METU Studies in Development, 38 (August), 2011, 125-146

The effects of agricultural liberalization on sectoral water use: A CGE Model for Turkey[1]

Yasemin Asu Çırpıcı
Yıldız Teknik Üniversitesi, İİBF, İktisat Bölümü, Yıldız, İstanbul
e-mail: yusanmaz@yahoo.com

Abstract

The aim of this study is to construct a water-CGE model for Turkey in order to examine the effects of a reduction in agricultural tariff rates on Turkey's international trade and on agricultural water use.

With agricultural trade liberalization Turkey becomes a net importer of agricultural products. The agricultural production declines and results in a reduction in the agricultural water use.

The same simulation is considered with an increase in agricultural productivity. The trade distortions resulting from tariff reductions are compensated. Water use in the fruit sector increases while in other agricultural sectors it declines although the production and net exports in all agricultural sectors increase.

Keywords: CGE models, agricultural tariffs, water use.

JEL codes: D58, Q17, Q25.

1. Introduction

Computable general equilibrium (CGE) models are effective in making economy-wide policy analysis. They cover the interrelationship between production activities, factors of production, households, government and the rest of the world. Therefore, it is possible to analyze both the direct and the indirect effects of a policy change or an economic shock throughout the economy. These features make CGE modeling a suitable method for analyzing water-related issues.

There are many studies in the literature that examine different water-related aspects within a CGE framework. One of the leading Applied General Equilibrium (AGE) model analyzing water management policies is presented by Berck, Robinson and Goldman (1991). They used the model

[1] The model analyzed in this study is developed in the writer's PhD. Dissertation (Çırpıcı, 2008).

to find the effects of reducing water inputs in the San Joaquin Valley of California on the GDP of the Valley, on sectoral output, employment and land use.

Following this study, many water-extended CGE models are constructed for different countries: Goldin and Roland-Holst (1995), Löfgren (1996), Decaluwe et. al. (1998, 1999), Tirado et. al. (2003), Thabet (2003), Stringer and Wittwer (2001), Kraybill et. al. (2002), Robinson and Gehlhar (1995), Cabral (2005), Azdan (2001), Mukherjee (1995), Diaz-Rodriguez (2000), Diao and Roe (2000, 2003), Vaux and Howitt (1984), and Diao et. al. (2002), Seung et. al. (1998), Goodman (2000) are some examples of them.

There are many CGE applications for Turkey. Pioneer work is the one of Celasun's (1986). Harrison et. al. (1992) analyzed trade liberalization in Turkey. Köse (1996) studied Customs Union's effect on Turkish economy while Tunç (1997) constructed a financial CGE model and Doğruel et. al. (2003) examined agricultural reforms.

Other examples are: Yeldan (1989) of export subsidies and international trade regime, Köse and Yeldan (1996) of income distribution, Diao et. al. (1999) of trade liberalization and fiscal adjustments, Telli et. al. (2005) of the theoretical foundations of the disinflation program and its structural weakness. Also there are other studies covering financial sector as Lewis (1992) and Yeldan (1998). Environmental issues are analyzed by Yeldan and Roe (1994) and Telli et. al. (2008).

Çakmak et al. (1996) analyzed the Turkish agriculture by using a CGE model in which there is one agricultural and three non-agricultural sectors. While, Diao and Yeldan (2001) developed a CGE model with a detailed agricultural sector in order to analyze the effects of global agricultural trade liberalization.

Doğruel et al. (2003) constructed a CGE model for Turkey with six sectors of which one is an aggregate agriculture sector. They analyzed the feasible alternatives of agricultural reform.

Although there are variety of CGE applications for Turkey, neither one was to add water as an input until the study by Çırpıcı (2008) in which both the effects of a trade liberalization and a "water-tax" scenario was examined using a water-extended CGE model for Turkey. This article is based on this first study for Turkey that includes water in a CGE model. After Çırpıcı (2008) another water extended-CGE model was constructed for Turkey by Çakmak et al. in 2008. The model is named Turkish Agricultural Computable General Equilibrium Model with Water (TACOGEM-W). The model is rather detailed (both in regional and sectoral terms) with 20 agricultural and 9 non-agricultural activities in five regions. Using this model, Çakmak et. al. (2008) analyzed the effects of a permanent increase in the agricultural world prices and the climate change and they also examined the impact of transferring water from rural to urban areas. In 2010 Dudu et al. again by the use of TACOGEM-W investigated the economy-wide effects of climate change in Turkey.

The aim of this study is to construct a water-extended CGE model for Turkey in order to analyze the effects of agricultural liberalization on sectoral water use. The model consists of four agricultural sectors and a non-agricultural sector. The resent available Input-Output Table is the one for 2002. However, this Table was not balanced. Therefore, agricultural sector disaggregation is made in accordance with the detail in 1998 Input-Output (I-O) Table as 1) growing cereals and other crops, 2) growing vegetables, horticultural specialties and nursery products, 3) growing fruit, nuts, beverage and spice crops and 4) other agriculture sectors. All other sectors are added as a fifth sector under the heading "non-agricultural sector".

There are four factors of production: labor, capital, land and water, though land is not applied to the non-agricultural sector. All factors are mobile across the sectors and the total supply of factors is fixed exogenously. While full utilization of labor, capital and land are assumed, it is supposed that a certain amount of water is not consumed. In water-CGE models mostly Cobb-Douglas and CES functions are preferred to represent the production structure. Using CES functions necessitates the use of an exogenous elasticity of substitution parameter. For Turkey there are few calculations of this parameter (see for example Dahl and Erdoğan, 2000; De Santis, 2002), however different studies give quite different results for the parameter since it is sensitive to the data set and the method preferred to calculate it. Moreover, Cobb-Douglas production structure is easier to apply. Therefore, it is preferred to the CES function. A nested production structure in agriculture is applied with a Leontief production function to combine water and land inputs, while a Cobb-Douglas production function is implemented to combine the water-land composite with capital and labor.

Armington specification on the trade structure is applied. Accordingly, domestic and traded goods are taken to be imperfect substitutes.

There is an ongoing debate on an international scale for liberalizing agricultural trade. Although WTO countries seem to agree on the need for liberalization in agriculture, no agreement has been achieved so far on further liberalization of trade in agricultural products. Turkey implemented the necessary decreases in its agricultural tariff rates committed in the Agreement on Agriculture (AoA) of WTO. However, this did not lead to a real overall average tariff reduction. In this study, a trade simulation is performed in order to analyze a situation in which Turkey decreases its agricultural tariff rates leading to a real decrease in its overall average applied tariffs.

