Poor households experience slightly larger welfare gain than rich households. However, inequality, measured with the Gini index, increases over time under all scenarios. This result is driven by the much higher rate of capital accumulation of rich households than the one of poor. This occurs because households rely differently on various sources of income. The drop in government transfer affects poor households relatively strongly. As a result, their income falls, and they use their amount of capital assets to smooth consumption.

Overall it can be seen that introducing heterogeneous households into a dynamic CGE model yields interesting insights about welfare and the dynamic behavior of income distribution across households. Since distributional aspects are of great importance, this analysis hopes to provide additional theoretical insights as well as useful policy implications.
5 Conclusions

In this dissertation a dynamic CGE model has been constructed to study the impacts of preferential trade liberalisation on the Jordanian economy. The dynamic general equilibrium approach allows to capture fully the chain of events taking place when tariffs, their interactions and their intertemporal effects.

The standard model discussed in chapter 3 is characterised by one representative household, who maximises discounted lifetime utility by choosing future paths of optimal consumption and investment. The model has been calibrated to 1998 data, and it has been used to analyse how the Association Agreement with the EU affects consumers welfare and macroeconomic variables in Jordan.

Revenue losses due to foregone import duties force the government to implement complementary measures such as reduction in transfers to household or tax reform. Therefore, together with the Association Agreement with the EU, simulations include domestic policy responses accompanying the trade liberalisation process. The Jordanian economy benefits from the Association Agreement in terms of lower import prices of consumption and investment goods. This brings about positive long-run effects on all macroeconomic variables and welfare gain. Whereas the impact on welfare is positive under all scenarios, implementation of domestic policy reforms aiming at alleviating the loss in government revenue affects negatively private consumption in the short-run and raise concerns about political feasibility of the trade liberalisation process.

The standard trade model has been augmented by introducing heterogeneous households. The six household classes have different income, initial endowments of assets, transfers from the government and from abroad, wage rate, income tax rate and individual preferences. Very importantly, it is also assumed that households are characterised by different discount rates, which are calibrated from the 2002 households survey. This assumption makes this approach new and different from all other previous studies on poverty and income distribution.

The results on aggregate variables are qualitatively the same as those yielded by the standard trade model.

Introducing heterogeneous households into a dynamic CGE model yields very interesting insights about welfare and the dynamic behavior of income distribution across households. The analysis confirms that different households respond differently to trade liberalisation impacts, and it suggests that trade liberalisation alleviates poverty in the long-run. Moreover, poor households in the economy are those who experience larger welfare gain, contrary to the widespread fear that trade liberalisation might be harmful for the poor.

However, the analysis suggests also trade liberalisation creates also losers, i.e. some specific household group that experiences a drop in welfare. Trade liberalisation, therefore, is not Pareto improving. Finally, trade liberalisation leads to increasing income inequality over time. Given the importance of poverty and income inequality issues, this analysis hopes to provide theoretical contributions and useful policy implications.

6 Appendices

6.1 Appendix 1. Update of the I-O table

Table A.1 below shows the correspondence between the H.S. for goods - at the top level of disaggregation - and the classification used by the DOS for activities 1 to 3. The concordance is direct and straightforward for most of the sectors, except for the HS categories IX and XIV.

HS Classification	DOS Classification
I	1
II	1
III	3.1
IV	3.1
V	2
VI	3.4
VII	3.5
VIII	3.2
IX	1 and 3.3
Х	3.3
XI	3.2
XII	3.7
XIII	3.5
XIV	3.5 and 3.6
XV	3.6
X V I	3.7
X V II	3.7
X V III	3.7
XX	3.7
XXI	3.7
Unspecified	3.7

Table A.1. Correspondence table

Table A.2 shows the further correspondence needed for top categories IX and XIV of the H.S.. In order to match the H.S. categories with the DOS ones, a higher degree of disaggregation had to be used, specifically 2-digit for one sub-category and 4-digit for the remaining ones.

Further disage	regation for HS	main categorie	es IX and XIV
HS-top	HS-2digit	HS-4digit	DOS
		4401	
		4402	
		4403	
		4404	1
		4405	1
		4406	
		4407	
		4408	
		4409	
		4410	
		4410	
		4411	
		4412	
		4413	
		4414	
		4415	
		4416	
		441/	
		4418	
		4419	
		4 4 2 0	
	4 4	4 4 2 1	3.3
		4501	
		4502	1
		4 5 0 3	
	4 5	4504	3.3
IX	46	3	.3
		7101	
		7102	
		7103	
		7104	
		7105	3.5
		7106	
		7107	
		7108	
		7109	
		7110	
		7111	
		7112	
		7113	
		7114	
		7115	
		7116	
		7117	
X IV	71	7118	3.6
	a (1		1 37737

Table A.2. Correspondence for IX and XIV.

Table A.3 below provides the list of codes and commodity descriptions of the H.S. used by the DOS in dealing with external trade statistics.

Code	Commodity Description
Ι	Live animals; animal products
II	Vegetable products
	Animal or vegetable fats and oils and their cleavage products; prepared edible
III	fats; prepared animal or vegetable waxes
	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured
IV	tobacco substitutes
V	Mineral products
VI	Products of the chemical or allied industries
VII	Plastics and articles thereof; rubber and articles thereof
	Raw hides and skins, leather, furskins and articles thereof; saddlery and
	harness; travel goods. handbags and similiar containers; articles of animal gut
VIII	(other than silk-worm gut)
	Wood and articles of wood; wood charcoal; cork and articles of cork;
	manufactures of straw of esparto or of other plaiting materials; basketware
IX	and wickerwork
	Pulp of wood or of other fibrous cellulosic material; waste and scrap of paper
Х	or paperboard; paper and paperboard and articles thereof
XI	Textiles and textile articles
	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks,
	whips, riding-crops and parts thereof; prepared feathers and articles made
XII	therewith; artificial flowers; articles of human hair
	Articles of stone, plaster, cement, asbestos mica or similar materials; ceramic
XIII	products; glass and glassware
	Natural or cultured pearls, precious or semi-precious stones, precious metals,
XIV	metals clad with precious metal and articles thereof; imitation jewellery;coin
XV	Base metals and articles of base metals
	Machinery and mechanical appliances; electrical equipment; parts thereof;
	sound recorders and reproducers, television image and sound recorders and
XVI	reproducers, and parts and accessories of such articles
XVII	Vehicles, aircraft, vessels and associated transport equipment
	Optical, photographic, cinematographic, measuring, checking, precision,
	medical or surgical instruments and apparatus; clocks and watches; musical
XVIII	instruments; parts and accessories thereof
XX	Miscellaneous manufactured articles
XXI	Works of art, collectors' pieces and antiques
	Unspecified

Table A.3. H.S. top classification.

The concordance table between the B.T.N. and the DOS classification is not included because its size is too large.

The remaining tables below show the complete dataset used in the update. As pointed out above, data for 1987 are revised and differ from the original preliminary dataset, and data for 2001 are mostly preliminary. At the end of appendix 1 there are graphs showing the trends of some coefficients.

