IMPACTS OF POLICY CHANGES ON TURKISH AGRICULTURE: AN OPTIMIZATION MODEL WITH MAXIMUM ENTROPY

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ABSTRACT

IMPACTS OF POLICY CHANGES ON TURKISH AGRICULTURE: AN OPTIMIZATION MODEL WITH MAXIMUM ENTROPY

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Turkey moves towards integration with EU since 1963. The membership will involve full liberalization of trade in agricultural products with EU. The impact of liberalization depends on the path of agricultural policies in Turkey and the EU. On the other hand, agricultural protection continues to be the most controversial issue in global trade negotiations of World Trade Organization (WTO). To evaluate the impacts of policy scenarios, an economic modeling approach based on non-linear mathematical programming is appropriate. This thesis analyzes the impacts of economic integration with the EU and the potential effects of the application of a new WTO agreement in 2015 on Turkish agriculture using an agricultural sector model. The basic approach is Maximum Entropy based Positive Mathematical Programming of Heckelei and Britz (1999). The model is based on a static optimization algorithm. Following an economic integration with EU, the net export of crops declines and can not tolerate the boom in net import of livestock products. Overall welfare affect is small. Consumers benefit from declining prices. Common Agricultural Policy (CAP) supports are determinative for the welfare of producers. WTO simulation shows that a 15 percent reduction in Turkey's binding WTO tariff commitments will increase net meat imports by USD 250 million.

Keywords: Turkish Agricultural Sector Model, Membership of Turkey to the EU, WTO, Positive Mathematical Programming (PMP), Maximum Entropy (ME).

ÖZ

TÜRK TARIMINDA POLİTİKA DEĞİŞİKLİKLERİNİN ETKİLERİ: MAKSİMUM ENTROPİ İLE BİR OPTİMİZASYON MODELİ

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Türkiye, 1963'den beri, AB ile bütünleşme konusunda ilerliyor. Üyelik, Türkiye ve AB arasında tarım malları ticaretinde tam bir liberalleşme öngörmektedir. Bu liberalleşmenin etkileri, Türkiye ve AB'nin tarım politikalarının izleyeceği yola bağlıdır. Diğer taraftan, tarımsal korumalar Dünya Ticaret Örgütü (DTÖ) müzakerelerinde en sorunlu konu olmaya devam etmektedir. Değişik politika ve senaryo alternatiflerinin etkilerini değerlendirmek için doğrusal-olmayan matematiksel programlama metoduna dayanan ekonomik modelleme yaklaşımı uygundur. Tezimiz, Türkiye için bir tarımsal sektör modeli kurarak, AB ile olabilecek bir ekonomik entegrasyonun ve/veya gerçekleşebilecek yeni bir DTÖ anlaşmasının Türk tarım sektörü üzerindeki etkilerini incelemektedir. Maksimum Entropiye dayanan Pozitif Matematiksel Programlama (Heckelei ve Britz, 1999) çalışmamızın temel yaklaşımıdır. Model statik bir optimizasyon algoritmasına dayanmaktadır. AB ile ekonomik integrasyonun sonucunda, bitkisel ürün ihracatı azalarak, patlayan net hayvansal ürün ithalatını tolere edememektedir. Genel refah etkisi azdır. Tüketiciler düşen fiyatlardan faydalanmaktadırlar. Üreticilerin refahında Ortak Tarım Politikası (OTP)'nın destekleri belirleyicidir. Diğer taraftan, Türkiye'nin DTÖ gümrük tarifesi taahhütlerindeki yüzde 15 azalma net et ithalatını 250 milyon dolar artırmaktadır.

Anahtar Kelimeler: Türkiye Tarımsal Sektör Modeli, Türkiye'nin AB Üyeliği, DTÖ, Pozitif Matematiksel Programlama (PMP), Maksimum Entropi (ME).

To my Father, TANER ERUYGUR

« İlim ilim bilmektir, ilim kendin bilmektir
Sen kendini bilmezsin, ya nice okumaktır »*

YUNUS EMRE

* *Knowledge is to know what knowledge is*
Knowledge is to know thyself
If you know thyself not
All your study means nought

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CHAPTER I

INTRODUCTION

Policy makers, if they wish to forecast the response of citizens, must take the latter into their confidence.

Lucas, R.E., Jr. (1976)
Econometric Policy Evaluation: a Critique.

Turkey has proceeded on a path towards integration with the EU since the Association Agreement (known as the Ankara Agreement) in 1963. This Agreement envisaged the progressive establishment of a customs union which would bring the two sides closer together in economic and trade matters. The Ankara Agreement was supplemented by an additional protocol signed in November 1970, which set out a timetable for the abolition of tariffs and quotas on goods circulating between Turkey and the EEC (then name of the EU). The customs union, (excluding agricultural products) between Turkey and the EU was established in 1995. At the Helsinki European Council of December 1999 Turkey was officially recognized as a candidate state on an equal footing with other candidate states. On 17 December 2004, the European Council defined the perspective for the opening of accession negotiations with Turkey. In October 2005, the screening process concerning the analytical examination of the *acquis* has started. The accession, if any, may be unlikely to happen before 2015 since the Commission reported that the EU will need to define its financial perspective for the period from 2014 before negotiations can be concluded. The EU membership of Turkey will lead to full liberalization of agricultural trade with the EU since the current customs union with the EU does not involve agricultural products. Çakmak and Kasnakoğlu (2002) points out that the benefits of liberalization are bound to depend on the path of agricultural policies both in Turkey and in the EU, and also on the process of accession negotiations. In this context, analyzing the potential effects of Turkey's EU membership on agricultural production and trade in Turkey takes on greater importance.

Agricultural protection continues to be the most controversial issue in global trade negotiations. Although limited, the industrial countries have started to reduce distortions in their agricultural trade policies. The pressures for liberalization of agricultural trade will probably rise in the future. The Uruguay Round Agreement on Agriculture (1995) included a commitment to further progressive liberalization of the sector. A new round of negotiations was launched in Doha in November 2001. On 31 July 2004, the WTO's 147 Member Governments approved a Framework Agreement. The Framework Agreement affirms that substantial overall tariff reductions will be achieved as a final result from negotiations (FAO, 2005a, p.29). In December 2005, negotiations at the Hong Kong Ministerial ended with an agreement to ensure the parallel removal of all forms of export subsidies and disciplines on all export measures with equivalent effect by the end of 2013. However, the July 2006 negotiations in Geneva failed to reach an agreement about reducing farming subsidies and lowering import taxes. Hence, an application before 2015 seems unlikely. Analyzing the potential effects of a new WTO agreement is crucial both to determine the attitude of Turkey during the negotiations and to design necessary agricultural policies for the impacts.

In order to evaluate the possible impacts of a variety of policy alternatives and scenarios, an economic modeling approach based on non-linear mathematical programming is appropriate. In this framework, *two sets of scenarios* are defined and analyzed for their impacts in the year 2015 using an *agricultural sector model* for Turkey. The first group is *Non-EU Scenarios*. This set includes two simulations. First simulation describes the non membership situation in which it is assumed that there will be no changes in the current agricultural and trade policies of Turkey until 2015. Second simulation assumes that there will be 15 percent decrease in Turkey's binding WTO tariff commitments in 2015. The second group is *EU Scenarios*. This set includes three simulations. First simulation assumes that Turkey is not a member of EU but extends the current Customs Union agreement with the EU to agricultural products. Second simulation describes the situation that Turkey is a member of EU in 2015. The last simulation represents a second membership scenario; the difference is that, in this simulation, higher improvements in the product yields than the first one is assumed.

Our model (TAGRIS) represents the *third* generation of policy impact analysis using sector models, following TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002) and further develops and improves their methodologies. The basic calibration approach undertaken involves *Positive Mathematical Programming* with *Maximum Entropy* following Paris and Howitt (1998), particularly Heckelei and Britz (1999 and 2000). Foreign trade is allowed in raw and in raw equivalent form for processed products and trade is differentiated for EU, USA and the rest of the world (ROW). The base period of the model is the average from 2002 to 2004. Model has 4 regions.

Chapter II gives a brief review of Turkish agriculture and agricultural policies together with recent changes. A review of economic models employed in agricultural policy analysis is presented in Chapter III. The calibration of our model is based on Maximum Entropy Economics of Golan *et al* (1996) and is not easy to perceive. This new area of econometrics will be reviewed comprehensively in Chapter IV. Chapter V represents the calibration approach of Positive Mathematical Programming and its new versions based on maximum entropy following Paris and Howitt (1998) and Heckelei and Britz (1999 and 2000). Our model applies the contribution of Heckelei and Britz (1999 and 2000) in the calibration process. Turkish Agricultural Sector Model is presented in Chapter VI. In this chapter, first we will see the basic structure of the model and present the regional definitions and data sources. Second, demand and supply calibrations of model will be presented. Third section of Chapter VI is devoted to the estimation of yield growths using *Generalized Maximum Entropy* (GME) estimator following Golan *et al* (1996). Chapter VII represents the scenarios and simulation results. The first section in this chapter belongs to *Non-EU Scenarios*. Apart from the scenario definitions and results, a brief review for WTO and its polices is also provided. The second section represents the EU-Scenarios and simulations results together with a sub section devoted to the review of Common Agricultural Policy of the EU. Updated CAP support estimates for the membership of Turkey are discussed at the end of this section. Finally, Chapter VIII is reserved for concluding remarks.

CHAPTER II

TURKISH AGRICULTURE AND AGRICULTURAL POLICY

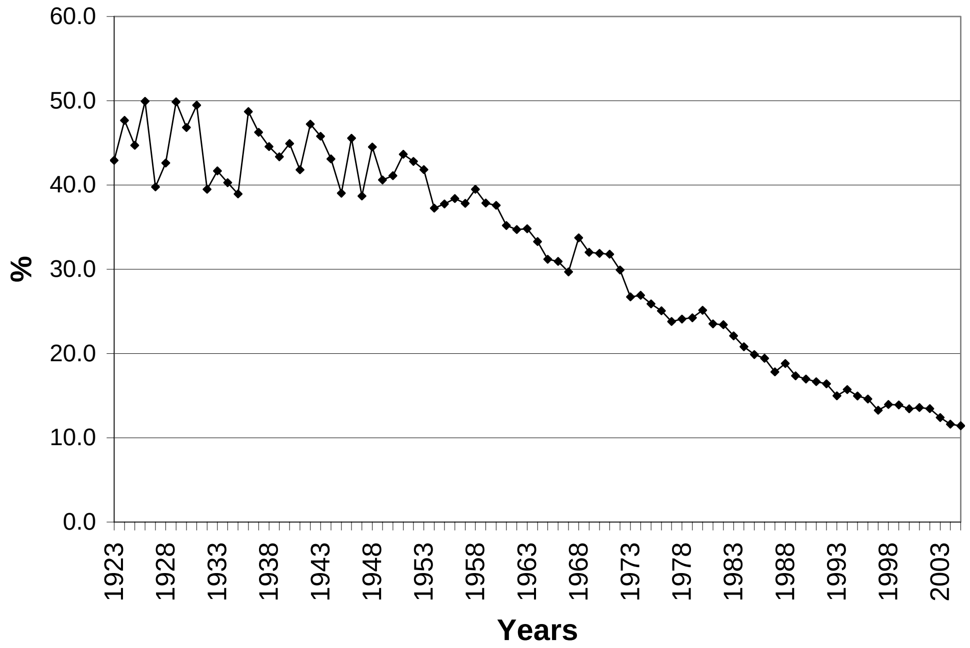
The sciences do not try to explain, they hardly even try to interpret, they mainly make models. By a model is meant a mathematical construct which, with the addition of certain verbal interpretations, describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work.