The same simulation is repeated under the assumption of a productivity increase in agriculture. This is important for Turkey in order for it to increase its comparative advantage in the international arena. This is indicated in the studies concerning the EU-Turkey trade relations. Turkey has nearly half of both its imports and exports with the EU. Several studies indicate that Turkey can not benefit from the Customs Union (CU) enlargement or from an accession with the EU unless it applies the necessary structural change policies. This is true even for the sectors that Turkey has a competitive advantage in, namely fruit and vegetable sectors. In fact, Abay (2005) states that without enhancing the quality and standards, Turkey can not benefit from this advantage. He also indicates that for the products which Turkey is short in supply (such as cereals and oil seeds) it is important to increase the productivity. Also, Çakmak and Kasnakoğlu (2002) showed that even a small increase in the productivity in the livestock sector can eliminate the negative impact of a possible accession on livestock production.

In the next part, the general structure of the model is given and the simulation result can be found in the third part.

2. Water-CGE Model for Turkey

The model constructed in this study is a single-country, 5-sector, saving-driven, small-open, static CGE model for Turkey with four factors of production. Apart from the other CGE models for Turkey, it has a nested production structure. Land and water form a composite good and this together with capital and labor, comprises the total agricultural production. This structure is similar to the work of Mukherjee (1995), except she used CES production function in the second stage, while in this case the Cobb-Douglas production function is preferred.

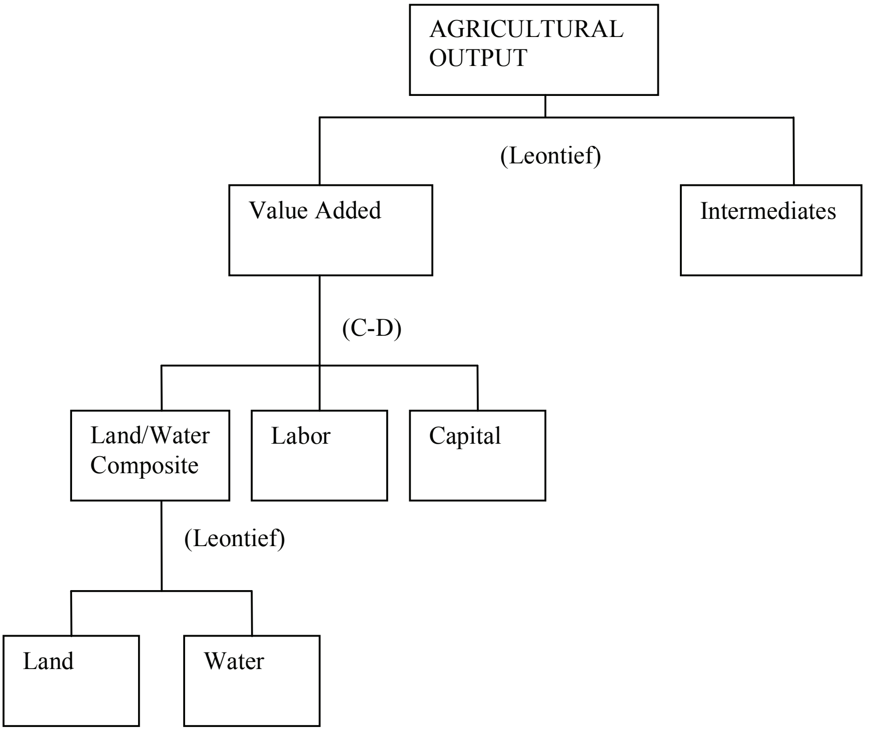
Agricultural sectors are decomposed according to the 1998 Input-Output Table's detail. Accordingly, three agricultural sectors are taken as growing of cereals and other crops n.e.c. (C), growing vegetables, horticultural specialties and nursery products (V), and growing fruit, nuts, beverage and spice crops (FR) and all other agricultural sectors in I-O Table are aggregated within "other agricultural sector" (OA).

The nested agricultural production structure is shown in Figure 1. Two of the four factors of production, land and water, comprise a composite good. This composite input in turn, is linked with capital and labor through a constant return to scale the Cobb-Douglas (C-D) production function given in Equation 1.

$$XS_i = A_i K_i^{\alpha_i} L_i^{\beta_i} TW_i^{(1-\alpha_i-\beta_i)} \tag{1}$$

Here, K_i is capital, L_i is labor and TW_i is the land/water composite.

Figure 1
Structure of Agricultural Output



Sectoral output is assumed to be a Leontief function of sectoral value-added and intermediate inputs. Thus, no substitution is allowed between the primary factors and intermediates. Intermediate input demand in each sector, *i*, is determined by the fixed Leontief coefficients a_{ij}'s.

$$INT_i = \sum_j a_{ij} XS_j \qquad (2)$$

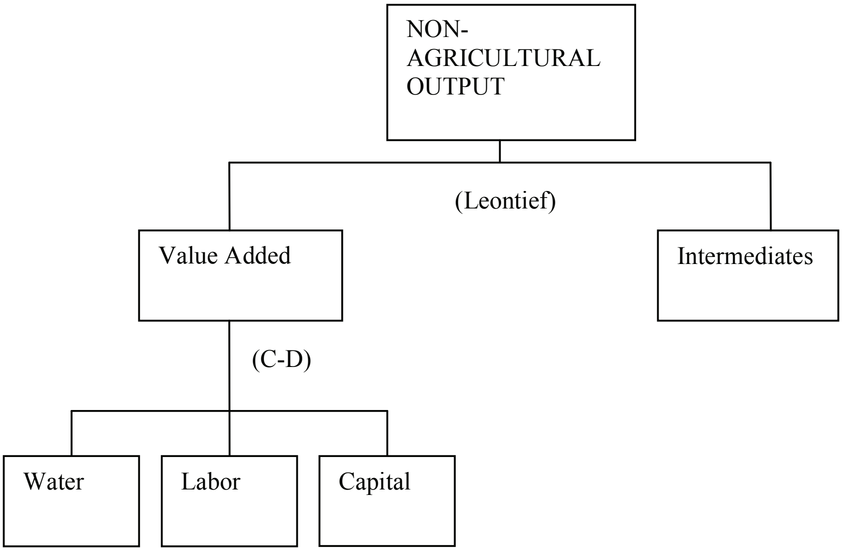
Land is not applied to non-agricultural production. For the non-agricultural sector, labor, capital, and water inputs are aggregated through a C-D Production function:

$$XS_{NA} = A_{NA} K_{NA}^{\alpha_{NA}} L_{NA}^{\beta_{NA}} H_{NA}^{(1-\alpha_{NA}-\beta_{NA})} \qquad (3)$$

Here, K_{NA} and L_{NA} represent non-agricultural capital and labor respectively and H_{NA} represents the water input.

Value-added and intermediate inputs are combined in a Leontief function to form the sectoral output (See Figure 2).

Figure 2
Structure of Non-Agricultural Output



The aggregate supplies of factors of production in each sector are fixed and given exogenously. Labor and capital inputs are assumed to be fully utilized. Since not all water resources can be used at once, water input is assumed to be partly consumed, the remaining is allowed to flow. There is no separate production sector for water. Sectoral water usage is assumed to be determined in a competitive market as are the other factors of production.