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1987	163.5	59.2	136.8	18.2	22.3	143.7	58.3	52.0	26.2	710.5
1988	166.2	83.8	151.1	24.3	33.5	179.5	65.1	54.9	24.2	754.9
1989	200.2	119.4	201.5	32.1	48.9	381.1	85.0	87.6	45.7	865.4
1990	250.6	105.7	237.9	31.3	47.3	424.0	87.6	69.7	41.0	997.5
1991	271.0	121.6	174.4	46.3	54.2	407.6	115.9	96.3	47.0	973.0
1992	345.1	115.7	307.8	59.3	65.7	647.8	144.8	141.4	61.2	1306.2
1993	299.1	107.9	250.6	54.8	74.9	620.5	133.6	106.5	85.4	1658.0
1994	356.0	109.1	383.4	76.4	90.2	677.9	163.8	126.9	128.0	1668.2
1995	398.7	103.3	491.9	85.2	114.1	775.5	198.5	145.7	150.3	1675.5
1996	433.2	125.2	440.4	92.6	110.2	764.5	182.3	157.3	126.3	1768.6
1997	446.8	137.8	529.1	80.6	112.7	766.3	200.4	137.9	125.4	1730.5
1998	409.7	162.8	512.2	76.2	120.3	731.7	170.7	130.6	136.5	1615.7
1999	417.7	184.3	465.4	72.8	110.6	668.2	181.5	142.6	136.0	1640.5
2000	419.3	142.5	538.9	71.3	108.0	818.1	199.9	140.7	147.3	1662.6
2001	433.6	141.6	510.7	171.9	121.3	836.9	219.4	167.6	169.1	1831.2
										,
	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1987	1 293.5	2 133.4	3.1 219.5	3.2 30.0	3.3 35.1	<u>3.4</u> 354.1	3.5 119.3	3.6 79.9	3.7 39.8	4-9 1835.4
1987 1988	1 293.5 299.0	2 133.4 168.4	3.1 219.5 205.3	3.2 30.0 36.1	3.3 35.1 49.8	3.4 354.1 395.8	3.5 119.3 124.3	3.6 79.9 74.7	3.7 39.8 38.0	4-9 1835.4 1940.4
1987 1988 1989	1 293.5 299.0 327.6	2 133.4 168.4 277.4	3.1 219.5 205.3 292.5	3.2 30.0 36.1 48.6	3.3 35.1 49.8 65.4	3.4 354.1 395.8 599.2	3.5 119.3 124.3 153.4	3.6 79.9 74.7 116.7	3.7 39.8 38.0 64.1	4-9 1835.4 1940.4 2119.4
1987 1988 1989 1990	1 293.5 299.0 327.6 433.6	2 133.4 168.4 277.4 257.9	3.1 219.5 205.3 292.5 372.3	3.2 30.0 36.1 48.6 59.9	3.3 35.1 49.8 65.4 71.8	3.4 354.1 395.8 599.2 662.7	3.5 119.3 124.3 153.4 170.2	3.6 79.9 74.7 116.7 109.7	3.7 39.8 38.0 64.1 71.7	4-9 1835.4 1940.4 2119.4 2327.6
1987 1988 1989 1990 1991	1 293.5 299.0 327.6 433.6 477.6	2 133.4 168.4 277.4 257.9 249.9	3.1 219.5 205.3 292.5 372.3 273.2	3.2 30.0 36.1 48.6 59.9 75.4	3.3 35.1 49.8 65.4 71.8 81.4	3.4 354.1 395.8 599.2 662.7 660.8	3.5 119.3 124.3 153.4 170.2 200.7	3.6 79.9 74.7 116.7 109.7 132.1	3.7 39.8 38.0 64.1 71.7 75.6	4-9 1835.4 1940.4 2119.4 2327.6 2451.5
1987 1988 1989 1990 1991 1992	1 293.5 299.0 327.6 433.6 477.6 582.7	2 133.4 168.4 277.4 257.9 249.9 249.5	3.1 219.5 205.3 292.5 372.3 273.2 485.8	3.2 30.0 36.1 48.6 59.9 75.4 87.5	3.3 35.1 49.8 65.4 71.8 81.4 96.5	3.4 354.1 395.8 599.2 662.7 660.8 975.6	3.5 119.3 124.3 153.4 170.2 200.7 260.2	3.6 79.9 74.7 116.7 109.7 132.1 198.8	3.7 39.8 38.0 64.1 71.7 75.6 91.9	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3
1987 1988 1989 1990 1991 1992 1993	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4
1987 1988 1989 1990 1991 1992 1993 1994	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6
1987 1988 1989 1990 1991 1992 1993 1994 1995	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3 263.6	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3 582.3	2 133.4 168.4 257.9 249.9 249.5 217.7 214.3 263.6 282.3	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7 689.3	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1 130.7	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0 149.7	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6 1193.5	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9 307.3	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4 207.3	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8 175.5	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4 4193.6
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3 582.3 582.3 585.6	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3 263.6 282.3 311.4	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7 689.3 781.4	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1 130.7 119.9	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0 149.7 158.4	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6 1193.5 1232.4	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9 307.3 348.6	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4 207.3 190.0	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8 175.5 180.0	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4 4193.6 4311.0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3 582.3 585.6 545.5	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3 263.6 282.3 311.4 337.2	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7 689.3 781.4 838.8	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1 130.7 119.9 123.5	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0 149.7 158.4 170.2	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6 1193.5 1232.4 1238.2	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9 307.3 348.6 301.8	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4 207.3 190.0 189.7	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8 175.5 180.0 196.4	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4 4193.6 4311.0 4307.5
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3 582.3 585.6 545.5 525.1	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3 263.6 282.3 311.4 337.2 352.3	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7 689.3 781.4 838.8 731.3	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1 130.7 119.9 123.5 124.9	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0 149.7 158.4 170.2 168.8	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6 1193.5 1232.4 1238.2 1171.3	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9 307.3 348.6 301.8 335.1	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4 207.3 190.0 189.7 211.7	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8 175.5 180.0 196.4 198.1	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4 4193.6 4311.0 4307.5 4399.8
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000	1 293.5 299.0 327.6 433.6 477.6 582.7 490.3 540.2 563.3 582.3 585.6 545.5 525.1 531.5	2 133.4 168.4 277.4 257.9 249.9 249.5 217.7 214.3 263.6 282.3 311.4 337.2 352.3 317.9	3.1 219.5 205.3 292.5 372.3 273.2 485.8 404.5 604.5 742.7 689.3 781.4 838.8 731.3 871.8	3.2 30.0 36.1 48.6 59.9 75.4 87.5 83.1 121.6 133.1 130.7 119.9 123.5 124.9 137.5	3.3 35.1 49.8 65.4 71.8 81.4 96.5 107.7 135.7 163.0 149.7 158.4 170.2 168.8 164.7	3.4 354.1 395.8 599.2 662.7 660.8 975.6 926.4 1040.1 1194.6 1193.5 1232.4 1238.2 1171.3 1346.9	3.5 119.3 124.3 153.4 170.2 200.7 260.2 257.7 309.6 335.9 307.3 348.6 301.8 335.1 350.2	3.6 79.9 74.7 116.7 109.7 132.1 198.8 156.1 185.8 204.4 207.3 190.0 189.7 211.7 220.1	3.7 39.8 38.0 64.1 71.7 75.6 91.9 133.0 196.2 212.8 175.5 180.0 196.4 198.1 215.8	4-9 1835.4 1940.4 2119.4 2327.6 2451.5 3056.3 3646.4 3827.6 4005.4 4193.6 4311.0 4307.5 4399.8 4604.3