John Von Neumann (1955)
Methods in the Physical Sciences

II.A. REVIEW OF TURKISH AGRICULTURAL SECTOR

Agriculture is still an important sector of the Turkish economy even though its share in total GDP has been declining overtime (Figure 1). In 1923, the contribution of agricultural sector to GDP was about 43 percent; it gradually declined to 11.4 percent in 2005. OECD (2005, pp.24-25) reports the share of gross value added of agriculture within total GDP in Turkey as 11.1 percent in

2003. This figure is 2.0, 2.0 and 1.2 percent for OECD[1], EU15[2] and G7[3] averages in the same year. This high value for Turkey highlights the still prevailing importance of agricultural sector within the Turkish economy.



Source: Turkstat (2006a).

Figure 1 Share of Agriculture in total GDP (1923-2005)

In Table 1, employment in agriculture is reported as 6.5 million which represents 29.5 percent of total employment of Turkey (22.0 million) in 2005. Agricultural sector employs 21.7 percent of employed males and 51.6 percent of employed females with 3.5 and 3.0 million, respectively. It is seen that sector stand-alone employs half of the employed females in Turkey. From

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[1] Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

[2] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, Spain, United Kingdom.

[3] USA, Canada, Japan, France, Germany, Italy and UK.

Table 1, it can also be observed that agricultural sector provides employment for almost all females in the rural areas with about 84 percent share in the rural employment. Furthermore, Çakmak (2004, p.5) reports that 75 percent of total employed females in agriculture (2.3 million) work as "*unpaid family labor*". The figures in Table 1 reveal the importance of agricultural sector in terms of total and rural employment in Turkey, especially for employed females.

Table 1 Agricultural Employment in Turkey, 2000-2001 and 2005

	Employment (1000)		Percent of Total Emp.		Percent of Rural Emp.	
	2000-01	2005	2000-01	2005	2000-01	2005
Agricultural Emp.	**7,929**	**6,493**	**36.8**	**29.5**	**71.5**	**61.4**
Male	4,285	3,550	27.4	21.7	60.7	50.1
Female	3,644	2,943	61.9	51.6	90.2	83.9

Source: Çakmak and Eruygur (2006), Turkstat (2006c).

Çakmak (2004, p.6) proposes that the agricultural sector is still helping to overcome the chronic nature of unemployment in Turkey since it eases the detrimental effect of lack of human capital on the growth rates of the labor force. Indeed, the illiteracy in the agricultural employment is significantly higher than the rest of the economy. The illiteracy rate in agricultural employment is reported as 18 percent in Table 2. The major contributor to this high rate is employed females with 28.5 percent illiteracy. The figure is only 2.6 percent for Construction sector which ranks as second behind the agricultural sector in terms of the illiteracy rate. This shows the deficiency of human capital in Turkish agriculture.

Table 2 Employment and Education, 2003 (percent)

	Education					
	Illiterate	Literate No-School	Primary	Junior High	High School	Higher Education
Agriculture	**18.1**	**6.1**	**65.0**	**6.0**	**4.4**	**0.4**
Male	8.5	6.5	69.7	8.0	6.7	0.6
Female	28.5	5.8	59.9	3.8	1.9	0.1
Manufacturing	**1.2**	**1.1**	**51.9**	**15.1**	**23.5**	**7.2**
Construction	2.6	2.6	58.2	13.8	15.8	7.2
Trade and Services	1.4	1.1	34.2	13.9	28.2	21.3
Total	**7.1**	**2.9**	**48.8**	**11.4**	**18.8**	**11.0**

Source: Çakmak (2004, p.8), Turkstat (2004a).

Farms in Turkey are usually family-owned, small and fragmented. While the average cultivated area per agricultural holding was about 5.2 ha in 1991; it increased to about 6 ha in 2001. About 85 percent of holdings occupying 41 percent of the land were smaller than 10 ha. The remaining 15 percent of holdings were from 10 to 50 ha. The cultivated land by these holdings constitutes almost half of the total cultivated land. The average size of agricultural holdings expands from west towards the southeastern part of the country. Çakmak (2004, p.3) explains this situation mainly by climate and fertility differences among regions.

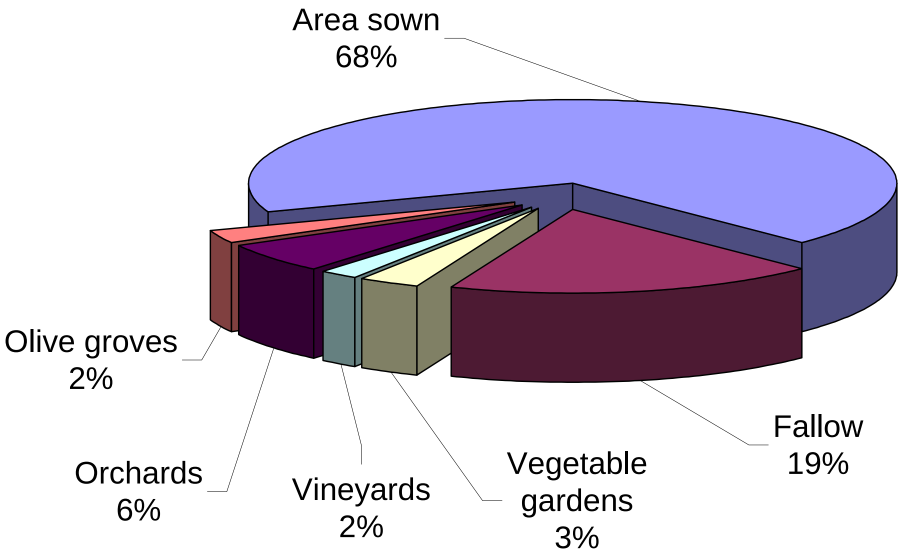
The climate in Turkey could be characterized as semi-arid in vast regions of the country. While the coastal areas enjoy milder climates, the inland Anatolian plateau experiences extremes of hot summers and cold winters with limited rainfall. Mean annual precipitation in Turkey is 642.6 mm. According to 2001 Agricultural Census of Turkstat, the total irrigated land is reported as 5.2 million hectares. The irrigated cultivated land is given as 4.7 million hectares (2001 Agricultural Census of Turkstat). This figure includes both the private and public irrigation schemes. Ministry of Agriculture and Rural Affairs (MARA) reports that 3.7 million hectare is irrigated by public organizations: of which 65 percent is by DSI[4] and 35 percent is by KHGM[5]. The irrigated land by private sources amounts to 1.0 million hectares. DIS reports total economically irrigable cultivated area of Turkey as 8.5 million hectares. Hence, Turkey may increase its irrigated area to 8.5 million hectares in the future (Akder, 2005, p.2). However, the largest part of Turkey's cultivated land will remain under rain fed conditions (Çağatay and Güzel, 2004).

Figure 2 summarizes the distribution of cultivated land of Turkey in 2004. Turkey has 26.6 million hectares of cultivated land of which 18.1 million hectares is sown (68 %) and 5.0 million hectares is fallow lands (19 %). It has

[4] General Directorate of State Hydraulic Works.

[5] General Directorate of Rural Services.

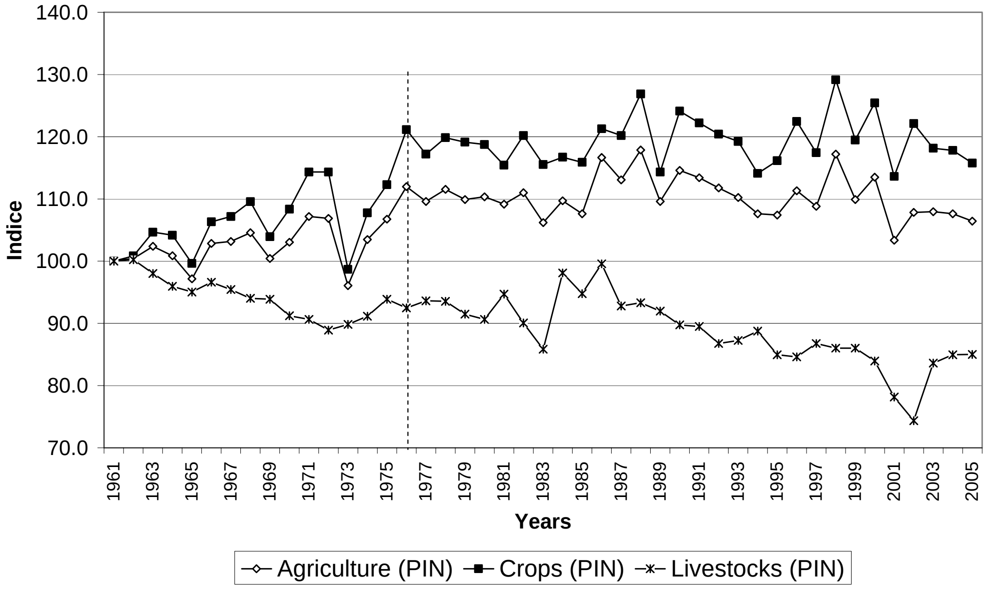
0.8 million hectares of vegetable gardens (3 %); 0.5 million hectares of vineyards (2 %); 1.6 million hectares of fruit trees (6 %); and 0.6 million hectares of olive trees (2 %) in 2004.



Source: Turkstat (2006b)

Figure 2 Distribution of Cultivated Land in Turkey (2004)

Figure 3 shows the changes in Turkey's per capita agricultural production index between 1961 and 2005. In the figure, per capita production indices for crop and livestock production are also plotted since 1961. As the figure reveals, the per capita crop production index deviates around the value of 120 since 1976. A similar pattern is observed for per capita total agricultural production index around the value of 110. Hence, one can state that, there is no long lasting rise both in per capita crop and total agricultural production since 1976. Figure 3 shows that the per capita production of livestock products has decreased gradually by about 25 percent between 1961 and 2002, with some non-persisting recoveries around 1985-1987. On the other hand, in the last three years, an upward (about 10 percentage point) movement is observed.



Note: Net indices are based on production deducted of amounts used for feed and seed.
Source: FAOSTAT (2006).