There are two agents in the model: the private and the public. Public agents represent all the state owned enterprises and the private agent represents the households. Public revenues consist of tax revenues and income from abroad while private income is composed of income from factor ownership less taxes, and domestic and foreign transfers.

The Armington specification is used so that imported and domestically produced goods are assumed to be imperfect substitutes. Households consume a composite good composed of domestic and foreign products. Subject to their current incomes, households minimize their costs. As a result, the households decide on the composition of domestic and imported goods in their consumption bundle. Accordingly, sectoral composite good, CC_i, is formulated as a *Constant Elasticity of Substitution* (CES) aggregation of the domestic commodity, DC_i, and the imported foreign good, M_i as given in Equation 4.

$$CC_i = ac_i(bc_i M_i^{-\gamma_i} + (1-bc_i)DC_i^{-\gamma})^{-1/\gamma_i} \quad (4)$$

Here, γ_i is the elasticity of substitution parameter and is taken to be exogenous.

Subject to CC_i, households minimize their cost function given in Equation 5

$$Pd_i.DC_i + Pm_i.M_i \tag{5}$$

where, Pd_i and Pm_i are sectoral domestic and imported goods' prices respectively.

The first order condition of the cost minimization problem gives:

$$\frac{M_i}{DC_i} = \left(\frac{bc_i}{1-bc_i}\right)^{\sigma_{m_i}} \left(\frac{Pd_i}{Pm_i}\right)^{\sigma_{m_i}} \quad \text{where } \sigma_{m_i} = \frac{1}{1+\gamma_i} \tag{6}$$

On the other hand, the representative producer in each sector is assumed to maximize its total revenue from domestic and foreign sales (EX_i). So, their decision is about whether to produce for the domestic or the foreign market.

The producer's problem can be formulized as:

$$\text{Max} \quad Pd_i.DC_i + Pe_i.EX_i \tag{7}$$

$$\text{s.t. } XS_i = at_i(bt_i EX_i^{-\mu_i} + (1-bt_i)DC_i^{-\mu})^{1/\mu_i}$$

where, Pe_i is sectoral exported good's price.

The first order condition can be shown to be:

$$\frac{EX_i}{DC_i} = \left(\frac{1-bt_i}{bt_i}\right)^{\sigma_{e_i}} \left(\frac{Pe_i}{Pd_i}\right)^{\sigma_{e_i}} \quad \text{where } \sigma_{e_i} = \frac{1}{1-\mu_i} \tag{8}$$

De Santis (2002) provides estimated elasticities for Turkey. Accordingly, both σ_{m_i} and σ_{e_i} are taken to be equal to 2. In order to reflect the comparative advantage of Turkey in foreign trade, it is further assumed that the response of the vegetable and the fruit sectors should be lower than this rate. Therefore, elasticities for these sectors are taken to be 0.5.

2.1. Equilibrium conditions

Public saving is the difference between public revenues and public expenditures. Private saving is calculated as a fixed proportion (MPS) of the disposable private income. Thus, the model closure is "saving driven". Private saving calculated from the exogenous saving rate is assumed to determine the investment level through the saving-investment balance. Total private investment is distributed to the sectors in fixed shares. Total public investment (*TOTGINV*) is calculated from government primary balance (*GPRMBAL*) equation:

$$GPRMBAL = GREV - TGCON - TOTGINV - INTRSRAT * TRANS \tag{9}$$

In accordance with the economic program of 2003, *GPRMBAL* is taken to be as a proportion of *GDP*. *INTRSRAT*[2] is the ratio of interest payments to domestic banks in government transfers.

Total saving (public, private and foreign) is equal to the total investment:

$$GSAV + PRSAV + FSAV = TINV \tag{10}$$

Commodity balance, describing the supply and demand equivalence of composite commodities, is given below. The sum of private and public consumption demands, $PRCON_i$ and $GCON_i$ respectively, investment demand, INV_i, and the intermediate demand, INT_i, has to be equal to the sectoral absorption, namely to the supply of the composite good, CC_i.

$$CC_i = INT_i + PRCON_i + GCON_i + INV_i \tag{11}$$

Current account balance implies

$$\sum PM_i IM_i + NPFE + FIP = \sum PE_i EX_i + FSAV + NPFI + PFTR \tag{12}$$

Here, *NPFE* is the net private factor payments to the rest of the world (row); *FIP* is the foreign interest payments; *NPFI* is the net private factor income from row; *PFTR* is the public foreign transfers, and *FSAV* is the foreign savings.

3. Simulation results

Turkey, according to the AoA, has reduced its agricultural tariff ceiling value by 24 percent (each year 2.4 percent for ten years) from 1994 to 2004. However, as seen in Table 1, the applied average tariff rate increased from 44.84 percent to 55.10 percent with fluctuations.

Yet, starting from 44.84 percent in 1994, reduction of 24 percent should have lead to 20.84 percent tariff rate in 2004. However, the observed value in 2004 was 55.10 so, there is a difference of 34.26 percent between the expected value and the applied one. Applying the same calculation for 2003, from 1994 to 2003 the tariff rates should have been reduced by 2.4x9 = 21.60 percent, corresponding to a 23.24 (= 44.84-21.60) percent tariff value. However, again from Table 1 one can see that the applied value in 2003 was 54.90 percent. The difference between the realized (54.90) and expected tariff rate (23.24) is about 32 percent. The first simulation applied here tries to answer a "what if" question to understand the situation when the applied tariff value is 23.24 instead of 54.90 percent. In the simulation, effects of a reduction in tariff rate, tm_i, of a 32 percent for all agricultural sectors is analyzed. All the values and the percentage changes are given in real terms.

[2] Is calculated to be equal to 0.484 as the proportion of public domestic interest payments within public transfers.

Table 1
Turkey's Average Agricultural Tariff Rates

Years	EU and EFTA	Other Countries	Average
1994	43.64	46.03	44.84
1995	31.23	34.58	32.91
1996	46.93	49.55	48.24
1997	50.60	51.60	51.10
1998	52.90	53.10	53.00
1999	52.00	53.10	52.55
2000	56.50	57.60	57.05
2001	55.60	56.60	56.10
2002	54.70	55.70	55.20
2003	54.40	55.40	54.90
2004	54.60	55.60	55.10

Source: DTM (2004).

As expected, tariff reduction in agriculture leads to a reduction in agricultural import prices, PM. The largest price decrease is observed in the other agriculture sectors (30 percent). The main sector within "the other agricultural sector" is the livestock sector. In fact, the other sectors such as fishery, forestry and some related agricultural services share only a small portion. Therefore, relating the comments about this sector to the livestock production will not be misleading. So, the analysis in this study about this sector should be read in this manner. In fact, the significant decline in the imported prices appears to be a clear-cut result of this, since Turkey does not have much chance in the international markets of the livestock production, being far behind (both in terms of price level and productivity) especially the North European Countries. Import price changes in the other sectors are also substantial: 11, 25 and 28 percent for cereal, vegetable, and fruit sectors, respectively.