Table A.5. Disaggregated output (producer prices, million JD)

	1	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1987	381.6	256.2	303.7	81.8	72.9	350.6	151.2	187.3	331.4	1580.5
1988	406.0	289.9	294.6	92.1	91.5	342.4	160.8	177.0	396.1	1668.3
1989	447.3	403.9	384.1	124.9	109.7	516.1	193.3	228.0	427.1	1838.5
1990	684.2	474.6	588.7	152.3	149.6	577.1	214.6	250.3	503.7	2051.0
1991	731.8	451.0	469.8	188.0	170.7	584.3	254.0	279.4	479.2	2128.7
1992	840.0	469.2	690.6	238.7	199.5	955.4	330.4	428.7	811.7	2492.6
1993	746.4	496.3	594.5	231.2	213.8	898.7	326.2	436.9	991.2	2817.0
1994	786.1	436.7	792.3	250.6	227.6	920.6	446.7	413.7	825.9	3023.7
1995	830.3	527.2	827.9	239.5	282.7	1033.8	473.8	497.5	867.1	3112.4
1996	1066.8	544.8	866.4	235.8	257.9	984.5	467.7	498.2	1037.4	2929.6
1997	882.5	580.3	965.4	222.0	244.9	1081.7	486.7	469.8	1050.3	3026.9
1998	862.5	472.4	1008.6	241.7	244.9	1103.0	436.7	420.6	1031.7	3183.8
1999	823.0	589.4	895.9	225.0	226.4	995.4	447.8	405.4	972.8	3251.1
2000	892.0	796.6	1032.6	252.6	262.0	1162.6	491.8	435.5	1267.7	3226.1
2001	876.2	771.2	974.7	350.0	296.2	1227.0	536.5	510.3	1225.1	3544.2

Table A.6. Supply (million JD)

	2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4-9
1990	115	1608	1639	2448	64	1437	1832	120	5502
1991	119	1642	1694	2511	70	1465	1897	122	20977
1992	125	2062	2092	3094	111	1817	2288	117	59160
1993	125	2199	2109	3124	116	1846	2341	120	63217
1994	129	1784	1831	3292	187	2149	2825	290	67658
1995	131	1945	2082	3704	207	2232	3163	317	71710
1996	143	2002	2125	3830	221	2254	3210	330	74455
1997	145	2120	2206	3925	245	2345	3295	330	77563
1998	153	2226	2316	4084	261	2353	3383	313	9603

Table A.7. Number of firms.

















6.2 Appendix 2. The Standard Trade Model

2.A. List of equations

(time index dropped for simplicity) Capital accumulation equation

$$\dot{K} = I - \delta K$$

Disposable income

$$YD = (1 - t^{Y}) \left[wL + (1 - t^{K}) rK + TR + erFREM \right]$$

Euler equation

$$\frac{\dot{C}}{C} = \frac{\left(1-t^{Y}\right)\left(1-t^{K}\right)r}{P^{I}} - \rho - \delta$$

Composite private consumption

$$C = \Omega^C \prod_{i=1}^N c_i^{\theta_i^C}; \Omega^C > 0; 0 < \theta_i^C < 1$$

$$P^C C = \sum_{i=1}^N P_i^X c_i$$

$$\frac{c_i}{c_j} = \frac{\theta_i^C P_j^X}{\theta_j^C P_i^X}; \, i,j=1,2,..,N$$

Consumption price index

$$P^{C} = \frac{1}{\Omega^{C}} \prod_{i=1}^{N} \left(\frac{P_{i}^{X}}{\theta_{i}^{C}}\right)^{\theta_{j}^{C}}; N = 10$$

Private consumption demand functions

$$c_i = \theta_i^C \frac{P^C C}{P_i^X}$$

Composite government consumption

$$G = \Omega^G \prod_{i=1}^N g_i^{\theta_i^G}; \, \Omega^G > 0; \, 0 < \theta_i^G < 1$$

$$P^G G = \sum_{i=1}^N P_i^X g_i$$

$$\frac{g_i}{g_j} = \frac{\theta_i^G P_j^X}{\theta_j^G P_i^X}; i, j = 1, 2, .., N$$

Government consumption price index

$$P^{G} = \frac{1}{\Omega^{G}} \prod_{i=1}^{N} \left(\frac{P_{i}^{X}}{\theta_{i}^{G}} \right)^{\theta_{j}^{G}}; N = 10$$

Government consumption demand functions

$$g_i = \theta_i^G \frac{P^C G}{P_i^X}$$

Composite investment

$$I = \Omega^I \prod_{i=1}^N inv_i^{\theta_i^I}; \, \Omega^I > 0; \, 0 < \theta_i^I < 1$$

$$P^{I}I = \sum_{i=1}^{N} P_{i}^{X} inv_{i}$$

$$\frac{inv_i}{inv_j} = \frac{\theta^I_i P^X_j}{\theta^I_j P^X_i}; \, i,j=1,2,..,N$$

Investment price index

$$P^{I} = \frac{1}{\Omega^{I}} \prod_{i=1}^{N} \left(\frac{P_{i}^{X}}{\theta_{i}^{I}}\right)^{\theta_{j}^{I}}; N = 10$$

Investment demand functions

$$inv_i = \theta_i^I \frac{P^I I}{P_i^X}$$

Leontief production function

$$Q_i = \min\left\{\frac{VA_i}{a_{0,i}}, \frac{q_{j,i}}{a_{j,i}}, \dots\right\}; i, j = 1, 2, \dots, N$$

Value-added production function

$$VA_{i} = A_{i} \left[\alpha_{i} LD_{i}^{\frac{\sigma_{i}-1}{\sigma_{i}}} + (1-\alpha_{i}) KD_{i}^{\frac{\sigma_{i}-1}{\sigma_{i}}} \right]^{\frac{\sigma_{i}}{\sigma_{i}-1}}; 0 < \alpha_{i} < 1; \sigma_{i} > 0; \sigma_{i} \neq 1$$

$$P_i^{VA}VA_i = wLD_i + rKD_i$$

$$\frac{KD_i}{LD_i} = \left[\frac{w}{r}\frac{(1-\alpha_i)}{\alpha_i}\right]^{\sigma_i}$$

Labour demand function

$$LD_i = (A_i)^{(\sigma_i - 1)} VA_i \left(\frac{\alpha_i P_i^{VA}}{w}\right)^{\sigma_i}$$