Figure 3 Net Per Capita Agricultural Production Indices for Turkey

Table 3 shows some basic indicators of the Agro-Food sector for the period 1998-2005. Agro-food sector trade statistics contain all products included in the WTO-Agreement on Agriculture: all Harmonized System (HS) chapters from 1 to 24, excluding fish but including other agricultural raw products. Growth of real agricultural value added in 2005 is striking with 20.4 percent. However, most of this increase can be explained by the sudden decline in agricultural employment in the same year (Çakmak and Eruygur, 2006). On the other hand, the unemployment rate in rural area seems alarming since there is a considerable expansion in 2005 compared to the whole period of 1998-2005. Table 3 demonstrates that the Agricultural Value Added per Employed (AVAE) is always higher than GDP per capita between 1998 and 2005. This implies that agricultural workers who can capture their returns to labor are better off than the general population since AVAE can be seen as an approximation for return to labor in the agricultural sector. In 2004, the agricultural value added per employed is about 10 percent higher than GDP per capita. If we take the period average, the figure is about 13 percent. Shapouri *et al* (2005, pp.3-4) report that, in 2001, for the developed countries the average AVAE was almost 40 percent higher than average per capita GDP. The same holds true for the developing countries, where average AVAE was also higher, measuring 14 percent greater than average per capita GDP. Turkey is very close to the developing countries' average in this respect. Only in the least developed countries is AVAE less than average per capita, which can be seen as an indicator of rural poverty (Shapouri *et al*, 2005, pp.3-4).

Table 3 illustrates that Turkey remained as a net exporter in Agro-Food products since 2002. The ratio of exports to imports has reached its highest value in 2005 except the crisis year of 2001. The share of Agro-Food exports in total exports seems to be stabilized at around 10 percent, but the proportion of the processed products is increasing (Çakmak and Akder, 2005).

Table 3 Basic Indicators of the Agro-Food Sector, 1996-2005

	1998-99	2000	2001	2002	2003	2004	2005
GDP per capita (cur. USD)	3,012	2,941	2,146	2,622	3,412	4,187	-
Agricultural Value-Added & Productivity							
Share of Agriculture in GDP (percent)	13.9	13.4	13.6	13.4	12.4	11.6	11.4
Growth of Agricultural VA (percent)	1.7	3.9	-6.5	6.9	-2.5	2	5.6
Agricultural VA per employed (cur. USD)	3,517	3,622	2,173	2,862	3,941	4,601	5,742
Growth of Real Agricultural VA per employed (percent)	-1.2	22.8	-10.2	15.9	1.5	-1.2	20.4
Employment							
Employment in Agriculture (million)	9	7.8	8.1	7.5	7.2	7.4	6.5
Share of Ag. Employment in Total (%)	41	36	37.6	34.9	33.9	34	29.5
Rural Unemployment Rate (percent)	3.5	3.9	4.7	5.7	6.5	5.9	6.8
Foreign Trade in Agro-food Products							
Agro-food Imports (cur. USD billion)	2.5	3.1	2.3	3	4	4.5	4.6
Agro-food Exports (cur. USD billion)	4.5	3.6	4.1	3.7	4.9	6	7.7
Agro-food Exports/Agro-food Imports	1.8	1.2	1.8	1.2	1.2	1.3	1.7
Share of Agro-food Imports in Total (%)	5.8	5.7	5.6	5.8	5.8	4.6	3.9
Share of Agro-food Exports in Total (%)	16.7	13	13.1	10.4	10.3	9.5	10.5

Source: Çakmak and Eruygur (2006), Turkstat (2006a), (2006b), (2006c), SPO (2006).

Table 4 summarizes the value and structure of agricultural production for the years 2003 and 2004. The value of total agricultural production of Turkey in 2004 is reported about USD 43,000 million.

Table 4 Value and Structure of Agricultural Production in Turkey

	2003		2004	
	Production Value (million USD)	Share in Total (percent)	Production Value (million USD)	Share in Total (percent)
Total	***36,086***	***100.0***	***42,725***	***100.0***
Crop Products	**27,132**	**75.2**	**32,622**	**76.4**
Field Crops	12,025	33.3	15,028	35.2
Cereals	6,308	17.5	8,216	19.2
Industrial Crops	2,450	6.8	3,021	7.1
Other Field Crops	3,268	9.1	3,791	8.9
Vegetables	6,769	18.8	7,618	17.8
Fruits,olive,tea	8,338	23.1	9,976	23.4
Livestock and Poultry Products	**8,953**	**24.8**	**10,102**	**23.6**
Meat	3,437	9.5	4,239	9.9
Cattle	1,638	4.5	2,225	5.2
Sheep, goat	414	1.1	481	1.1
Poultry	1,384	3.8	1,532	3.6
Milk	3,835	10.6	4,170	9.8
Cattle	3,373	9.3	3,680	8.6
Sheep, goat	461	1.3	490	1.1
Eggs	1,158	3.2	1,092	2.6
Other livestock products	403	1.1	463	1.1

Source: Çakmak and Eruygur (2006); Turkstat (2006b) and CBRT (2006).

Table 4 shows that crop production constitutes about 75 percent of the value of total agricultural output; the remaining 25 percent comes from livestock products. Field crops have the largest share in crop products. They provide 35 percentage points of the 75 percent share of crop products in the value of total agricultural output. Cereal production represents more than half of the field crops production value. Industrial crops have 20 percent share in the production value of field crops. Fruits and vegetables amount to 40 percent of the value of total agricultural production of Turkey. Meat and Milk have almost equal shares with around 10 percent in the total agricultural production value. Eggs rank third behind them in the group of livestock and poultry products with around 3 percent of total value.

According to 2004 figures, wheat constitutes the largest share in cereal value with 65 %, followed by barley (23 %), maize (9 %) and rice (around 2 %). Cotton (50 %), sugarbeet (34 %) and tobacco (15 %) make up about 99 percent of the production value of industrial crops. Chick-peas, dry beans and lentil are the important pulses. Sunflower and potato are the two main oil and tuber crops, respectively.

Table 5 Crop Production in Turkey

	2003			2004		
	Area	Production	Value	Area	Production	Value
	1000ha	1000 tons	mil. USD	1000ha	1000 tons	mil. USD
Total	26,014	93,710	27,132	26,593	95,796	32,622
Cereals	13,414	30,658	6,308	13,833	33,958	8,216
Wheat	9,100	19,000	4,228	9,300	21,000	5,322
Barley	3,400	8,100	1,287	3,600	9,000	1,863
Maize	560	2,800	603	545	3,000	743
Rice	65	223	100	70	294	150
Pulses	1,514	1,558	982	1,326	1,584	1,143
Chick-peas	630	600	385	606	620	464
Lentils	442	540	282	439	540	322
Industrial Crops	1,299	13,798	2,450	1,238	14,668	3,021
Tobacco	191	153	425	193	133	437
Sugar beet	315	12,623	723	315	13,517	1,025
Cotton	630	2,295	1,199	640	2,455	1,520
Oilseeds	647	2,359	560	635	2,501	677
Sunflower	545	800	415	550	900	539
Tuber crops	292	7,308	1,726	272	7,084	1,971
Potatoes	195	5,300	1,163	179	4,800	1,226
Vegetables	818	24,019	6,769	805	23,036	7,618
Tomatoes		9,820	2,412		9,440	2,979
Melons (all)		5,950	1,273		5,575	1,313
Peppers		1,790	637		1,700	758
Fruits,olive,tea	2,656	14,010	8,338	2,722	12,965	9,976
Apples		2,600	1,090		2,100	1,029
Olives		850	881		1,600	1,745
Citrus		2,488	785		2,708	1,120
Hazelnuts		480	607		350	575
Grapes		3,600	1,998		3,500	2,398
Tea (green)		869	232		1,105	309
Fallow land	4,991			4,956		

Note: 2004 values are provisional estimates.
Source: Çakmak and Eruygur (2006); Turkstat (2006b).

Table 6 shows the distribution of the livestock and poultry production in terms of both quantity and value. Cattle are the main source of livestock production (59 percent share in total value). Poultry products rank second in the group with USD 2,600 million representing 26 percent of the total production value. Remaining 15 percent comes from sheep and goat (10 percentage points) and other livestock products (5 percentage points).

Table 6 Livestock and Poultry Production in Turkey

	2003			2004		
	Head (1000)	Production 1000 tons	Value mil. USD	Head (1000)	Production 1000 tons	Value mil. USD
Total			8,953			10,102
Cattle	9,901		5,042	10,173		5,943
Meat		292	1,638		367	2,225
Milk		9,563	3,373		9,649	3,680
Sheep, goat	32,203		966	31,811		1,071
Meat		74	414		80	481
Milk		1,048	461		1,031	490
Poultry	283,674		2,542	302,799		2,625
Meat		899	1,384		914	1,532
Eggs		792	1,158		691	1,092
Other Prod.			403			463

Note: 2004 values are provisional estimates.
Source: Çakmak and Eruygur (2006); Turkstat (2006b)

Table 7 shows the agricultural imports and exports of Turkey over the 2003-2005 average. It is seen that Turkey has a net exporter position worth of USD 1,800 million in agricultural trade. Turkey's net exporter position mainly results from the net exports to EU with USD 1,787 million. Raw agricultural products constitute the main part of the net exports to EU. The opposite is true for agricultural trade with the rest of the world (ROW). The processed agricultural products represent the main part of net exporter position of Turkey against ROW. On the other hand, against USA, Turkey is a net agricultural product importer with around USD 750 million. This mainly results from raw agricultural product imports, which amount to USD 736 million.

The agricultural export volume of Turkey to EU25 is about USD 3,000 million, which constitutes 48 percent of Turkey's total agricultural exports (45 percent for EU15, 3 percent for EU10[6]). In terms of agricultural exports, USA is not an important trade partner of Turkey since the export volume to USA represents only 5 percent of Turkey's total agricultural exports. The remaining 47 percent of agricultural exports goes to countries in the rest of the world.