Table 2
Trade-Related Changes

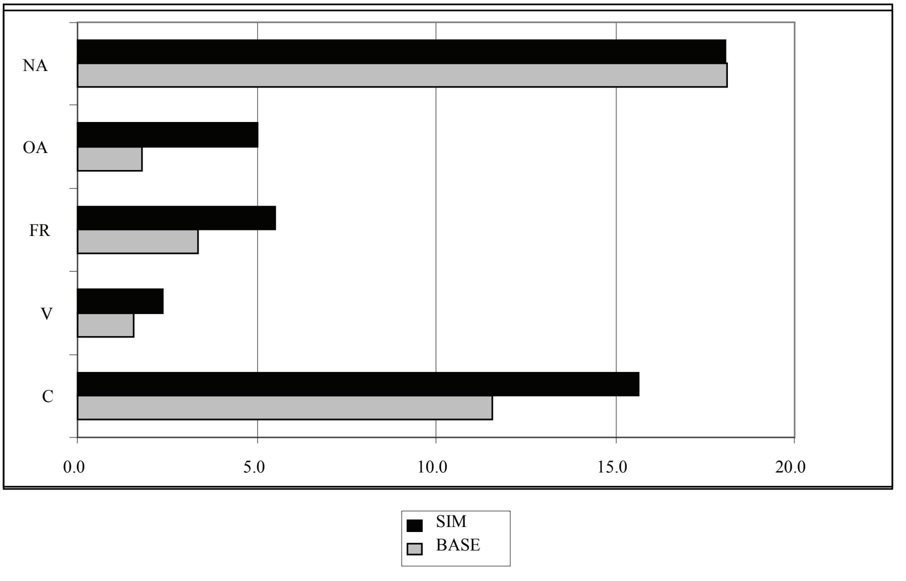
(real, million TL)

	BASE RUN			SIMULATION		
	IM	EX	NET EXPORTS (NE)	IM	EX	NET EXPORTS (NE)
C	3218	2282	-936	4346	2204	-2142
V	158	301	144	245	303	59
FR	322	2516	2195	529	2508	1979
OA	409	227	-181	1,171	224	-948
NA	106229	9317	-1306	106704	94855	-1185

In relation to the change in import prices, as agricultural imported goods become cheaper with the reduction of tariff rates, agricultural imports increase (see Table 2). The largest increase is observed in the other agriculture sectors, nearly threefold, as the world prices of livestock products are much lower than the domestic prices. Non-agricultural imports also increase, resulting in an overall real increase of about 2.4 percent in total imports.

Exports in the vegetable sector increase by 0.7 percent while in the other agriculture sectors' exports decline. As observed from Table 2, although Turkey remains to be a net exporter in fresh fruits and vegetables, its net exports have declined. The increase in exports of non-agricultural sectors does not meet the increase in imports and this results in about 9 percent deterioration in overall trade deficit.

Figure 3
Percentage Shares of the Imports within the Total Consumption



The Armington specification makes it possible to decompose the overall consumption into domestic and imported goods consumption. Imported agricultural goods become cheaper with the reduction in tariff rates and this leads to an increase in the consumption of these goods. Figure 3 shows the percentage shares of imported goods in total consumption. It can be seen that the consumption of agricultural goods shifted from domestic to imported goods. In fact, the share of agricultural imported goods within the total agricultural consumption increases from 5.8 percent to 8.9 percent in agricultural sectors. Changes in the percentage shares of the imported goods are significant with 35, 54 and 63 percent change for cereal, vegetable and fruit consumptions, respectively. The greatest change is for the other agriculture sectors from 1.8 to 5 percent corresponding to a 183 percent increase. On the other hand, for non-agricultural sectors the total share of the imported goods remains almost the same.

On the supply side, domestic agricultural production declines, except for vegetable production, while non-agricultural production increases. One can see the percentage of increases in production in Figure 4. As mentioned before, the only agricultural sector in which exports increase is the vegetable sector. This results in an increase in production in this sector. Although households consume more imported fruit products compared to the base-run, they do not change their domestic consumption significantly. This leads to a relatively small decrease in fruit production. On the other hand, changes in domestic consumption in other agricultural sectors are much higher. The greatest decline in production is in cereal production, with a 4 percent decrease, as the domestic consumption declines the most for this sector.

Figure 4

Percentage Increase in Domestic Production Compared to Base Run

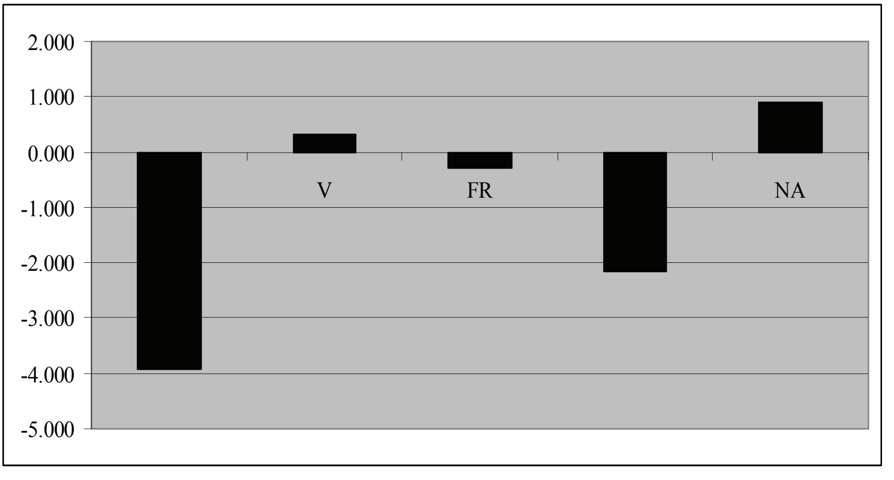


Table 3 displays the overall results of the simulation in comparison with the base-run in real values. There is a real increase in the GDP value by 0.5 percent. Private and public incomes increase by approximately 0.4 and 1.2 percent, respectively. The increase in imported good consumption which is far beyond the decrease in domestic agricultural consumption leads to about a 0.5 increase in the overall agricultural consumption. Total increase in the income level resulted in a total increase in the real consumption from 656.757 to 660,798. Total production also rises in both value and quantity terms on the other hand, the share of agriculture in the total production decreases while the non-agricultural share increases. Both the total imports and exports increase but the overall effect is deterioration in the trade deficit.