Capital demand

$$KD_i = (A_i)^{(\sigma_i - 1)} VA_i \left[\frac{(1 - \alpha_i) P_i^{VA}}{r}\right]^{\sigma_i}$$

Value-added price

$$P_{i}^{VA} = \frac{1}{A_{i}} \left[w^{(1-\sigma_{i})} \left(\alpha_{i} \right)^{\sigma_{i}} + r^{(1-\sigma_{i})} \left(1-\alpha_{i} \right)^{\sigma_{i}} \right]^{\frac{1}{1-\sigma_{i}}}$$

CES Armington function

The equations below have been used in the calibration procedure in a general form; more specifically, in the model the same equations apply to private consumption, government consumption, investment and intermediate inputs: therefore X_i has to be replaced by c_i , g_i , inv_i and $q_{j,i}$; M_i has to replaced by cm_i , gm_i , $invm_i$ and $qm_{j,i}$; and cd_i , gd_i , $invd_i$ and $qd_{j,i}$ will replace D_i , where the subscripts *i* and *j* indicate the production sector; functional parameters and prices are the same for all specific forms.

$$\begin{split} X_{i} &= \Phi_{i} \left[\varepsilon_{i} \left(M_{i} \right)^{\frac{\gamma_{i}-1}{\gamma_{i}}} + \left(1 - \varepsilon_{i} \right) \left(D_{i} \right)^{\frac{\gamma_{i}-1}{\gamma_{i}}} \right]^{\frac{\gamma_{i}}{\gamma_{i}-1}} \\ \Phi_{i} &> 0; \ 0 < \varepsilon_{i} < 1; \ \gamma_{i} > 0; \ \gamma_{i} \neq 1; \ i = 1, 2, ..., 10 \end{split}$$

$$P_i^X X_i = P_i^M M_i + \left(1 + vat_i^D\right) P_i^D D_i$$

$$\frac{D_i}{M_i} = \left[\frac{\left(1-\varepsilon_i\right)P_i^{MF}}{\varepsilon_i\left(1+vat_i^D\right)P_i^D}\right]^{\gamma_i}$$

Imports demand function

$$M_i = \left(\Phi_i\right)^{(\gamma_i - 1)} X_i \left(\frac{\varepsilon_i P_i^X}{P_i^M}\right)^{\gamma_i}$$

Domestic goods demand function

$$D_i = \left(\Phi_i\right)^{(\gamma_i - 1)} X_i \left[\frac{(1 - \varepsilon_i) P_i^X}{(1 + vat_i^D) P_i^D}\right]^{\gamma_i}$$

Composite CES Armington price

$$P_i^X = \frac{1}{\Phi_i} \left\{ \left(P_i^M \right)^{(1-\gamma_i)} \left(\varepsilon_i \right)^{\gamma_i} + \left[\left(1 + vat_i^D \right) P_i^D \right]^{(1-\gamma_i)} \left(1 - \varepsilon_i \right)^{\gamma_i} \right\}^{\frac{1}{1-\gamma_i}} \right\}^{\frac{1}{1-\gamma_i}}$$

Cobb-Douglas total imports

The equations for total imports have been used in the calibration procedure in the general form described below; in the model, the same equations apply to private consumption, government consumption, investment and intermediate inputs: therefore M_i has to replaced by cm_i , gm_i , $invm_i$ and $qm_{j,i}$; and M_i^j will be replaced by cm_i^j , gm_i^j , $invm_i^j$ and $qm_{i,k}^j$, where *i* and *k* are production sector indeces and *j* is index indicating the foreign region; functional parameters and prices are the same for all specific forms.

$$\begin{split} M_i &= \Phi_i^M \left(M_i^{EU} \right)^{\varepsilon_i^{EU}} \left(M_i^{RW} \right)^{\varepsilon_i^{RW}} \\ \Phi_i^M &> 0; \ 0 < \varepsilon_i^{EU}, \varepsilon_i^{RW} < 1; \ \varepsilon_i^{EU} + \varepsilon_i^{RW} = 1; \ i = 1, 2, .., N \end{split}$$

$$P_i^M M_i = P M_i^{EU} M_i^{EU} + P M_i^{RW} M_i^{RW}$$

$$\frac{M_i^{EU}}{M_i^{RW}} = \frac{\varepsilon_i^{EU} P M_i^{RW}}{\varepsilon_i^{RW} P M_i^{EU}}$$

Regional imports demand functions

$$M_{i}^{j} = \varepsilon_{i}^{j} rac{P_{i}^{M} M_{i}}{P M_{i}^{j}}; \, i = 1, 2, .., 10; \, j = EU, RW$$

Import composite price

$$P_i^M = \frac{1}{\Phi_i^M} \left(\frac{PM_i^{EU}}{\varepsilon_i^{EU}}\right)^{\varepsilon_i^{EU}} \left(\frac{PM_i^{RW}}{\varepsilon_i^{RW}}\right)^{\varepsilon_i^{RW}}$$

Import prices

$$PM_{i}^{j} = erPWM_{i}\left(1 + tm_{i}^{j}\right)\left(1 + vat_{i}^{M}\right); \ j = EU, RW$$

CET function

$$\begin{aligned} Q_{i} &= \chi_{i} \left[\lambda_{i} \left(E_{i} \right)^{\frac{1+\Psi_{i}}{\Psi_{i}}} + \left(1 - \lambda_{i} \right) \left(D_{i} \right)^{\frac{1+\Psi_{i}}{\Psi_{i}}} \right]^{\frac{\Psi_{i}}{1+\Psi_{i}}} \\ \chi_{i} &> 0; \ 0 < \lambda_{i} < 1; \ \Psi_{i} > 0; \ i = 1, 2, ..., N \end{aligned}$$

 $P_i^Q Q_i = P_i^E E_i + P_i^D D_i$

$$\frac{D_i}{E_i} = \left[\frac{\lambda_i P_i^D}{\left(1 - \lambda_i\right) P_i^E}\right]^{\Psi_i}$$

Export supply function

$$E_i = \frac{Q_i}{\left(\chi_i\right)^{\left(1+\Psi_i\right)} \left(P_i^Q\right)^{\Psi_i}} \left(\frac{P_i^E}{\lambda_i}\right)^{\Psi_i}$$

Domestic good supply function

$$D_i = \frac{Q_i}{\left(\chi_i\right)^{\left(1+\Psi_i\right)} \left(P_i^Q\right)^{\Psi_i}} \left(\frac{P_i^D}{1-\lambda_i}\right)^{\Psi_i}$$

Composite output price

$$P_i^Q = \frac{1}{\chi_i} \left[\frac{\left(P_i^E\right)^{(1+\Psi_i)}}{(\lambda_i)^{\Psi_i}} + \frac{\left(P_i^D\right)^{(1+\Psi_i)}}{(1-\lambda_i)^{\Psi_i}} \right]^{\frac{1}{1+\Psi_i}}$$