[6] Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Table 7 Agricultural Imports and Exports of Turkey (2003-05 average)

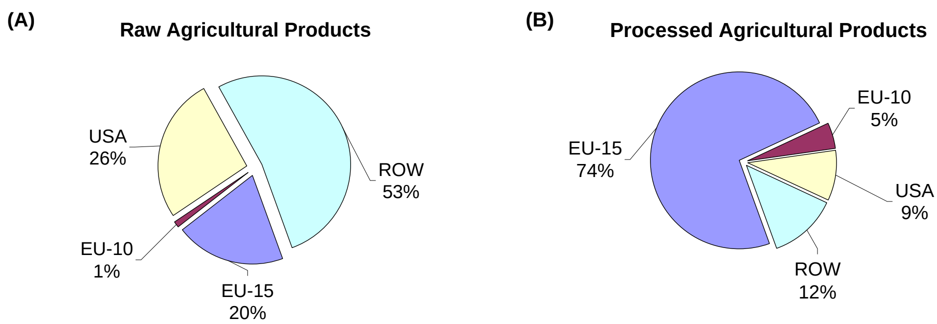
	INTERNATIONAL TRADE (Million USD)			
	EU-25	USA	ROW	TOTAL
EXPORTS				
All Products	32,917	4,507	23,875	61,299
Agricultural Products	2,972	328	2,889	6,189
Raw	2,281	296	2,093	4,670
Processed	691	32	796	1,519
IMPORTS				
All Products	42,719	4,537	47,294	94,551
Agricultural Products	1,185	1,075	2,106	4,366
Raw	819	1,031	2,048	3,898
Processed	366	43	58	468
NET EXPORTS				
All Products	-9,803	-30	-23,419	-33,252
Agricultural Products	1,787	-747	783	1,823
Raw	1,462	-736	45	772
Processed	325	-11	738	1,051

Source: UFT (2006)

About half of Turkey's imports of agricultural products originate from rest of the world block (48 %). The remaining half is almost equally shared by EU25 (27 %) and USA (25 %). From Source: UFT *(2006)*

Figure 4.A, a similar distribution is observed for raw agricultural imports of Turkey. However, Source: UFT *(2006)*

Figure 4.B illustrates that, for the processed agricultural products, the picture is completely different. Imports from EU25 constitute 79 percent of total processed agricultural imports of Turkey. This reveals an important feature of the agricultural trade between Turkey and EU25.



Source: UFT (2006)

Figure 4 Raw and Processed Agricultural Imports (2003-2005 average)

II.B. TURKISH AGRICULTURAL POLICY AND RECENT CHANGES

In the past, agricultural policies of Turkey were mainly determined based on Five Year Development Plans. Although several policy objectives were listed in the official documents it seems that two of them have been always in the minds of Turkish policy makers (Çakmak, 1998, p.3): (1) increasing yields and production volume, and (2) increasing agricultural incomes and ensuring income stability. Apart from these two main objectives, policy makers gave emphasis to realize self-sufficiency, as well. For the sake of first objective, Turkey expanded its cultivated lands, promoted the use of chemical inputs, gave credits at subsidized interest rates and heavily invested in irrigation systems. All these increased both the yield and production in the country. For the second objective, governments mainly used output price support policies and trade measures. However, Çakmak, Kasnakoğlu and Akder (1999, p.52) state that the objectives, instruments and constraints of Turkish agricultural policies were usually mixed up. For instance, policy tool such as increasing the productivity of inputs have been stated as an objective in the Development Plans.

Main policy instruments that the Turkish Governments used in order to fulfill their objectives can be summarized under the headings of output price supports, reductions in input costs, trade policies, supply control measures, direct payments, and general services (Çakmak, Kasnakoğlu and Akder, 1999).

Output price supports have been the most widely used agricultural policy instrument in Turkey. The use of output price supports started in 1932 and implemented to wheat production. Until 1960s, the support purchases were limited with some cereals (between 8 and 10) such as poppy, tobacco and sugar beet. Until the end of 1960s, the list had increased to 17. In the 1970s, support purchases became operational for 22 products. After 1981, the number of products included in the support purchases started to decrease and in 1990 only 10 products were defined to get this support. In 1991, the list was again populated and reached to 26 products in 1992. In 1994, the support purchases were limited to cereals, tobacco, tea and sugarbeets. In 2000, directly supported products decreased to wheat and sugarbeet and in 2002 the supports were almost removed.

Input subsidies represent the second important tool used in Turkish agricultural support policies. The main categories are: credit subsidies; price subsidies on fertilizers, seeds and pesticides; irrigation subsidies through operation and maintenance costs (Çakmak, Kasnakoğlu and Akder, 1999, pp.54-55). The fertilizer subsidy has been held constant in nominal terms since 1997, resulting in a reduction of the unit subsidy from approximately 45 % of the total price at the end of 1997 to approximately 15 % in 2001 (Çakmak, 2004, p.9).

Trade policies represent another group of policy instruments used in the agricultural policies in Turkey. Prior to 1980, the imports of agricultural products were highly restricted. There were export restrictions in the form of licensing and registration requirements for several agricultural inputs and products. After 1980, significant changes took place in the direction of elimination of licenses, and reduction of duties in favor of special fund taxes. After the Uruguay Round Agreement on Agriculture, Turkey made necessary commitments on tariffs and export subsidies. Border measures consist of import tariffs without any specific duties and import restrictions, and export subsidies are as per commitments to WTO (Çakmak, 1998, p.5).

The use of supply controls and direct payments measures in the agricultural policy of Turkey were limited.

General services form the last group of policy tools. This group mainly consists of four components: infrastructure services; research, training and extension services; inspection services; and pest and disease control services. State investments in irrigation, land improvement, soil and water conservation, roads, electricity, water and pasture land improvement are the major elements of infrastructure services (Çakmak, 1998, p.5).

Protective trade policies in major crops combined with government procurement, input subsidies, and heavy investment in irrigation infrastructure on a fully subsidized basis have created a net inflow of resources from the government to agriculture, but have had many negative effects on the agricultural sector and the economy as a whole. The benefits of the subsidies have gone mainly to larger, wealthier farmers. Moreover, the support system failed to enhance the productivity growth despite its heavy burden on taxpayers and consumers in the last decade (Çakmak, 2004, p.9).

Turkey has started a structural adjustment and stabilization program towards the end of 1999 due to the economic crisis. The crisis environment together with the liberalization wave in the international trade and Turkey's candidacy to EU, forced Turkey to embark on a process of agricultural policy reform in 2000. The process gained momentum in 2001 and targeted in two major areas: to diminish the fiscal burden of state supports on the budget, and to move towards a more efficient structure in production. The "Agricultural Reform Implementation Project" (ARIP)[7], supported by the World Bank[8], has constituted the base of the reform process. The primary objective of ARIP was to form a detailed framework for the implementation of the reform program. At the same time the project was designed to relieve the potential short-term adverse effects of subsidy removal, and to facilitate the transition to efficient production patterns.

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[7] Approved by the Decision of Cabinet of Ministers with No.2001/2707 and Date.17/07/2001.

[8] The Project Appraisal Document of ARIP can be found from the web site of the World Bank: http://www-wds.worldbank.org/servlet/WDSServlet?pcont=details&eid=000094946_01061304010561

The recent developments in the agricultural reform process can be summarized by the three major themes of ARIP (Çakmak and Eruygur, 2006). The first theme was to phase out the government intervention in the output, credit and fertilizer markets and the introduction of *direct income support* (DIS) for all farmers through per hectare payment independent from the choice of crop. This leg of the support suffered heavily by the lack of public information campaign. It achieved the target to cushion the short-term losses against the removal of old subsidy system. However, the payments have never been paid by the full amount. The announced full payment per year has been made in two yearly installments. Recently enacted support for diesel and fertilizers constitute another form of direct income support. One of the most important successes during the implementation of the reform program has been to discipline the budgetary transfers to the sector.

The second element of the program has been to focus on the commercialization and privatization of SEE's, including TÜRKŞEKER (Turkish Sugar Company) and TEKEL (Turkish Alcohol and Tobacco Company), restructuring of TMO (Soil Products Office) and quasi-governmental Agricultural Sales Cooperative Unions (ASCUs) which in the past intervened to support certain commodity prices on behalf of the government. As a result, the fiscal burden of ASCUs declined. Cigarette and alcohol products companies of TEKEL were up for privatization. Alcohol Products Company was privatized. Sugar Law, enacted in 2002, puts strict quotas at the plant level. The privatization of the Sugar Company has not been undertaken yet. In the grain sector, after quite few years of intervention, TMO increased its volume of intervention purchases.

The third theme under the program was the introduction of one-time alternative crop payments to farmers who require assistance in switching out of surplus crops to net imported products. The program intended to cover the costs of shifting from producing hazelnuts, tobacco and sugar beet to the production of oilseeds, feed crops and corn. Participation to alternative crop payments has been limited due to mixed signals from the government to the farmers. The signals were not convincing that the government will shift to regulatory position in hazelnuts, sugar and tobacco. Tobacco farmers have displayed highest participation due to the Tobacco Law which ceased TEKEL to be the price maker in the market, and left the price formation to the bidding mechanism. Turkish farmers switched almost 60,000 hectares out of tobacco in the areas targeted by the ARIP. However, this took place in 2000-2001 just prior to the support offered under the ARIP's FT (Farmer Transition) component becoming available. As a result, farmers switching out of only about 3,000 hectares of tobacco into other crops have benefited under the FT component, whereas the ARIP was designed to fund farmers switching out of 36,000 hectares of tobacco.

As a result, starting from 2005, while the weight of DIS payments in the total budgetary support to agriculture has been decreasing, the share of crop specific deficiency payments and support to livestock production has been increasing. The new items in the policy agenda, such as the environmental protection schemes, crop insurance support, rural development projects have not been able to have proper share in funding. Medium term policy agenda items of the government include promotion of a sustainable rural finance system; increased expenditures in rural infrastructure targeted to irrigation, storage and marketing facilities and expansion of agricultural extension activities.

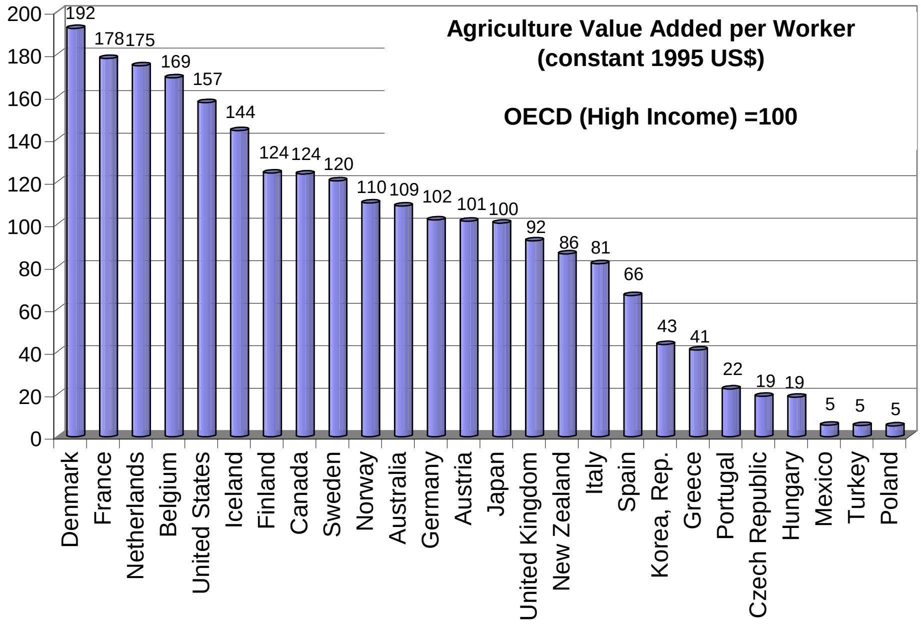
The evaluation of agricultural support policies should be done using the tools of economic theory. According to the economic theory, the agricultural supports have two main components: (1) *transfers from consumers*, and (2) *transfers from taxpayers*. The latter represents the budgetary burden of the support policies. In Turkey, in discussing the size of agricultural support policies, usually, this component is treated as if it represents the whole size of the support policies. However, the burden of agricultural support policies also includes the transfers from consumers who pay higher prices than the border prices. Furthermore, this part represents generally a sizeable portion of total transfers to agriculture. Indeed, Table 8 reports that *this component* represents *71 percent* of Turkey's total transfers to agricultural sector in 2005.