Table 3
The Overall Results of the Simulation
(real, million TL)

	BASE-RUN	SIM
GDP	358700	360455
Value of Production	601885	605473
Agriculture	60216	5895
Non-agriculture	541669	546523
Share of Agriculture (%)	10.0	9.7
Share of Non-Agriculture (%)	90.0	90.3
Volume of Production	281861	281877
Agriculture	44375	43315
Non-agriculture	237486	238562
Share of Agriculture (%)	15.7	15.4
Share of Non-Agriculture (%)	84.3	84.6
	BASE-RUN	SIM
GDP	358700	360455
Total Consumption	656757	660798
Agriculture	70608	70946
Non-agriculture	586149	589852
Incomes		
Private	308459	309697
Public	108376	+10966
Total Trade		
Imports	110334	112996
Exports	98496	100093

Changes in the allocation of factors of production in each sector, in comparison to a base-run value of 1 can be seen in Table 4. There is a capital flow from agriculture to non-agricultural sectors. Water and land use in agriculture declines as production reduces. Labor use in cereal productions and other agriculture productions decrease.

The excess supply of water increases from 95,000 to 109,304 billion m^3. Water use changes in accordance with the domestic production. The greatest decrease of 4 percent is observed in cereal production which is then followed by the other agricultural sectors. As domestic production almost remains constant for fruit and vegetable production, changes in water use in these sectors remains below 1 percent.

Table 4
Changes in Input Use

(Base = 1.00)

SECTORS	LABOR	CAPITAL	LAND	WATER
C	0.9613	0.9541	0.9566	0.9566
V	10.049	0.9973	0.9999	0.9999
FR	10.008	0.9933	0.9959	0.9959
OA	0.9805	0.9732	0.9757	0.9757
NA	10.114	10.018		10.082

To sum up, the first simulation results show that a 32 percent decrease in tariff rates leads to a 0.5 percent increase in GDP, and 0.4 and 1.2 percent increase in private and public income respectively. Consumers benefit from the decreasing prices and the increasing incomes. However, the model does not give any information about the possible deteriorations in income distribution. Factors of production mostly flow from agricultural sectors to others, only labor for fruit and vegetable production increases. The vegetable sector is the only sector for which agricultural production and exports increase. The overall foreign trade volume increases, but in the agricultural sectors net export values decline.

3.1. Productivity analysis

Increasing productivity in agriculture is important for Turkey in order for it to increase its comparative advantage in the international arena. This fact is mentioned in studies concerning the EU-Turkey trade relations. In fact, Turkey is far behind the EU in agricultural productivity. Studies on Turkey-EU relations (as Abay (2005), Çakmak and Kasnakoğlu (2002)) indicate that Turkey can not benefit from CU enlargement or from an accession to EU unless it applies the necessary structural change policies. This is true even for the sectors that Turkey has a competitive advantage in, namely fruit and vegetable sectors.

Consider constant returns to scale Cobb-Douglas production function in a perfectly competitive economy:

$$Y = AK^{\alpha}L^{\beta}TW^{\gamma} \quad \text{with} \quad \alpha + \beta + \gamma = 1. \tag{13}$$

Here, A represents the technology parameter while K, L and TW are the capital, labor and land/water composite used for production. The formulation for productivity growth can be given as:

$$\left(\frac{dA}{A}\right)^{SR} = \frac{dY}{Y} - s_K \frac{dK}{K} - s_L \frac{dL}{L} - s_{TW} \frac{dTW}{TW} \tag{14}$$

where $(dA/A)^{SR}$ is the growth of value added after the contribution of inputs are removed; the term referred to as the Solow Residual. The parameters s_K, s_L and s_{TW} are the share of capital labor and land/water inputs in value added respectively. Calculated percentage changes are given in Table 5[3].

The change in productivity is assumed to be the geometric average of ten years' productivity growth rates $(dA/A)^{SR}$ given in Table 5. Accordingly, an 18 percent cumulative increase in productivity in agriculture is examined.

Table 5

Results of the Productivity Calculations

	dL/L	dK/K	dTW/TW	dY/Y	dA/A
1993	-9.830	2.565	-0.145	-1.283	2.062
1994	12.Eki	-0.418	0.494	-0.725	-5.819
1995	3.041	2.209	-3.022	1.965	0.711
1996	1.971	3.883	0.568	4.400	2.151
1997	-4.558	5.193	-0.452	-2.337	-2.004
1998	2.286	4.244	0.391	8.369	5.914
1999	-2.025	-0.365	-0.619	-4.991	-3.862
2000	-12.27	2.709	-1.576	3.857	8.543
2001	4.119	-0.175	-0.115	-6.508	-8.160
2002	-7.801	-0.680	0.869	6.865	10.164
2003	-3.929	-1.764	-2.081	-2.500	0.257

The general results of the simulation with productivity increase are displayed in Table 6. As can be seen, productivity increase leads to a higher increase in both the value and the volume of the production when compared to the pure tariff reduction simulation. While the value of agricultural production declines with tariff reduction, an increase in productivity in agriculture offsets this decline and results in an even higher value than the base run.

Results show that productivity increase leads to a larger increase in GDP values compared to the base run. In fact, about a 0.5 percent increase of GDP reach to about 2.8 percent with productivity increase. Comparing the trade simulation alone and the same simulation with productivity, it can be seen that, productivity increase leads to a further 2.4 percent and 1.3 percent increase in private and public incomes, respectively.

[3] The capital stock variable is taken from the study of Saygılı et. al. (2005). Labor and land data is obtained from TURKSTAT (2005), water values are taken from DSİ, and finally the agricultural value added is from the World Bank's web-site. The s_K and s_L and s_{TW} parameters are calculated within the model to be approximately, 0.4, 0.3, and 0.3, respectively. Productivity change for the period of 1993 to 2003 is calculated.

Table 6
General Results of the Simulation with Productivity Increase
(real, million TL)

	BASE	SIM	PROD. INCREASE
GDP	358700	360455	368698
Value of Production	601885	605473	624906
Agriculture	60216	5895	70901
Non-agriculture	541669	546523	554005
Volume of Production	281861	281877	284605
Agriculture	44375	43315	43699
Non-agriculture	237486	238562	240905
Total Consumption	656757	660798	682221
Agriculture	70608	70946	804
Non-agriculture	586149	589852	60182
Incomes			
Private	308459	309697	317096
Public	108376	10966	111103
Total Trade			
Imports	110334	112996	115904
Exports	98496	100093	102855

As observed in the Table 7, productivity increase in agriculture results in a larger decline in agricultural prices. While tariff reduction alone leads to a price decrease of at most 1.3 percent for the other non-agricultural sectors, with productivity improvement, price decreases ranging from 10 to 17 percent can be observed. The largest decline is observed for fruit products. While the non-agricultural prices decline in the first simulation, the productivity improvement leads to an increase in the prices. Nevertheless, both the agricultural and the non-agricultural consumption increases.