CET composite exports

$$\begin{split} E_{i} &= \chi_{i}^{E} \left[\lambda_{i}^{EU} \left(E_{i}^{EU} \right)^{\frac{1+\Psi_{i}^{E}}{\Psi_{i}^{E}}} + \lambda_{i}^{RW} \left(E_{i}^{RW} \right)^{\frac{1+\Psi_{i}^{E}}{\Psi_{i}^{E}}} \right]^{\frac{\Psi_{i}^{E}}{1+\Psi_{i}^{E}}} \\ \chi_{i}^{E} &> 0; \ 0 < \lambda_{i}^{EU}, \lambda_{i}^{RW} < 1; \ \lambda_{i}^{EU} + \lambda_{i}^{RW} = 1; \ \Psi_{i}^{E} > 0; \ i = 1, 2, ..., N \end{split}$$

$$P_i^E E_i = P E_i^{EU} E_i^{EU} + P E_i^{RW} E_i^{RW}$$

$$\frac{E_i^{EU}}{E_i^{RW}} = \left(\frac{\lambda_i^{RW} P E_i^{EU}}{\lambda_i^{EU} P E_i^{RW}}\right)^{\Psi_i^E}$$

Exports supply functions

$$E_{i}^{j} = \frac{E_{i}}{\left(P_{i}^{E}\right)^{\Psi_{i}^{E}}\left(\chi_{i}^{E}\right)^{\left(1+\Psi_{i}^{E}\right)}} \left(\frac{PE_{i}^{j}}{\lambda_{i}^{j}}\right)^{\Psi_{E}}; i = 1, 2, ..., N; j = EU, RW$$

Export composite price

$$P_{i}^{E} = \frac{1}{\chi_{i}^{E}} \left[\frac{\left(PE_{i}^{EU}\right)^{1+\Psi_{i}^{E}}}{(\chi_{i}^{E})^{\Psi_{i}^{E}}} + \frac{\left(PE_{i}^{RW}\right)^{1+\Psi_{i}^{E}}}{(\chi_{i}^{D})^{\Psi_{i}^{E}}} \right]^{\frac{1}{1+\Psi_{i}^{E}}}$$

Export prices

$$PE_i^j = erPWE_i; j = EU, RW$$

Domestic goods VAT revenue

$$VAT^{D} = \sum_{i=1}^{N} vat_{i}^{D} P_{i}^{D} D_{i}$$

Imported goods VAT revenue

$$VAT^{M} = \sum_{i=1}^{N} \sum_{j=EU,RW} vat_{i}^{M} \left(1 + tm_{i}^{j}\right) erPW_{i}^{M}M_{i}^{j}$$

Imports tariffs revenue

$$TM = \sum_{i=1}^{N} \sum_{j=EU,RW} tm_i^j er PW_i^M M_i^j$$

Capital rent tax revenue

$$TK = t^K r K$$

Income tax revenue

$$TY = t_i \left[wL + \left(1 - t^K \right) rK + TR + erFREM \right]$$

 $Government \ budget$

$$VAT^{D} + VAT^{M} + TY + TK + TM + erFRG = TR + G$$

Labour market equilibrium

$$L = \sum_{i=1}^{N} LD_i$$

Capital goods market equilibrium

$$K = \sum_{i=1}^{N} K D_i$$

Domestic goods markets equilibrium

$$X_{i} = \sum_{j=1}^{N} q_{i,j} + c_{i} + inv_{i} + g_{i}$$

External equilibrium

$$\sum_{i=1}^{N} PW_i^M M_i = \sum_{i=1}^{N} PW_i^E E_i + FREM + FGR$$

2.B. Glossary

N: number of production sectors (N = 10)

er: exchange rate (numeraire)

L: labour supply

K: capital supply

C: private consumption

 P^C : private consumption price index

YD: personal disposable income

TR: government transfers to households

FREM: foreign remittances to households

 t^{Y} : income tax rate

 t^{K} : tax on capital income

 $\rho :$ household's discount rate

 δ : deprecation rate of capital

 P_i^X : composite price of good *i*

- c_i : household's consumption of good i
- Ω^{C} : shift parameter in the Cobb-Douglas private consumption function
- θ_i^C : good i's share parameter in the Cobb-Douglas private consumption function

I: aggregate investment

 P^{I} : price index of aggregate investment

 inv_i : sector *i*'s investment demand

 Ω^{I} : shift parameter in the Cobb-Douglas investment function

 θ_i^I : good *i*'s share parameter in the Cobb-Douglas investment function

G: aggregate government consumption

 P^G : price index of aggregate government consumption

 g_i : government consumption of good i

 $\Omega^G\!\!:$ shift parameter in the Cobb-Douglas government consumption function

 θ_i^G : good *i*'s share parameter in the Cobb-Douglas government consumption function

tion

 VA_i : sector *i*'s value-added production

 P_i^{VA} : sector *i*'s value-added price

 LD_i : sector *i*'s demand for labour

 KD_i : sector *i*'s demand for capital

 A_i : shift parameter of the value-added production function in sector i

 σ_i : elasticity of substitution between primary inputs in sector *i*

 α_i : share parameter of labour used in the production of good *i*

w: nominal wage rate

r: nominal return to capital

 Q_i : total output of sector i

 P_i^Q : composite output price of sector *i*

 $q_{j,i}$: intermediate input produced by sector j used in the production of sector i

 $a_{0,i}$: fixed coefficient of value-added output for sector i's production

 $a_{j,i}$: fixed coefficient of intermediate input j in the production of good i

 X_i : total domestic absorption of sector i

 M_i : total imports of sector i

 cm_i : private consumption demand for import good produced by sector i

 gm_i : government consumption demand for import good produced by sector i

 $invm_i$: investment demand for import good produced by sector i

 $qm_{j,i}$: imported intermediate input produced by sector j used in the production of sector i

 D_i : total domestic production of sector i

 cd_i : private consumption demand for domestic good produced by sector i

 gd_i : government consumption demand for domestic good produced by sector i

 $invd_i$: investment demand for domestic good produced by sector i

 $qd_{j,i}$: intermediate input produced domestically by sector j used in the production of sector i

 Φ_i : shift parameter in the CES Armington function of sector *i*

 ε_i : imports share parameter in the CES Armington function of sector *i*

 $\gamma_i:$ sector i 's elasticity of substitution between imports and domestically-produced output

 P_i^X : composite price of domestic absorption of sector *i*

 P_i^M : import price of sector *i*

 P_i^D : price of sector *i*'s domestically-produced good

 vat_i^D : VAT rate on sector *i*'s domestically-produced good

 M_i^j : imports of sector *i* from region *j*

 cm_i^j : private consumption of good *i* imported from region *j*

 gm_i^j : government consumption of good *i* imported from region *j*

 $invm_i^j$: investment demand for good *i* imported from region *j*

 $qm_{i,k}^{j}$: intermediate input consumption of good *i* used in the production of sector k and imported from region j