Table 8 Turkey: Agricultural Support Estimates and Total Transfers (USD million)

Indicators	1986-89	1996-99	2000	2001	2002	2003	2004	2005
Total value of prod. (at farm gate)	18,911	33,583	32,172	21,574	26,766	37,300	41,468	46,239
Total value of cons. (at farm gate)	15,641	28,534	26,533	19,658	23,524	34,187	37,902	42,635
Producer Support Estimate (PSE)	3,388	7,974	6,912	682	5,769	11,159	11,225	12,192
Market price support (MPS)	2,410	5,934	5,742	-47	4,199	8,919	8,673	9,445
MPS/PSE, %	71.1	74.4	83.1	-6.9	72.8	79.9	77.3	77.5
Percentage PSE	17.0	22.2	20.7	3.1	20.4	28.2	25.5	24.9
General Services Sup. Est. (GSSE)	407	3,250	3,752	3,186	2,044	986	662	1,658
Research and development	55	40	23	29	33	36	26	27
Agricultural schools	3	5	5	3	5	6	4	4
Inspection services	63	75	75	56	69	72	92	116
Infrastructure	7	10	5	4	2	4	3	3
Marketing and promotion	187	3,085	3,632	3,083	1,926	854	525	1,491
Transfers to SEEs	187	3,085	3,632	3,083	1,926	854	525	1,491
Transfers to SEEs/TSE, %	4.9	27.5	34.1	79.7	24.6	7.0	4.4	10.8
Consumer Support Estimate (CSE)	-2,614	-5,797	-5,678	-102	-4,016	-8,853	-7,928	-8,947
Transfers (consumers-> producers)	-2,678	-6,146	-5,862	-138	-4,119	-9,469	-9,015	-10,034
Other transfers from consumers	-68	-143	-139	9	5	70	443	334
Excess feed cost	132	492	323	27	98	545	644	754
Percentage CSE	-16.7	-20.2	-21.4	-0.5	-17.1	-25.9	-20.9	-21.0
Total Support Estimate (TSE)	3,795	11,224	10,663	3,868	7,814	12,144	11,887	13,850
Transfers from consumers	2,746	6,288	6,001	129	4,114	9,398	8,572	9,700
Transfers from consumers/(TSE-BR), %	71.1	55.3	55.6	3.3	52.7	77.8	74.9	71.8
Transfers from taxpayers	1,117	5,078	4,801	3,730	3,695	2,676	2,871	3,816
Transfers from taxpayers/(TSE-BR), %	28.9	44.7	44.4	96.7	47.3	22.2	25.1	28.2
Budget revenues (BR)	-68	-143	-139	9	5	70	443	334
GSSE/TSE, %	10.7	29.0	35.2	82.4	26.2	8.1	5.6	12.0
TSE/GDP, %	4.2	6.0	5.4	2.7	4.3	5.1	3.9	3.8
R&D/TSE, %	1.4	0.4	0.2	0.8	0.4	0.3	0.2	0.2
Infrast./TSE, %	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GDP	89,799	187,961	198,789	144,895	183,447	239,799	301,225	361,625

Note: For indicator definitions, see A1 in Appendix.
Source: OECD (2006a)

Policies that transfer resources from consumers do not have any explicit productivity increasing impact. On the other hand, the transfers from tax payers can be distributed to productivity increasing policies. R&D and extension activities can be seen as the main effective components of productivity increasing policies. However, if we consult to Table 8, we see that in Turkey the share of R&D activities in Total Support Estimate to agriculture has declined from 1.4 in 1986 to 0.2, almost nil, in 2005. Furthermore, as can be seen from Figure 5, the productivity of agricultural sector in Turkey is considerably low, which further highlights the importance of productivity enhancing policies.



Notes: (1) World Bank reports the agriculture value added per worker as a measure of agricultural productivity. Value added in agriculture measures the output of the agricultural sector less the value of intermediate inputs. (2) The index value is set to 100 for High Income OECD average.

Source: World Bank (2004)

Figure 5 Agricultural Productivity Index (2001)

The *distribution* of resources devoted to agricultural supports is more important and determinative than their *size* in terms of future developments. In 2005, Turkey used USD 3,816 million to support its agricultural sector from its budgetary resources. However, the amount devoted to R&D and extension programs was only about USD 37 million. Hence, supports going to R&D programs would expand to only USD 74 million even if government doubles the total amount of budgetary resources provided that the distribution does not change.

The consumers in Turkey transferred USD 9,700 million to agricultural sector in 2005 due to price distortionary policies. This corresponds to 2.6 percent of total GDP. In the same year government transferred USD 3,816 million to the sector. However, since the part devoted to productivity increasing policies is quite low, very small portion of this support is directed to measures to reduce the transfers from consumers in the incoming years. On the contrary, according to us, a better policy framework seems to be to invest more and more on productivity enhancing policies and decrease the burden on consumers as the productivity increases. This would raise the welfare of both the producers and consumers. In addition, expansion in productivity combined with decreasing prices due to the reductions in border measures would push competitiveness of Turkish agricultural products in the international area and would likely enlarge the agricultural exports of Turkey. This can further expand the welfare of both the producers, and the consumers since producers also act as consumers. Moreover, the declines in border measures would make Turkey advantageous in WTO negotiations and open the way to further gains.

CHAPTER III

ECONOMIC MODELLING FOR AGRICULTURAL POLICY IMPACT ANALYSIS

In practice all econometric specifications are necessarily false models…The applied econometrician, like the theorist, soon discovers from experience that a useful model is not one that is true or realistic but one that is parsimonious, plausible and informative.

Martin Feldstein
Inflation, Tax Rules and Investment:
Some Econometric Evidence
Econometrica, Vol. 50, No. 4 (Jul., 1982), pp. 825-862

III.A. MODELLING APPROACHES

The literature displays a number of dichotomies in describing economic modeling approaches. Normative (prescriptive) models are different from positive models on the basis of the questions they answer. Normative models give answers to the question of "What should happen?" On the other hand, positive models reply to the question of "What will happen?" This dichotomy is crucial in terms of policy analysis since a normative model does not ask the "right" question for the purpose of impact analysis. Hence, for an economic impact analysis, positive approach is more appropriate. The positive model can be solved under different assumptions about policy parameters, and the corresponding solutions can provide some information about the possible consequences of policy changes (Hazel and Norton, 1986, p.5).

In this framework, four types of economic modeling forms are widely used in agricultural policy analysis: Global Trade Models, Computable General Equilibrium Models (CGE), Agricultural Sector Models, and finally Farm Level Models. The basic features of these models are presented in this chapter.

III.A.1. Global Trade Models

Tongeren *et al* (2000) provide a detailed assessment of the present state of applied modeling in the area of international trade in agriculture and related resource and environmental modeling. A total of 18 global trade models are reviewed in the study (Table 6). They describe a standard global partial equilibrium model with the following characteristics: global coverage, parametric differences defined between countries, comparative static analysis, perfect substitute goods, a pooled market for the products, price wedge with ad valorem tariff equivalents, factor markets and exogenous non-agricultural markets. Clearly, all models have different individual characteristics, for example, they can be recursive dynamic (AGLINK, FAO World Model, FAPRI, GAPsi), land allocation may be endogenous (AGLINK, FAO World Model, WATSIM), quantitative policies are modeled explicitly (AGLINK, ESIM, GAPsi, MISS and WATSIM), or they may include bilateral trade by using the imperfect substitute products assumption (SWOPSIM).

Standard general equilibrium international trade models include the following features: global coverage, parametric differences between countries and/or regions, comparative static, imperfect substitute goods, bilateral trade relations, price wedge with ad valorem tariff equivalents, theoretical consistency implied by model structure, and endogenous quantities and prices in all markets, including factor markets.

Table 9 Selected Global Trade Models

Partial Equilibrium Models	• AGLINK (OECD) • ESIM (USDA, Stanford University, University Göttingen) • FAO World Model (FAO) • FAPRI (Iowa State University) • GAPsi (FAL Germany) • MISS (INRA Rennes) • SWOPSIM (USDA/ERS), WATSIM (University Bonn, European Commission)
General Equilibrium Models	• G-cubed (McKibbin and Wilcoxen, US EPA) • GTAP (Purdue University, GTAP consortium) • GREEN (OECD) • INFORUM (University of Maryland) • MEGABARE/GTEM (ABARE Australia) • Michigan BDS (University of Michigan) • RUNS (OECD) • WTO House Model (WTO Secretariat)

Source: Tongeren et al (2000)

According to Tongeren *et al* (2000, p.8), the comparative static modeling has not gone out of fashion although ten models out of eighteen uses a recursive dynamic approach which permits them to generate time paths of variables. However, recursive dynamics do not guarantee time-consistent behavior achieved by inter-temporal equilibrium models. Out of eighteen selected models, forward looking time consistent behavior is only introduced into one model, G-cubed, which does not have a detailed agricultural focus, but concentrates more on macroeconomic impact analysis.

Global trade models are generally products of extensive research projects. They require data for all the trade blocks or regions defined in the model. They basically focus on the trade relations. They are usually designed to analyze the impacts of economic integrations, customs union agreements, and trade liberalization policies.

III.A.2. Computable General Equilibrium Models (CGE)

General equilibrium theory is the reflection of the idea that markets in economies are mutually interdependent. Changes in demand and supply conditions in one market usually have repercussions on supply and demand conditions, and consequently on equilibrium prices in several other markets simultaneously. In this context, computable general equilibrium (CGE)[9] modeling uses the general equilibrium theory as a scientific tool in empirical analyses of resource allocation and income distribution issues in economies. The structure of the CGE models may vary according to the modeling objective. However, some specific features can be attributed to CGE models. These models are multi-sector models based on real world data of one or more national economies. Most of the CGE models are rather aggregated. In a typical CGE model there is one or possibly a few households, and the number of production sectors generally changes between 3 and 50. In general, the technology is assumed to exhibit constant returns to scale, and preferences are assumed to be homothetic. Households are assumed to maximize their utility and firms are assumed to maximize their profits. Excess demand functions are homogenous of degree zero in prices and satisfy Walras' law. Product and factor markets are competitive and relative prices are flexible to clear all product and factor markets. CGE models are, in most cases, focused on the real side of the economy and hence they do not take into account the financial asset markets. A typical CGE model endogenously determines relative product and factor prices and the real exchange rate.