Table 7
Sectoral Price Changes with Productivity Increase
(Base=1.00)

	PC		PM	
	SIM	PROD.	SIM	PROD.
C	0.994	0.897	0.891	0.891
V	0.997	0.882	0.747	0.747
FR	0.998	0.829	0.716	0.716
OA	0.987	0.886	0.697	0.697
NA	0.998	1.005	1.000	1.000

The first simulation results showed that with the reduction in tariff rates, Turkey becomes a net importer for agricultural products, although it remains to be a net exporter of fruits and vegetables. But, productivity increase offsets this trade distortion and further increases the net exports to a higher value than the base run for the first three sectors given in Table 8. On the other hand, it can be seen that productivity increase is ineffective in preventing the decline in the other agricultural net exports. Although the decline is lower than in the case of tariff reduction alone, the comparative advantage of the trade partners of Turkey still remains insuperable.

Table 8
Sectoral Net Exports

	BASE	SIM	PROD
C	-935.85	-2,142	-656
V	143.53	58.559	184.303
FR	2194.8	1978.7	3869.7
OA	-181.13	-947.64	-736.92
NA	-13060	-11850	-15710

There is a challenging result of this second simulation indicating an increase in the comparative advantage for fruit and vegetable production as the domestic prices decline and the net exports improve significantly. In fact, this improvement is much larger than the trade deficit observed in the other agricultural sectors. Hence, the overall agricultural net exports more than doubled compared to the base-run (see Table 9).

Table 9
Agricultural and Non-Agricultural Trade

Exports	BASE-RUN	SIM	PROD.
Agr	5326.84	5238.68	8510.73
Non-Agr	93169.502	94854.1	94344.2
Imports	BASE-RUN	SIM.	PROD.
Agr	4105.49	6291.32	5850.07
Non-Agr	106229	106704	110054
Net-Exports	BASE-RUN	SIM.	PROD.
Agr	1221.34	-1052.63	2660.66
Non-Agr	-13059.4	-11850.2	-15709.4

For all agricultural sectors trade liberalization with a productivity increase is much more favorable than reducing the tariff rates without taking any precautions. Improving the productivity is of great concern for Turkey in case there is an opening up to the foreign competition.

Non-agricultural sectors are affected negatively from the agricultural productivity increase in terms of the trade deficit. Both the production and the export levels are increased in non-agricultural sectors but at the same time import is increased further. It seems that importing some non-agricultural products became more favorable. The model does not distinguish between agricultural and non-agricultural income levels. But, probably it will be convenient to think that the agricultural value added is used to finance the import increase in non-agricultural sectors. Note that, as can be seen from Table 6, the total private and public incomes increase about 0.4 and 1.18 percent respectively with pure tariff reduction while they increase about 2.80 and 2.52 percent respectively in tariff reduction with productivity increase. So, the overall income effect is notable.

Table 10
Percentage Change in Agricultural Water Use
Compared to the Base-Run

	Domestic Production		Water Use	
	SIM	PROD	SIM	PROD
C	-4.163	9.923	-4.337	-3.456
V	0.105	13.032	-0.006	-2.286
FR	-0.468	17.460	-0.414	12.027
OA	-2.372	8.696	-2.428	-6.503
ONA	0.707	2.485	0.821	0.613

In general, we observe that the increase in production can be obtained by decrease in the use of factors of production. In this respect, while there is a significant increase in production and exports in all agricultural sectors, factor use is lower than the first simulation, except for the fruit production. As can be seen in Table 10, the decline in the domestic production resulted from the tariff reduction reflected in a similar reduction in sectoral water uses. On the other hand, with productivity increase, although domestic production increases about 10, 13 and 9 percent for cereal, vegetable and other agriculture sectors respectively, water uses for these sectors fall to 4, 2 and 7 percent respectively.

One must note that the productivity improvement examined here is in purely technical terms. Namely, it is about changing the technology parameter in the production function. Hence, the model does not give any information about the path leading to this improvement. Results show that the increase in production and exports is achieved by reducing the cultivated area for cereal, vegetable and livestock production with lower factors of production use. Namely, all the input uses for these sectors, including land, are reduced.

On the other hand, fruit production is spread to a larger area. In fact, about 3.5, 2.3 and 6.5 percent of the land used for cereal, vegetable and livestock production, respectively, is turned into fruit orchards. The fruit sector is on a development path. Gül and Akpınar (2006) examined the fresh fruit production in the world and in Turkey between 1961 and 2004. They observed that there was a significant increase in the fresh fruit production in the world during this period. They attributed this improvement to increase in both the cultivated land and the productivity for fresh fruit production whereas they concluded that for the production increase in nuts, enlargement of the cultivated land was determinative. The production increase in Turkey, in general, is observed to be above the world average. This increase was observed to be due to productivity increase for the fresh fruit production while for nut production productivity together with increase in cultivated land played an important role.

One must note that the standards of the fruit and the vegetable products are very important in world trade. Hence, the misuse of fertilizers and pesticide harm our exports. Also, Koç (2005) indicates that the fresh fruit and the vegetable products subject to exports are insufficient in meeting the quantity and quality demanded in international markets.

By analyzing the model results one can observe that the increase in production is realized both by productivity improvement and increase in cultivated area. Significant increase in the exports most probably results from the increase in quality and the variety in fruit production. The uptrend in the sector and the potential advantageous position in the foreign markets, leads to a resource transfer to this sector. The result is a 17.5 percent and a 15.5 percent increase in production and export, respectively, compared to the base-run with about 11 percent increase in labor and capital inputs and about 12 percent increase in water and land use.

4. Conclusion

In this study, a water-CGE model for Turkey is built in order to analyze the effects of trade liberalization in agriculture on international trade and sectoral water use.

Turkey is participating in the debates of tariff reduction since it is a member of WTO and a candidate country for the EU. In accordance to the WTO AoA, Turkey has made commitments for tariff reduction in agriculture and has implemented them. Nevertheless, utilization of the advantages of some specifications of the Agreement has kept the applied average tariff rates high. In the simulation performed in this work, the consequences of a reduction of applied average tariff rates are analyzed.

The simulation results indicate an increase in GDP and private income due to the agricultural tariff reduction. Cheaper imported goods, having access to the domestic market, lead to a price decrease and this in turn increases the total consumption.

Tariff reduction leads to an increase in the imports of all sectors and a decrease in exports for agricultural sectors except for the vegetable sector. Although Turkey remains to be a net exporter of fruit and vegetable products, net exports for these sectors are also in decline. The highest trade distortion is observed in the other agriculture sectors. This is due to the livestock production which is included in this sector and which Turkey is not able to compete with the pricing, quality and productivity in European countries.