 PM_i^j : sector *i*'s price of imports from region *j*

 Φ_i^M : shift parameter in the imports CES function of sector *i*

 ε_i^j : region j's share parameter in the imports CES function of sector i

 tm_i^j : import tax rate applying to sector *i*'s imports from region *j*

 vat_i^M : VAT rate on sector *i*'s imported goods

 PW_i^M : sector *i*'s world price of imports

 E_i : total exports of sector i

 P_i^E : export price of sector *i*

 χ_i : shift parameter in the CET function of sector *i*

 λ_i : export share parameter of sector *i*

 $\Psi_i:$ elasticity of transformation between exports and domestically-sold output of sector i

 E_i^j : total exports of sector *i* to region *j*

 χ_i^E : shift parameter in the CET exports function of sector *i*

 λ_i^j : share parameter of exports to region j in sector i

 Ψ_i^E : elasticity of transformation between exports to different regions of sector *i*

 PE_i^j : price of exports to region j of sector i

 PW_i^E : world price of exports of sector *i*

 VAT^{D} : domestic goods VAT revenue

 VAT^M : imported goods VAT revenue

TM: aggregate import tariffs revenue

TK: capital tax revenue

TY: income tax revenue

FRG: foreign grants to the government

6.3 Appendix 3. The Poverty Model

3.A. List of equations

(time index dropped for simplicity) Capital accumulation equation

$$\dot{K}_i = SAV_i - \delta K_i = -\frac{YD_i - P_CC_i}{P_I} - \delta K_i, \ i = 1, 2, ..., H$$

Disposable income

$$YD_i = (1 - \tau_i)(w_iL_i + rK_i + Tr_i + erFT_i)$$

Euler equation

$$\frac{\dot{C}_i}{C_i} = \frac{\left(1 - \tau_i\right)r}{P^I} - \rho_i - \delta$$

Composite private consumption

$$C_{i} = \Omega_{i}^{C} \prod_{j=1}^{N} c_{i,j}^{\theta_{i,j}^{C}}; \ \Omega_{i}^{C} > 0; \ 0 < \theta_{i,j}^{C} < 1; \ i = 1, 2, .., H; \ j = 1, 2, .., N$$

$$P_i^C C_i = \sum_{j=1}^N P_j^X c_{i,j}$$

$$\frac{c_{h,i}}{c_{h,j}} = \frac{\theta_{h,i}^C p c_j}{\theta_{h,j}^C p c_i}; \ i, j = 1, 2, ..., N; \ h = 1, 2, ..., H$$

Consumption prices

$$P_i^C = \frac{1}{\Omega_i^C} \prod_{j=1}^N \left(\frac{P_j^X}{\theta_{i,j}^C} \right)^{\theta_{ij}^C}$$

Private consumption demand functions

$$c_{i,j} = \theta_{i,j}^C \frac{P_i^C C_i}{P_j^X}$$

Composite government consumption

$$G = \Omega^{G} \prod_{j=1}^{N} g_{j}^{\theta_{j}^{G}}; \, \Omega^{G} > 0; \, 0 < \theta_{j}^{G} < 1; \, j = 1, 2, ..., N$$

$$P^G G = \sum_{i=j}^N P_j^X g_j$$

$$\frac{g_i}{g_j} = \frac{\theta_i^G P_j^X}{\theta_j^G P_i^X}; \ i, j = 1, 2, .., N$$

Government consumption price index

$$P^{G} = \frac{1}{\Omega^{G}} \prod_{j=1}^{N} \left(\frac{P_{j}^{X}}{\theta_{j}^{G}} \right)^{\theta_{j}^{G}}$$

Government consumption demand functions

$$g_j = \theta_j^G \frac{P^C G}{P_j^X}$$

Composite investment

$$I = \Omega^{I} \prod_{j=1}^{N} inv_{j}^{\theta_{j}^{I}}; \ \Omega^{I} > 0; \ 0 < \theta_{j}^{I} < 1; \ j = 1, 2, .., N$$

$$P^{I}I = \sum_{j=1}^{N} P_{j}^{X} inv_{j}$$

$$\frac{inv_i}{inv_j} = \frac{\theta_i^I P_j^X}{\theta_j^I P_i^X}; \, i, j = 1, 2, .., N$$

Investment price index

$$P^{I} = \frac{1}{\Omega^{I}} \prod_{j=1}^{N} \left(\frac{P_{j}^{X}}{\theta_{j}^{I}} \right)^{\theta_{j}^{I}}$$

Investment demand functions

$$inv_j = \theta_j^I \frac{P^I I}{P_j^X}$$

Leontief production function

$$Q_j = \min\left\{\frac{VA_j}{a_{0,j}}, \frac{q_{i,j}}{a_{i,j}}, \dots\right\}$$

Value-added production function

$$VA_{j} = A_{j} \left[\sum_{i=1}^{H} \alpha_{i,j} LD_{i,j}^{\frac{\sigma_{j}-1}{\sigma_{j}}} + \left(1 - \sum_{i=1}^{H} \alpha_{i,j}\right) KD_{j}^{\frac{\sigma_{j}-1}{\sigma_{j}}} \right]^{\frac{\sigma_{j}}{\sigma_{j}-1}}$$
$$i = 1, 2, ..., H; \ j = 1, 2, ..., N$$

$$P_j^{VA}VA_j = \sum_{i=1}^H w_i LD_{i,j} + rKD_j$$

Labour demand functions

$$L_{i,j} = \left(A_j\right)^{\left(\sigma_j - 1\right)} V A_j \left(\frac{\alpha_{i,j} P_j^{VA}}{w_i}\right)^{\sigma_j}$$

Capital demand

$$K_j = (A_j)^{(\sigma_j - 1)} V A_j \left[\frac{\left(1 - \sum_{i=1}^N \alpha_{i,j} \right) P_j^{VA}}{r} \right]^{\sigma_j}$$

Value-added price

$$P_j^{VA} = \frac{1}{A_j} \left[\sum_{i=1}^N (w_i)^{(1-\sigma_j)} (\alpha_{i,j})^{\sigma_j} + r^{(1-\sigma_j)} \left(1 - \sum_{i=1}^N \alpha_{ij} \right)^{\sigma_j} \right]^{\frac{1}{1-\sigma_j}}$$

CES Armington function

The equations below have been used in the calibration procedure in a general form; more specifically, in the model the same equations apply to private consumption, government consumption, investment and intermediate inputs: therefore X_i has to be replaced by $c_{h,i}$, g_i , inv_i and $q_{j,i}$; M_i has to replaced by cm_i , gm_i , $invm_i$ and $qm_{j,i}$; and cd_i , gd_i , $invd_i$ and $qd_{j,i}$ will replace D_i , where the subscript h stands for household and the subscripts i and j indicate the production sector; functional parameters and prices are the same for all specific forms.