The core of a CGE model consists of a balanced set of accounts embedded within a social accounting matrix (SAM) for a base year (or period). SAM is a set of accounts written in a condensed matrix form. In a simple SAM the rows

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[9] Some economists prefer to call them as Applied General Equilibrium (AGE) models due to the different constructs used empirical modeling with weak connections with the theory of general equilibrium (Mercenier and Srinivasan, 1994).

and columns can be divided into three different sections representing (production) sectors, factors (of production) and institutions (several categories of households, state and local government)[10]. Each row of the SAM represents the incomings of a sector, factor or institution. The corresponding column represents the outgoings of the sector, factor or institution. An important point is that the sum of the row elements of SAM has to be equal to the sum of the corresponding column elements. Thus the incomings and the outgoings of each sector, factor and institution have to be equal (Round, 2003).

Static and dynamic versions of the CGE models exist. However, as Bergman and Magnus (2003) claim, there is slight ambiguity in the exact meaning of "*dynamic*" in this context. Models in which forward looking behavior for households and firms is assumed and in which stock accumulation relations are explicitly included should be denoted as "*dynamic*". However, several static CGE models are used for *multi-period* analyses. As the model is static the agents are implicitly assumed have myopic expectations, that is, to base resource allocation decisions entirely on current conditions. Following Bergman and Magnus (2003), these CGE models are named as "*quasi-dynamic*". Hence, in terms of time dimension, three types of CGE models can be seen in the economic literature: static, quasi-dynamic and dynamic.

Apart from the static-dynamic dimension, it is useful to distinguish between single-country, multi-country and global models. By their nature, single-country models tend to be more detailed in their sectoral disaggregation and include several household types. Multi-country and global models, on the other hand, tend to have less sectoral details and are generally constructed to carry out impact analysis of the changing multilateral policies.

Agriculture can be modeled as one aggregate sector or can be disaggregated to some extent in the CGE models. The more disaggregated a SAM is intended to be, the more extensive are the data requirements (Sadoulet and de Janvry,

[10] The rest of the world (ROW) is also regarded as an institution in this setup.

1995, p.280). These extensive data requirements limit the disaggregation level of agricultural sectors in CGE models. As it is the case for all modeling attempts, *aggregation* introduces bias in the results. Hertel (1999, p.8) rightly states two major problems about the aggregation of sectors. First, aggregation may lead to the creation of a false competition between countries producing fundamentally different products (e.g., rice and wheat). Aggregation of wheat and rice into a single sector implies that rice exporters compete directly with the wheat exporter in the same market. Second, aggregation can change the output and welfare effects by smoothing out tariff peaks which may exist at a disaggregated level. Hence, aggregation of products can change the main qualitative findings of a simulation study (Hertel, 1999, p.8). Another problem with excessive sectoral aggregation results from the fact that the differentiation between agricultural and non-agricultural sectors is not clear due to the requirement of processing prior to final consumption. Various trade measures such as *quotas* and tariff escalations may result in quite different impacts depending on the level of disaggregation. Refined sugar and sweeteners (especially, high fructose corn sweeteners) sectors, raw milk and milk products sectors, raw cotton and textile sectors can be listed as examples. Salvatici *et al* (2000, p.15) affirm a similar argument to the second one above (Hertel, 1999). Salvatici *et al* (2000, p.15) state that the relevant tariffs need to be averaged due to the aggregation. Independent from the method of averaging, this introduces a distortion into the model representation of existing tariff protection. The higher the commodity aggregation in the model, the tariff dispersion, and the commodity disaggregation in the definition of individual tariff lines, the higher the distortion. For example, as Lehtonen (2001, p.40) rightly points out, agricultural policies, like CAP (Common Agricultural Policy of EU) vary considerably across products. Some products can be subsidized and more regulated than others. With the aggregation of these products, the identification of alternative policies would be lost and little can be said about the policy effects. On the other hand, Tyers and Anderson (1992, pp.156-157) state that, due to the aggregation, the interaction and casual linkages between different agricultural production lines are rather weak in large CGE models.

Sadoulet and de Janvry (1995, p.362) propose that with a model that encompasses macroeconomic, sectoral, and social effects, it is almost impossible to disaggregate any of these aspects in much detail. Typical models consider 8 to 12 sectors, 2 to 4 labor types, and 6 to 8 household types, since with more disaggregation, the number of parameters on which estimates have to be made, and the difficulty of interpretation of the results, blurs the central results. In addition, Sadoulet and de Janvry (1995, p.362) state that, in most of the SAMs, activities are intended to stand for a representative productive agent. Firms that are aggregated under each heading should have the same production function, with a unique technology and a similar distribution of income. In agriculture, therefore, activities should correspond not to commodity aggregates, but rather to alternative production systems, each producing a variety of commodities with a given technology. Hence the agricultural sector should be disaggregated taking into account the definition of activities in the SAM. For example, a disaggregation into rain fed and irrigated agriculture or a further disaggregation of rain fed agriculture by farm size may be more appropriate according to the definition of activities in the SAM.

The treatment of land gains importance since land distinguishes the agricultural production in the agriculture focused CGEs. Another important point is the *heterogeneity* of land in agricultural production. As Hertel (1999, p.14) rightly points out, assuming that land is a homogenous factor will imply that cotton can be grown as easily in mountainous areas as in the irrigated plains. Thus, CGE models incorporating land homogeneity will overstate the supply response as they do not take into account the agronomic and the climatic factors constraining the production of some agricultural products.

Regional disaggregation stems as an additional issue in the agriculture-focused CGE models. Regional level social accounting matrices or even input output tables and the data about the inter-regional trade flows are hard to find (Hertel, 1999, p.10). Consequently, multi-regional CGE models are generally constructed at the international level where nations are treated as separate regions with their respective social accounting matrices.

In terms of welfare analysis, disaggregation of households in the economy is another important issue. Usually, data on factor payments to households is difficult to obtain. Therefore, many researchers choose to aggregate all private consumption into a single household (Hertel, 1999, p.9). If CGE analysis tends to address the distributional implications of agricultural policies, household disaggregation is necessary, but it obviously requires additional data mining for the modelers.

Another critical limitation of CGE models is their tendency to devote too little attention to the estimation of key behavioral parameters in the farm and food system. In most cases the parameters of the CGE models lack sufficient empirical justification. As a consequence, they may generate implausible results compared with partial equilibrium models currently used in the agricultural policy impact analysis (Hertel, 1999, p.6).

Sadoulet and de Janvry (1995, p.363) state that CGEs should not be used for the detailed predictions of the impact of very specific policy packages, as they cannot properly model the particularities of any specific policy. Similarly, Lehtonen (2001, pp.40-41) points out that the inclusion of some agricultural measures like set-aside obligations, physical production quotas and direct payments into the CGE models are often difficult. This deficiency results from the heavy aggregation of agricultural production and inadequate representation of physical resource constraints in CGE model. This situation is common in standard CGE models with only one representative product produced in each sector of the economy (Banse and Tangermann, 1996, p.5).

On the other hand, CGE models can serve as policy laboratories within the process of broad policy analysis. They underscore the main linkages among the different economic and social sectors of the economy and help the researcher understand the *branches* and *trickle-down effects* induced by a policy or a shock. Sadoulet and de Janvry (1995, p.363) claim that, therefore, the use of CGE models would be more appropriate to explore alternative policy choices, particularly their *intersectoral*, *inter-social* groups, and *inter-temporal* effects, and their impacts on a whole range of efficiency, equity, poverty, and political feasibility indicators. For example, using a CGE model, Güzel and Kulshreshtha (1995) analyze the price, quantity and income effects of exchange-rate changes on Canadian agricultural sectors by shocking the exchange rate under different simulations. They found that an appreciation of the Canadian dollar would harm agricultural households through decreased prices, outputs and incomes. CGE results indicate that overall the agricultural sectors would gain from a devaluation, but the effects on various sectors of the economy would be quite different. Their findings illustrate that exchange-rate and macroeconomic policy changes may be one of the causes of agricultural price and income instability, at least in Canada. Such an analysis can not be pursued by a partial equilibrium model as it ignores the interactions within the economy. Consequently, it seems that CGE models are more appropriate for this kind of broad policy analysis or to analyze the effects of macroeconomic policy changes.

III.A.3. Agricultural Sector Models

Agricultural sector models are partial equilibrium models, however, contrary to partial equilibrium multi-market (or multi-commodity) models, they may include different production technologies with cross effects, generally within the nonlinear mathematical optimization model setup. Partial equilibrium multi-market (or multi-commodity) models are usually based on estimated parameters of the simple demand and supply curves.

According to Bauer (1989, p.4), minimum requirement to label a model as a “sector model” seems that it should at least cover all of the important products in the agricultural or national accounting systems. In this framework, for example a "milk model" focusing only on milk and related products should be classified as a partial commodity market model.

One basic characteristic of an agricultural sector model is its multi-output and multi-input features, which implies several interdependences within the agricultural sector. A sector model should incorporate the interrelations between supply, demand, price determination, factor input, and agricultural income. Its complexity depends basically on the structural setup of these interdependences. Compared with partial multi-market models, a sector model including these interrelations permits a more comprehensive sectoral policy impact analysis. In this framework, a comprehensive sector model should be seen as a multi-disciplinary research approach integrating the knowledge and approaches of specialized agronomic and economic disciplines. A sector model should represent the actual state of the agricultural sector, and incorporate its main features as detailed as possible depending on the availability of the relevant data. As stated before, this is known as the *positive* (or descriptive) approach: the model should provide the potential effects of the changes in policies and resource endowments.

According to Hazel and Norton (1986, p.136), every sector model's structure contains the following five basic elements.

(1) A description of producers' economic behavior.
(2) A description of the production functions or the technology sets available to producers in each region of the model. These functions relate yields to inputs, and they need to be differentiated by production regime (irrigated versus rain-fed agriculture, crop versus livestock products, annual versus perennial crops).
(3) A definition of the resource endowments held by each group of producers such as land, irrigation water, family labor, initial stock of livestock, tree crops and farm machinery.

(4) A specification of market environment in which the producer operates. This specification involve market forms plus associated consumer demand functions, possibilities for international trade and corresponding import supply functions, export demand functions. In most cases, the import supply functions are simple, that is perfectly elastic at a given c.i.f. price.

(5) A specification of the policy environment of the sector, such as input output subsidies, guaranteed minimum price schedules, import quotas and tariffs, export taxes and subsidies.

The policy impact analysis using a sector model requires several steps. First the sector model is calibrated to the base year (or period average) data. In the process of calibration the values of missing parameters are obtained. The solution of the model is expected to replicate the base year data at this stage. Then, the expected policy changes are imposed on the model. Given these changes in the policy parameters, the model is run again and a new set of values for endogenous variables of the model are obtained. Since the model has *positive* (descriptive) structure, these new values are conceived as the response of the sector to the imposed policy change. The new values are compared with the base year scenario, resulting in a comparative static analysis.