Domestic agricultural production is reduced except for the vegetable sector, as the households' preferences change in favor of the imported agricultural products. Accordingly, the use of factors of production declines. Water use in the agricultural sectors reduces almost in proportion with the decline in the domestic production. Accordingly, the largest decline in the water use is realized in cereal production. Much lower reductions are seen in the fruit and vegetable sectors as change in the production of these sectors is small.

It is important for Turkey to achieve productivity increase in agriculture in order to increase its competitiveness in the international arena. Turkey is far behind the level of, especially its biggest trade partner, EU, in agricultural productivity. Therefore, in order to see the impact of a productivity improvement, the same simulation is repeated under a total agricultural productivity increase scenario.

Results showed that productivity increase in agriculture leads to a further increase in both GDP level and incomes. At the same time, it compensates the trade distortions in agricultural sectors resulting from the first simulation and net exports increase above the base run value. As a result the total net exports more than doubles.

Increase in both the domestic production and exports can be realized by the use of less factors of production in agricultural sectors, except for fruit production. Productivity improvement enables the producers to increase their production significantly by using less water. Also, cereal, vegetable and livestock production can be performed using less capital, labor and land. On the other hand, in order to achieve a higher production level in the fruit sector the cultivated land had to be increased.

Trade partners of Turkey are sensitive to the quality of the fruit and the vegetable products that they import and in the current situation, as Koç (2005) indicates, the fresh fruit and the vegetable products of Turkey which are subject to export are insufficient in meeting the quantity and quality demanded in international markets. Therefore, a significant increase in exports most probably is an indicator of an improvement in both the quality and the variety of the fruit and the vegetable products. This progress is realized in the vegetable sector by less use of inputs including land and water. On the other hand, cultivated land in the fruit sector increases and accordingly labor and water use also rise.

References

ABAY, (2005), "AB'de Meyve-Sebze Ortak Piyasa Düzenleri ve Türkiye'nin Uyumu Açısından Değerlendirilmesi", in Oktay, E. and Tunalıoğlu (eds.), *Türk Tarım Politikasının Avrupa Birliği Ortak Tarım Politikasına Uyumu*, Ankara: Ege University Agricultural Economics Department, No: 134, 27.

AZDAN, M. D. (2001), "Water Policy Reform in Jakarta, Indonesia: A CGE Analysis.", PhD dissertation, D. D. Southgate (advisor), Ohio State University, USA.

CABRAL, F. J. (2005), "Agricultural Subsidies Removal in North Countries: What About the Effects in Senegal?", *Paper presented in International Conference on Shared Growth in Africa*, ISSER/Cornell University/World Bank/DFID/USAID, La Palm Royal Beach Hotel, Accra, Ghana.

CELASUN, M. (1986) "A General Equilibrium Model of the Turkish Economy, SIMLOG-1: Validation Results (1978-1983) and Counterfactual Experiments with Wage Policies (1981-1983)", METU Studies in Development, 13(1-2), 29-94.

ÇAKMAK, E. H., DUDU, H., SARACOĞLU, Ş., DIAO, X. ROE, T. and TSUR, Y.(2008), "Macro-Micro Feedback Links of Irrigation Water Management in Turkey", Policy Research Working Paper No: 4781, The World Bank Development Research Group, Sustainable Rural and Urban Development Team.

ÇAKMAK, E. H., and KASNAKOĞLU, H. (2002), "Interactions between Turkey and EU in Agriculture: Analysis of Turkey's Membership to EU", Ankara: Ministry of Agriculture and Rural Affairs, Agricultural Economics Research Institute.

ÇAKMAK, E. H., YELDAN, E.and ZAIM, O. (1996), "The Rural Economy Under Structural Adjustment and Financial Liberalization: Results of a Macro-Integrated Agricultural Sector Model for Turkey", Revue Canadienne d'Etudes du Development, *Canadian Journal of Development Studies*, 17(3), 427-47.

ÇIRPICI, (2008), "Economy-Wide Analysis of Water Resource Management: A CGE Model for Turkey", *Unpublished PhD Dissertation*, METU, Ankara.

DAHL, C. and ERDOĞAN, M. (2000), "Energy and interfactor substitution in Turkey", OPEC Review, 24(1), 1-22.

DECALUWÉ, B., A. PATRY et L. SAVARD (1999), "When Water is no Longer Heaven Sent: Comparative Pricing Analysis in an AGE Model", Cahier de recherche No: 9908, CREFA, Université Laval, Québec.

————(1998), "Quand l'eau n'est pas un don du ciel: un MEGC appliqué au Maroc", *Revue d'économie du développement*, 3-4, 149-187.

DE SANTIS, (2002), "A Conjectural Variation Computable General Equilibrium Model with Free Entry", in A. Fossati and W.Wiegard, Routledge (eds.), Policy Evaluation with Computable General Equilibrium Models, London.

DIAO, X., and ROE, T. (2003), "Can a Water Market Avert the ''double-whammy'' of Trade Reform and Lead to a ''win–win'' Outcome?", *Journal of Environmental Economics and Management*, 45, 708–723.

————(2000), "The Win-Win Effect of Joint and Trade Reform on Interest Groups in Irrigated Agriculture in Morocco", in A. Dinar (ed.), *The Political Economy of Water Pricing Reforms*, Oxford University Press.

DIAO, X., ROE, T. and DOUKKALI, R. (2002), "Economy-Wide Benefits From Establishing Water User-Right Markets In a Spatially Heterogeneous Agricultural Economy", TMD Discussion Paper No: 103.

DIAO, X., YELDAN, E. (2001), "An Intertemporal, Multi-Region General Equilibrium Model of Agricultural Trade Liberalization in the South Mediterranean NIC's, Turkey, and the European Union", in: J. Von Hagen and M. Widgren (eds.), Regionalism in Europe, Geometries and Strategies After 2000, Massachusetts: Kluwer Academic Publishers, 195-220.

DIAO X., ROE, T. and YELDAN, E. (1999), "How Fiscal mis-Management May Impede Trade Reform: Lessons from An Intertemporal, Multi-Sector General Equilibrium Model for Turkey", The Developing Economies, 37(1), 59-88.

DIAZ-RODRIGUEZ, I.D. (2000), "Government Policies and Water Use in the Dominican Republic" PhD dissertation, Ohio State University.

DOĞRUEL, F., DOĞRUEL, S.A., YELDAN, E. (2003), "Macroeconomics of Turkey's agricultural reforms: an inter-temporal computable general equilibrium analysis" Journal of Policy Modeling, 25, 617–637.

DTM (2004), "Turkish Agricultural Product Average Tariff Rates", taken from T.C. DTM İthalat Genel Müdürlüğü on 26th of November 2004.

DUDU, H., ÇAKMAK, E. H. SARAÇOĞLU, Ş. D. (2010), "Türkiye'de iklim değişikliği ve tarım: CGE modellemesi yaklaşımı", İktisat İşletme Finans, 25(286), 9-33.