$$\begin{split} X_i &= \Phi_i \left[\varepsilon_i \left(M_i \right)^{\frac{\gamma_i - 1}{\gamma_i}} + \left(1 - \varepsilon_i \right) \left(D_i \right)^{\frac{\gamma_i - 1}{\gamma_i}} \right]^{\frac{\gamma_i}{\gamma_i - 1}} \\ \Phi_i &> 0; \ 0 < \varepsilon_i < 1; \ \gamma_i > 0, \ \gamma_i \neq 1; \ i = 1, 2, ..., N \end{split}$$

$$P_i^X X_i = P_i^M M_i + \left(1 + vat_i^D\right) P_i^D D_i$$

$$\frac{D_i}{M_i} = \left[\frac{\left(1-\varepsilon_i\right)P_i^{MF}}{\varepsilon_i\left(1+vat_i^D\right)P_i^D}\right]^{\gamma_i}$$

Imports demand function

$$M_i = \left(\Phi_i\right)^{(\gamma_i - 1)} X_i \left(\frac{\varepsilon_i P_i^X}{P_i^M}\right)^{\gamma_i}$$

Domestic goods demand function

$$D_i = \left(\Phi_i\right)^{(\gamma_i - 1)} X_i \left[\frac{(1 - \varepsilon_i) P_i^X}{(1 + vat_i^D) P_i^D}\right]^{\gamma_i}$$

Composite CES Armington price

$$P_i^X = \frac{1}{\Phi_i} \left\{ \left(P_i^M \right)^{(1-\gamma_i)} \left(\varepsilon_i \right)^{\gamma_i} + \left[\left(1 + vat_i^D \right) P_i^D \right]^{(1-\gamma_i)} \left(1 - \varepsilon_i \right)^{\gamma_i} \right\}^{\frac{1}{1-\gamma_i}} \right\}^{\frac{1}{1-\gamma_i}}$$

Cobb-Douglas total imports

The equations for total imports have been used in the calibration procedure in the general form described below; in the model, the same equations apply to private consumption, government consumption, investment and intermediate inputs: therefore $cm_{h,i}$, gm_i , $invm_i$ and $qm_{i,k}$ replace M_i ; and $cm_{h,i}^j$, gm_i^j , $invm_i^j$ and $qm_{i,k}^j$, where the subscripts *i* and *k* are production sector indeces, the superscript *j* indicates the foreign region, and the index *h* stands for household.

$$\begin{split} M_{i} &= \Phi_{i}^{M} \left(M_{i}^{EU} \right)^{\varepsilon_{i}^{EU}} \left(M_{i}^{RW} \right)^{\varepsilon_{i}^{RW}} \\ \Phi_{i}^{M} &> 0; \ 0 < \varepsilon_{i}^{EU}, \varepsilon_{i}^{RW} < 1; \ \varepsilon_{i}^{EU} + \varepsilon_{i}^{RW} = 1; \ i = 1, 2, .., N \end{split}$$

$$P_i^M M_i = P M_i^{EU} M_i^{EU} + P M_i^{RW} M_i^{RW}$$

$$\frac{M_i^{EU}}{M_i^{RW}} = \frac{\varepsilon_i^{EU} P M_i^{RW}}{\varepsilon_i^{RW} P M_i^{EU}}$$

Regional imports demand functions

$$M_i^j = \varepsilon_i^j \frac{P_i^M M_i}{P M_i^j}; i = 1, 2, ..., N; j = EU, RW$$

Import composite price

$$P_i^M = \frac{1}{\Phi_i^M} \left(\frac{PM_i^{EU}}{\varepsilon_i^{EU}}\right)^{\varepsilon_i^{EU}} \left(\frac{PM_i^{RW}}{\varepsilon_i^{RW}}\right)^{\varepsilon_i^{RW}}$$

Import prices

$$PM_{i}^{j} = erPWM_{i}\left(1 + tm_{i}^{j}\right)\left(1 + vat_{i}^{M}\right); \ j = EU, RW$$

CET function

$$\begin{aligned} Q_{i} &= \chi_{i} \left[\lambda_{i} \left(E_{i} \right)^{\frac{1+\Psi_{i}}{\Psi_{i}}} + \left(1 - \lambda_{i} \right) \left(D_{i} \right)^{\frac{1+\Psi_{i}}{\Psi_{i}}} \right]^{\frac{\Psi_{i}}{1+\Psi_{i}}} \\ \chi_{i} &> 0, \ 0 < \lambda_{i} < 1, \ \Psi_{i} > 0, \ i = 1, 2, ..., N \end{aligned}$$

$$P_i^Q Q_i = P_i^E E_i + P_i^D D_i$$

$$\frac{D_i}{E_i} = \left[\frac{\lambda_i P_i^D}{(1-\lambda_i) P_i^E}\right]^{\Psi_i}$$

Export supply function

$$E_i = \frac{Q_i}{\left(\chi_i\right)^{\left(1+\Psi_i\right)} \left(P_i^Q\right)^{\Psi_i}} \left(\frac{P_i^E}{\lambda_i}\right)^{\Psi_i}$$

Domestic good supply function

$$D_i = \frac{Q_i}{\left(\chi_i\right)^{\left(1+\Psi_i\right)} \left(P_i^Q\right)^{\Psi_i}} \left(\frac{P_i^D}{1-\lambda_i}\right)^{\Psi_i}$$

Composite output price

$$P_i^Q = \frac{1}{\chi_i} \left[\frac{\left(P_i^E\right)^{(1+\Psi_i)}}{(\lambda_i)^{\Psi_i}} + \frac{\left(P_i^D\right)^{(1+\Psi_i)}}{(1-\lambda_i)^{\Psi_i}} \right]^{\frac{1}{1+\Psi_i}}$$

CET composite exports

$$\begin{split} E_{i} &= \chi_{i}^{E} \left[\lambda_{i}^{EU} \left(E_{i}^{EU} \right)^{\frac{1+\Psi_{i}^{E}}{\Psi_{i}^{E}}} + \lambda_{i}^{RW} \left(E_{i}^{RW} \right)^{\frac{1+\Psi_{i}^{E}}{\Psi_{i}^{E}}} \right]^{\frac{\Psi_{i}^{E}}{1+\Psi_{i}^{E}}} \\ \chi_{i}^{E} &> 0; \ 0 < \lambda_{i}^{EU}, \lambda_{i}^{RW} < 1; \ \lambda_{i}^{EU} + \lambda_{i}^{RW} = 1; \ \Psi_{i}^{E} > 0; \ i = 1, 2, ..., N \end{split}$$

$$P_i^E E_i = P E_i^{EU} E_i^{EU} + P E_i^{RW} E_i^{RW}$$

$$\frac{E_i^{EU}}{E_i^{RW}} = \left(\frac{\lambda_i^{RW} P E_i^{EU}}{\lambda_i^{EU} P E_i^{RW}}\right)^{\Psi_i^E}$$

Exports supply functions

$$E_{i}^{j} = \frac{E_{i}}{\left(P_{i}^{E}\right)^{\Psi_{i}^{E}} \left(\chi_{i}^{E}\right)^{\left(1+\Psi_{i}^{E}\right)}} \left(\frac{P_{i}^{E}}{\lambda_{i}^{j}}\right)^{\Psi_{E}}; i = 1, 2, ..., N; j = EU, RW$$