Policy issues that can be addressed by agricultural sector models involve the effects of, for example, *trade and regional integration policies* (EU and WTO), *domestic agricultural support policies* directed to specific products or inputs, *direct income transfers*, *infrastructure* policies, *on* agricultural production and input demand and use, agricultural prices, agricultural product imports and exports, land use, consumer welfare, producer welfare, overall economic welfare, degree of self-sufficiency and government budget.

On the basis of the model structure, agricultural sector models can be constructed using econometric techniques or can be based on the optimization behavior of the agents. Without going into details, we should point out that econometric models require the use of statistical estimation methods; therefore they require relatively huge data to perform healthy estimations. However, this type of huge data set for production, marketing, consumption, input supply, technology, imports and exports of agricultural products is generally not available. Consequently, optimization models based on mathematical programming have been extensively used in agricultural sector modeling.

In agricultural sector modeling, apart from quantity, product *prices* are also *endogenous*. The approach for price endogenous models was motivated by Samuelson (1952) and then improved by Takayama and Judge (1964). The objective function of a price endogenous model is given by the Marshallian surplus (sum of consumers' and producers' surplus). The idea is simple: in a competitive equilibrium economy, the sum of consumers' and producers' surplus is maximized when the market equilibrium is achieved. Hence, if we maximize the Marshallian surplus, the values of price and quantity variables thereby obtained will reflect the competitive equilibrium solutions. In this way, apart from quantity, price is also endogenous.

Hence, the value of objective function Z can be written as:

$$Z = \int_0^q D(Q)dQ - \int_0^q S(Q)dQ \tag{1}$$

where $S(Q)$ and $D(Q)$ are the inverse supply and demand functions, respectively, P is price and Q is quantity.

Note that, the area below the supply curve given in Figure 6 is nothing but *total variable cost* of production, *TVC(S)*. Hence, the objective function for *i* goods can be rewritten as follows:

$$Z = \sum_i \left[\int_0^{q_i} D(Q_i)dQ_i - TVC(S_i) \right] \tag{2}$$

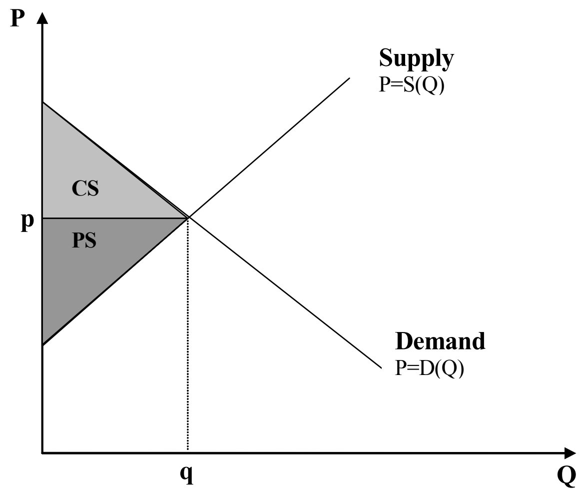

Figure 6 Maximization of Marshallian Surplus

Now assume that the production technology for the production of good *i* is:

$$S_i = y_i X_i \tag{3}$$

Moreover, denoting the unit requirements of fixed resources in production by a_{ki} and resource availability for k types of resources by b_k, the simple sector model with multiple goods can be expressed by the following problem:

$$Max \quad Z = \sum_i \left[\int_0^{q_i} D(Q_i) dQ_i - TVC(S_i) \right] \tag{4}$$

such that

$$Q_i \le S_i \qquad \forall i \qquad [\Pi_i] \tag{5}$$

$$\sum_i a_{ki} x_i = \sum_i a_{ki} . \frac{s_i}{y_i} \le b_k \qquad \forall k \qquad [\Phi_k] \tag{6}$$

$$Q_i, S_i \ge 0 \qquad \forall i \tag{7}$$

Note that the terms in the brackets at the right hand sides are the dual variables (shadow prices) corresponding to each primal equation. Equation (4) is the objective function, Equation (5) is the commodity balance equation, Equation (6) is the set of resource constraints, and Equation (7) is the non-negativity constraint.

The corresponding *Lagrangian* function is

$$\mathscr{L} = \sum_i \left[\int_0^{q_i} D(Q_i) dQ_i - TVC(S_i) \right] - \sum_i \Pi_i (Q_i - S_i) - \sum_k \Phi_i \left[\sum_i (a_{ki} / y_i) S_i - b_k \right] \tag{8}$$

The necessary *Kuhn-Tucker* conditions are:

$$\frac{\partial \mathscr{L}}{\partial Q_i} = D(q_i) - \Pi_i \le 0 \qquad \forall i \tag{9}$$

$$\frac{\partial \mathscr{L}}{\partial S_i} = -TVC'(S_i) + \Pi_i - \sum_k (a_{ki} / y_k) \Phi_k \le 0 \qquad \forall i, k \tag{10}$$

For the cases in which demand and supply are non zero, these first order conditions imply that:

$$\Pi_i = \underbrace{D(q_i)}_{p_i} \qquad \forall i \tag{11}$$

and

$$p_i = \Pi_i = TVC'(S_i) + \sum_k (a_{ki} / y_k) \Phi_k \qquad \forall i, k \tag{12}$$

Equation (11) implies that, at the optimal solution, model's shadow prices on the commodity balances (Π_i) are equal to the corresponding commodity prices, p_i. Equation (12) implies that, at the optimum, each product price is equal to the corresponding marginal cost of production. The marginal costs are defined as including both the *explicit costs* of purchased inputs at the margin $TVC'(S_i)$ and the *opportunity costs* of fixed resources at the margin. The shadow price Φ_k measures the marginal opportunity cost of resource *k*; it is the increment in consumer and producer surplus that would arise from the availability of an additional unit of resource *k*. The ratio a_{ki} / y_k is the amount of resource *k* required per unit of product *i*. Hence, the second term on the right hand side of Equation (12) is the resource opportunity cost of an additional unit of product *i* (Hazel and Norton, 1986, p.167).

The main drawback of using linear or even nonlinear programming models in policy analysis is the fact that the solution of agricultural sector models based on optimization algorithm generally produces *over-specialization*. This means that the optimum production pattern chosen by the model concentrates on one or a few crops and does not produce some crops that agricultural sector are actually growing. In other words, unless any fixed factor becomes binding the average and marginal cost curves are horizontal due to the fixed input-output proportions. Since this is in the core of *positive* agricultural sector modeling, it is worth to give an example. Suppose that the agricultural sector of the economy produces 50 agricultural products, denoted by q_i where i=1, 2,…, 50. Given that a sector model is positive or descriptive, the model solutions should replicate the data of the base year. This means that in order to be able to use a sector model in policy impact analysis, when we solve the sector model it should produce all of these 50 products at the observed levels. In this case, it is said that the model is *calibrated*. However, since it is not possible to observe all the costs that the sector faces, combined with the highly rectangular input-output matrix, normally the solution obtained from the model does not replicate the observed values in the base period. In order to overcome the *over-specialization* problem, early applications in the literature used the *flexibility constraints* putting upper and lower bounds for the activity levels. Later, the concept of *risk* aversion was incorporated in these models. However, both of these approaches may be problematic for policy impact analyses.[11]

The *calibration* of any model to the observed values is an important step in engineering and positive sciences. Theoretically consistent application of calibration in agricultural economics and particularly in the agricultural sector models has been rather recent. The first study on the use of calibration in economic models is the seminal working paper of Howitt and Mean (1985). This study is then followed by Howitt (1995a) and Howitt (1995b). The proposed calibration method with the name of Positive Mathematical Programming (PMP) is also consistent with microeconomic theory[12]. Kasnakoğlu and Bauer (1988) and Çakmak and Kasnakoğlu (2002) are the *two applications* that use the PMP methodology for calibration purposes in different versions of the Turkish Agricultural Sector Model (TASM).

Behavioral Calibration Theory of Howitt assumes that farmers operate in competitive markets and maximize profits. If farmers are rational agents, then there must be a reason to grow each crop to a certain amount. According to PMP method there are hidden (opportunity) costs associated with the production of each crop. These opportunity costs refer to costs that are only perceived by the farmers, which cannot directly be observed by modeler due to the lack of data. Examples involve heterogeneity of land, risk, rising marketing and transportation costs and so on. However, they can be recovered from the cropping pattern as it is assumed that farmers are aware of the full amount of production costs and only grow a crop as long as it brings more profit than others. The (technological, market and environmental) constraints facing the farmer may not be revealed explicitly by the sample information but are surely reflected in the marginal crop and livestock allocation decisions taken by the farmer. Hence, output decisions of farmers must incorporate and reflect

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[11] See Çakmak and Kasnakoğlu (2002) for the potential problems.

[12] See Hecklei and Britz (1999), Howitt (1995a and 1995b), and Çakmak (1992) for a detailed discussion about the consistency with micro theory and about the cost terms.

information about costs and constraints as perceived by the farmer. Modeler's task is to recover the maximum amount of economic information from these incomplete data, to decrypt the hidden cost information contained in the production decisions, and to reconstruct a total variable cost function in a way suitable for revealing patterns of farmers' behavior.

As Çakmak and Kasnakoğlu (2002) rightly pointed out this approach is consistent with the main goal of the sector models: to simulate the response of the producers to changes in market environments, resource endowments, and production techniques. Hence, although the models are optimization models mathematically, they become simulation models by incorporating the behavior of the agents (maximization of economic surpluses) into the models' structure.

Technically, Howitt's idea depends on the meaning of the dual value of a constraint as being the penalty that would be imposed on the objective function if the constraint is to be reduced by one unit. This is nothing but the *opportunity cost* of the constraint. Hence, the more profitable the crop the higher is the "dual value" of the constraint that limits its expansion in the production pattern. Conversely, crops that do not appear in the production pattern are those that have a low opportunity cost. Therefore, if the dual value or penalty is computed for a particular commodity and subtracted from the objective function, the model would choose crops with a low opportunity cost, i.e., it would choose crops that were not very profitable in the original solution and penalize those that were. Subtracting that value from the objective function penalizes the very profitable crops relative to other crops and reduces its amount in the optimal production pattern. The logic for commodities that would otherwise have been unprofitable activities is just the opposite.

A thorough discussion of the PMP algorithm is provided in Chapter V however, the implementation of the PMP approach can be summarized in two steps:

(1) Adding of the so called “calibration constraints” in the model structure, and obtaining their dual values.
(2) Adding calculated PMP coefficients to the objective function of model and removing “calibration constraints” which are no longer needed.

PMP method explained above was then developed further with the integration of *Generalized Maximum Entropy* (Golan *et al*, 1996) formalism by Paris and Howitt (1998). Later on, this approach was extended to more than one *cross sectional* framework by Heckelei and Britz (1999 and 2000), and used in the construction of *Common Agricultural Policy Regional Impact* (CAPRI) model of the EU.