GOLDIN, I., ROLAND-HOLST, D. (1995), "Economic Policies for Sustainable Resource Use in Morocco", in I. Goldin et L.A. Winters (eds.), *Economics of Sustainable Growth*, Cambridge (MA): Cambridge University Press.

GOODMAN, D.J. (2000), "More Reservoirs or Transfers? A Computable General Equilibrium Analysis of Projected Water Shortages in the Arkansas River Basin", *Journal of Agricultural and Resource Economics*, 25(2), 698-713.

GÜL, M., and AKPINAR, M. G. (2006), "Dünya ve Türkiye Meyve Üretimindeki Gelişmelerin İncelenmesi", *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi*, 19(1), 15-27.

HARRISON, G. H., RUTHERFORD, T. F., and TARR, D. G. (1992), "Piecemeal Trade Reform in Partially Liberalized Economies: An Evaluation for Turkey", Policy Research Working Paper Series from the World Bank, No: 951

KOÇ, D (2005) "Yaş Meyve Sebze", Başbakanlık Dış Ticaret Müsteşarlığı İhracatı Geliştirme Etüd Merkezi (İGEME), Ankara

KÖSE, A. H. (1996), Gümrük Birligi'nin Türkiye Ekonomisi Üzerine Etkileri: Bir Hesaplanabilir Genel Denge Modeli Çalısması*, Unpublished PhD Dissertation*, Hacettepe University, Ankara.

KÖSE, A. H., E. YELDAN (1996), "Çok Sektörlü Hesaplanabilir Genel Denge Modellemelerinin Veri Tabanı Üzerine Notlar: Türkiye 1990 SHM", *METU Studies in Development*, 23(1), 59-83.

KRAYBILL, D., DÍAZ-RODRÍGUEZ, I., SOUTHGATE, D. (2002), "A Computable General Equilibrium Analysis of Rice Market Liberalization and Water Price Rationalization In The Dominican Republic", *Presented at Fourteenth International Conference on Input-Output Techniques Université du Québec*, Montréal, Canada.

LEWIS, J. (1992) "Financial Repression and Liberalization in a General Equilibrium Model with Financial Markets", *Journal of Policy Modeling*, 14, 135-166.

LÖFGREN, H. (1996), "The cost of managing with less: Cutting water subsidies and supplies in Egypt's agriculture", IFPRI (1996) TMD Discussion paper, No: 7.

MUKHERJEE, N.I., (1995), "A Watershed Computable General Equilibrium Model", PhD. Dissertation, John Hopkins University.

ROBINSON, S. and GEHLAR, C. (1995), "Land, Water and Agriculture in Egypt: The Economy-wide Impact of Policy Reform", IFPRI, *Trade and Macroeconomics Division Discussion Paper*, No. 1, Washington D.C.

SAYGILI, Ş., CIHAN. C.and YURTOĞLU, H. (2005), "Türkiye Ekonomisinde Sermaye Birikimi, Verimlilik ve Büyüme: 1972-2003", Ankara: Ekonomik Modeller ve Stratejik Araştırmalar Genel Müdürlüğü.

SEUNG, C.K., HARRIS, T.R., MACDIARMID, T.R., SHAW, W.D. (1998), "Economic Impacts of Water reallocation: A CGE Analysis for the Walker River Basin of Nevada and California", *Journal of Regional Analysis and Policy*, 28(2), 13-34.

STRINGER, R., WITTWER, G. (2001), "Grapes, Wine and Water: Modeling Water Policy Reforms in Australia", Centre for International Economic Studies (CIES) Discussion Paper 0141, Centre for International Economic Studies and School of Economics, Adelaide University.

TELLI Ç., VOYVODA E. and YELDAN E. (2008), "Economics of Environmental Policy in Turkey: A General Equilibrium Investigation of the Economic Evaluation of Sectoral Emission Reduction Policies for Climate Change", *Journal of Policy Modeling,* 30(2), 321-340.

TELLI Ç., VOYVODA E. and YELDAN E. (2005), "A Macroeconomic General Equilibrium Model For Turkey: Disinflation, Fiscal Austerity and Labor Markets", *Paper presented at the Economic Research Forum Annual Conference*, Cairo, Egypt.

THABET, B. (2003), "Réforme de la politique des prix de l'eau d'irrigation en Tunisie: approche en équilibre general", PhD dissertation, ENSAER.

TIRADO, D., GOMEZ, C.M., REY-MAQUIEIRA, J. (2003), "Water Transfer vs Water Works: Insights from a Computable General Equilibrium Model for the Balearic Islands", First Draft, January 31.

TUNC, G. I. (1997) A financial computable general equilibrium model for Turkey: Policy Analysis with 1990 data, *Unpublished PhD Dissertation*, METU, Ankara.

TURKSTAT (2005), "Turkey's Statistical Yearbook, 2004", National Accounts.

VAUX, H. J. and HOWITT, R.E. (1984), "Managing Water Scarcity: An Evaluation of Inter-regional Transfers", *Water Resources Research*, 20, 785-792.

YELDAN, E. (1998), "Financial Liberalization and Fiscal Repression in Turkey: Policy Analysis in a CGE Model with Financial Markets", *Journal of Policy Modeling* 19(1), 79-117

YELDAN, A.E. (1989), "Structural Adjustment and Trade in Turkey: Investigating the Alternatives beyond Export-Led Growth", *Journal of Policy Modeling*, 11(2), 273-96.

YELDAN, E. AND ROE, T. (1994), "The Interface of Industrialization, Fiscal and Environmental Policies in a CGE Model for Turkey", *Paper presented at the Allied Social Science Association Meetings,* January 3-5, Boston.

Özet

Tarımsal liberalizasyonun sektörel su kullanımları üzerine etkisi: Türkiye için bir HGD Modeli

Bu çalışmanın amacı, suyu girdi olarak alan bir hesaplanabilir genel denge (HGD) modeli oluşturarak tarımsal tarifelerdeki bir düşüşün Türkiye'nin dış ticareti ve tarımsal su kullanımları üzerine etkilerini incelemektir.

Çalışma sonucunda, tarımsal liberalizasyon ile Türkiye'nin net tarım ithalatçısı konumuna geldiği, tarımsal üretimin ve buna bağlı olarak da tarımsal su kullanımının azaldığı gözlenmiştir.

Aynı simülasyon tarımsal üretkenliğin arttığı varsayımı altında tekrarlanmış, bu durumda tarife düşüşünün neden olduğu dış ticaretteki bozulmanın telafi edildiği görülmüştür. Bu senaryo altında, tüm tarım sektörlerinde üretim ve ihracat artarken su kullanımı meyve sektöründe artmış diğer tarım sektörlerinde ise düşmüştür.

Anahtar kelimeler: HGD modelleri, tarımsal tarifeler, su kullanımı

JEL kodları: D58, Q17, Q25.