Export composite price

$$P_{i}^{E} = \frac{1}{\chi_{i}^{E}} \left[\frac{\left(P_{i}^{E}\right)^{1+\Psi_{i}^{E}}}{\left(\chi_{i}^{E}\right)^{\Psi_{i}^{E}}} + \frac{\left(P_{i}^{D}\right)^{1+\Psi_{i}^{E}}}{\left(\chi_{i}^{D}\right)^{\Psi_{i}^{E}}} \right]^{\frac{1}{1+\Psi_{i}^{E}}}$$

Export prices

$$PE_i^j = erPW_i^E; \, j = EU, RW$$

Domestic goods VAT revenue

$$VAT^{D} = \sum_{i=1}^{N} vat_{i}^{D} P_{i}^{D} D_{i}$$

Imported goods VAT revenue

$$VAT^{M} = \sum_{i=1}^{N} \sum_{j=EU,RW} vat_{i}^{M} \left(1 + tm_{i}^{j}\right) erPW_{i}^{M}M_{i}^{j}$$

Import duties revenue

$$TM = \sum_{i=1}^{N} \sum_{j=EU,RW} tm_i^j PW_i^M M_i^j$$

Income tax revenue

$$TY = \sum_{i=1}^{H} \tau_i (w_i L_i + rK_i + Tr_i + erFT_i)$$

Aggregate government transfers to households

$$TR = \sum_{i=1}^{H} Tr_i$$

Government transfer to each household class

$$Tr_i = \pi_i TR; \ 0 < \pi_i < 1; \ \sum_{i=1}^H \pi_i = 1$$

Government budget

$$VAT^{D} + VAT^{M} + TY + TM + erFRG = TR + G$$

Labour market equilibrium conditions

$$L_i = \sum_{j=1}^N LD_{i,j}$$
; for each $i = 1, .., H$

Capital goods market equilibrium

$$\sum_{i=1}^{H} K_i = \sum_{j=1}^{N} KD_j$$

Domestic goods markets equilibrium

$$X_{j} = \sum_{i=1}^{N} q_{i,j} + \sum_{h=1}^{H} c_{h,j} + inv_{j} + g_{j}$$

External equilibrium

$$\sum_{j=1}^{N} PW_{j}^{M}M_{j} = \sum_{j=1}^{N} PW_{j}^{E}E_{j} + \sum_{i=1}^{H} FT_{i} + FGR_{i}$$

3.B. Glossary

H: number of households (H = 6)N: number of production sectors (N = 9)er: exchange rate (numeraire) SAV_i : saving of household i

 $YD_i:$ disposable income of household i

 Tr_i : government transfer to household i

 FT_i : foreign remittances to household i

 C_i : total consumption of household i

 P_i^C : consumption price (index) of household *i*

 $\tau_i:$ income tax rate applying to household i

 ρ_i : household *i*'s discount rate

 Ω_i^C : shift parameter in the private consumption Cobb-Douglas consumption function of household i

 $c_{i,j}$: household *i*'s consumption of good *j*

 P_i^X : composite price of good j

 $\theta_{i,j}^C$: share parameter in the private consumption Cobb-Douglas function of household *i* for good *j*

1010 i 101 good j

I: aggregate investment

 $P^{I}:$ price index of aggregate investment

 inv_i : sector *i*'s investment demand

 Ω^{I} : shift parameter in the Cobb-Douglas investment function

 θ_i^I : good *i*'s share parameter in the Cobb-Douglas investment function

G: aggregate government consumption

 P^G : price index of aggregate government consumption

 g_i : government consumption of good i

 $\Omega^G\!\!:$ shift parameter in the Cobb-Douglas government consumption function

 θ_i^G : good i's share parameter in the Cobb-Douglas government consumption func-

tion

 δ : deprecation rate of capital

 $L_{i,j}$: sector j's demand for labour of type i

 $K_{j:}$ sector j's demand for capital

 A_j : shift parameter of the value-added production function in sector j

 σ_j : elasticity of substitution between primary inputs in sector j

 $\alpha_{i,j}$: share parameter of labour of type *i* used in sector *j*

 VA_j : sector j's value-added production

 P_i^{VA} : sector j's value-added price

 w_i : nominal wage rate of labour of type i

r: nominal return to capital

 X_i : domestic absorption of sector *i*

 M_i : total imports of sector i

 cm_i : private consumption demand for import good produced by sector i

 gm_i : government consumption demand for import good produced by sector i

 $invm_i$: investment demand for import good produced by sector i

 $qm_{j,i}$: imported intermediate input produced by sector j used in the production of sector i

 D_i : domestic production of sector i

 cd_i : private consumption demand for domestic good produced by sector i

 gd_i : government consumption demand for domestic good produced by sector i

 $invd_i$: investment demand for domestic good produced by sector i

 $qd_{j,i}$: intermediate input produced domestically by sector j used in the production of sector i

 Φ_i : shift parameter in the CES Armington function of sector *i*

 ε_i : imports share parameter in the CES Armington function of sector i

 $\gamma_i:$ sector i 's elasticity of substitution between imports and domestically-produced output

 P_i^X : composite price of domestic absorption of sector *i*

 P_i^M : import price of sector *i*

 P_i^D : price of sector *i*'s domestically-produced good

 vat_i^D : VAT rate on sector *i*'s domestically-produced good

 M_i^j : imports of sector *i* from region *j*

 cm_i^j : private consumption of good *i* imported from region *j*

 gm_i^j : government consumption of good *i* imported from region *j*

 $invm_i^j$: investment demand for good *i* imported from region *j*

 $qm_{i,k}^{j}$: intermediate input consumption of good *i* used in the production of sector k and imported from region j

 PM_i^j : sector *i*'s price of imports from region *j*

 Φ_i^M : shift parameter in the imports CES function of sector *i*

 ε_i^j : region j's share parameter in the imports CES function of sector i

 tm_i^j : import tax rate applying to sector *i*'s imports from region *j*

 vat_i^M : VAT rate on sector *i*'s imported goods

 PW_i^M : sector *i*'s world price of imports

 Q_i : total output of sector i

 P_i^Q : composite output price of sector *i*

 E_i : total exports of sector i

 P_i^E : export price of sector *i*

 χ_i : shift parameter in the CET function of sector *i*

 λ_i : export share parameter of sector i

 $\Psi_i:$ elasticity of transformation between exports and domestically-sold output of sector i

 E_i^j : exports of sector *i* to region *j*

 χ_i^E : shift parameter in the CET exports function of sector *i*

 λ_i^j : share parameter of exports to region j in sector i

 Ψ_i^E : elasticity of transformation between exports to different regions of sector *i*

 PE_i^j : price of exports to region j of sector i

 PW_i^E : world price of exports of sector *i*

 VAT^{D} : domestic goods VAT revenue

 VAT^M : imported goods VAT revenue

TM: aggregate import tariffs revenue

TY: income tax revenue

TR: aggregate government transfers to households

FRG: foreign grants to the government

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