As an *alternative* to PMP methodology, another but less popular method to calibrate mathematical programming models has been proposed by McCarl (1982) and Önal and McCarl (1989 and 1991) by exploiting *Dantzig-Wolfe (1961) decomposition*. They suggest an aggregation procedure (*Exact Aggregation Procedure*) in order to correct aggregation errors in sector models. This aggregation procedure is also positive so it can be used in agricultural sector models in order to do policy impact analysis. Details can be found in McCarl (1982) and Önal and McCarl (1989 and 1991).

III.A.4. Farm Level Models

Farm level models are targeted to analyze the impact of the policy changes on a typology of farm households or enterprises. They are very detailed models compared with CGE and agricultural sector models. They can be constructed in linear or nonlinear programming form. Some of them are constructed to include risk aversion factor using, for example, MOTAD modeling and its extensions (Hazel and Norton, 1986, Chapter 5). Risk factor in farm level models can also be incorporated in the constraint sets, as well. In this case, basically, discrete stochastic programming and chance constrained programming models are used. Game theoretical farm level models based on maxi-min criteria are also constructed in the literature. However, note that, such models can only give information on short term effects of agricultural policies since they take, by their nature, all input and output prices are exogenous to the model. For example, they can be used to analyze the short run effects of input price changes on farmers' income (may be detailed to different farm types and different regions) and so on. Hanf and Noell (1989, p.105) point out that a farm level model should ideally be based on a stratified random sample of existing farms. Such material, however, is not available for most countries including Turkey.

III.A.5. Preferred Modeling Approach

Agricultural sector models allow for a detailed and comprehensive introduction of prevailing production technologies and cost structures into the modeling practices. They can be, and generally are, constructed at the individual product level. The commodities can be distinguished according to special types, such as durum wheat, common wheat and so on. Incorporation of all available data about the production techniques and costs into the input-output equations is possible. Agricultural sector models allow distinguishing products as irrigated and non-irrigated. Moreover, product yields may be defined according to different irrigation methods such as sprinkler, drip, border and so on. Differentiation of production technologies and costs by regions is easier than CGE models. Different soil types and associated yields by products and regions can be represented. Their model structures permit to represent the complex interactions between the livestock and crop productions comprehensively. For each individual commodity, imposition of almost all types of agricultural policies such as set-aside applications, deficiency payments, etc is feasible. Given that the commodities are not aggregated, impacts of border measure changes on imports and exports do not reflect aggregation bias, which is stated in Hertel (1999, p.8), Salvatici et al (2000, p.15) and Lehtonen (2001, p.40). Due to these advantages in terms of our objectives and taking into account the problems of using CGE models in the agricultural impact analysis, we decided to follow the *sector model* approach in our study. We calibrate the model with a new extension of PMP methodology following Heckelei and Britz (1999 and 2000). This new version permits to take into account some further cross sectional information such as regional differences of profitability and production scales in the estimation of full cost matrix. We will see this methodology in detail in Chapter V.

III.B. REVIEW OF SELECTED AGRICULTURAL SECTOR MODELS

In this section we analyze three different agricultural sector models. The first one is the Turkish Agricultural Sector model (TASM). First, we will represent a review for the early version and then we will see the TASM-EU version. These two models have greater importance in our analysis since our model represents the *third* generation in TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002) tradition. TURKSIM (Grethe, 2003) is the second model which will be reviewed in this section. Finally, the Common Agricultural Policy Regional Impact Analysis Model (CAPRI) of EU will be presented. CAPRI has also a special importance for our analysis, since the maximum entropy based PMP algorithm of Heckelei and Britz (1999 and 2000) that we used in the calibration of our model was developed for this model.

III.B.1. Turkish Agricultural Sector Model (TASM)

III.B.1.1. Early Versions of TASM

In connection with a World Bank mission to Turkey, the construction of TASM began in 1981. In the later updated Le-Si, Scandizzo and Kasnakoğlu (1983) version, the *risk* component was incorporated.[13] This version is cited by Hazell and Norton (1986, pp.288-289) and explored extensively. Different versions of TASM were developed by Kasnakoğlu and Howitt (1985) and Kasnakoğlu (1986). They incorporated nonlinear cost structures and solved the problem as a non-linear programming problem contrary to earlier linearized versions and utilized the *Positive Quadratic Programming* (PQP) approach developed by Howitt and Mean (1985) to validate and calibrate the model. This is an important aspect of TASM since; it is one of the first models which use PQP and then PMP approaches developed by Howitt. The model has frequently cited in the agricultural sector modeling literature because of this property. The version of TASM used in the study of Kasnakoğlu and Bauer (1988) was the improved version of Kasnakoğlu and Howitt (1985) and Kasnakoğlu (1986). Later, Bauer and Kasnakoğlu (1990) applied the PMP approach to TASM and the results showed consistent calibration over seven years (Howitt, 1995, p.330).

The following discussion will be based on the structure of TASM based on Kasnakoğlu and Bauer (1988). TASM incorporates production activities which account for over 90 % of the value of agricultural production in Turkey (Kasnakoğlu and Bauer, 1988, p.74). The objective function maximizes the sum of consumer and producer surpluses plus net exports as defined within the model. Various intermediate flows, e.g. between crop and animal production are incorporated. The core of the model includes production activities, resource constraints and a matrix of input-output coefficients. The input-output coefficients are derived from official statistics, based on a special production-cost structure survey. As Kasnakoğlu and Bauer (1988, p.74) rightly point out, this is an important and rarely available asset for these kind of models. The model contains the marketing of 55 agricultural commodities and 15 intermediate commodities. Agricultural supply and the domestic and international demand components are represented within its commodity

[13] This version of TASM is included in the GAMS model library which comes with GAMS installation.

balances. Agricultural production is modeled by a set of 120 production activities. For all crop activities two types of mechanization; animal power and tractor power are considered. For a large number of production activities, dry, irrigated and rain fed farming are modeled. Commodity balances ensure that the total demand and supply are balanced. Besides domestic production, imported products are included in the model as a second source of supply. On the demand side three main demand points are specified; (1) domestic demand for human consumption, (2) cereal and by-products demand for feeding animals, and (3) export demand in raw and processed forms. As stated above, supply side is calibrated using PMP approach. The demand functions are calibrated at the farm gate level, using price elasticities, base year consumption (production+imports-exports-seed use-feed use-increase in stocks) and farm gate prices. The price elasticities used in TASM are calculated from income elasticities using Frisch method (Le-Si, Scandizzo and Kasnakoğlu, 1983). For simulations and policy analysis, the demand curves are repositioned for population and income growths.

III.B.1.2. EU Augmented Version (TASM-EU)

TASM-EU is developed from TASM by Çakmak and Kasnakoğlu (2002) with the purpose of providing a consistent and integrated framework to ponder about the potential developments in the Turkish agricultural sector, particularly, in the case of EU membership. It was, basically, carrying the structure of TASM with regional disaggregation and detailed focus for the assessment of the potential changes in agricultural and trade policies, aiming to evaluate the impact of EU membership on agriculture in Turkey. The Model was intended to be used for impact analysis by the Ministry of Agriculture and Rural Affairs.

The base period of the model is the average from 1997 to 1999. The production side of the model is decomposable into sub-models for each of four geographical areas (Coastal, Central, Eastern, and GAP Region) for the exploration of interregional comparative advantage in policy impact analysis.

On the demand side, consumer behavior is regarded as price dependent, and thus market clearing commodity prices are endogenous to the model. The objective function is defined as the maximization of producers' and consumers' surplus plus net trade revenue. The crop and livestock sub-sectors are integrated endogenously, i.e. the livestock sub-sector gets inputs from crop production. Foreign trade is allowed in raw and in raw equivalent form for processed products and trade is differentiated for EU and the rest of the world (ROW). The model considers the sector as the price maker, but implicitly assumes that producers and consumers are price takers, and hence they operate in perfectly competitive markets both in output and factor markets (Çakmak and Kasnakoğlu, 2002, p.12). The supply side of the model incorporates elasticity based PMP methodology. The model contains more than 200 activities to describe the production of about 50 commodities with approximately 250 equations and 350 variables.

Each production activity defines a yield per hectare for crop production, yield per head for livestock and poultry production. Crop production activities use fixed proportion of labor, tractor power, fertilizers, seeds or seedlings. The livestock and poultry activities are defined in terms of dry energy requirements. The relation between inputs and outputs are those observed on farms in each region, and not necessarily biological or economic optima.

As in TASM, three demand nodes are defined in the TASM-EU. Domestic demand includes the domestic consumption of processed commodities in raw equivalent form. In addition, there is the demand for cereals used for feeding in the livestock sector. Also, the model allows for export of commodities at exogenous prices both in raw and raw equivalent form for processed commodities. It is possible to augment the supply of commodities through import activities at exogenously determined prices.

Output from crop production activities is divided into three categories: crop yield for human consumption, crop yield for animal consumption and crop by-product yield (forage, straw, milling by-products and oil seed by-products) for feed.

The commodity production activities in the model also constitute factor demand activities. Five groups of inputs i.e. land, labor, tractor power, fertilizer and seed, are incorporated for the crop production. Land is classified in four classes: (1) Dry and irrigated land for short cycle activities, (2) Tree land for long cycle activities, (3) Pasture land which includes range-land and meadow. Labor and tractor power requirements are specified on a quarterly basis. The labor input is measured in man-hour equivalents and shows actual time required on the field or per livestock unit. The tractor hours correspond to the usage of tractors in actual production and transportation related activities. Two types of fertilizer, namely nitrogen and phosphate, are measured in terms of nutrient contents. They are considered to be traded goods and are not restricted by any physical limits. In addition to the costs of labor, tractor and fertilizer, seed and seedlings (for vegetables and tobacco) are also included as production costs for annual crops. Fixed investment costs are assigned for perennial crops.

Livestock production is an integrated part of the model. The feed supply is provided from the crop production sector, and it is disaggregated into six categories: (1) Direct or raw equivalent commercial feed consumption of cereals (2) Two categories of processing by-products: milling by-products and oil seed by-products. (3) Straw or stalk by-products from the crop production. (4) Fodder crops, (5) Range land and meadow. The model makes sure that the minimum feed composition requirements are fulfilled. The explicit production cost for animal husbandry is labor. The outputs of the livestock and poultry production activities are expressed in terms of kg/head for livestock production.

III.B.2. TURKSIM Model

TURKSIM (Grethe, 2003) is a comparative static regional partial equilibrium model for the Turkish agricultural sector. It employs an econometric supply model based on behavioral equations. Model involves 14 crop products, 15 vegetable and fruit products, 5 animal products and 8 processed products. A total of 42 products are included in the supply model. The base period of TURKSIM is the average of the years 1997-1999 for plant products and the average of the years 1998-1999 for animal products. TURKSIM has 9 regions.

The macro economic variables income and real exchange rate are exogenous parameters. Import and export prices are also exogenous to the model. Import and export based domestic wholesale prices are calculated based on the respective world market prices. Wholesale prices are functions of international prices, domestic border prices, and observed price margins. TURKSIM basically consists of four sets of equations: (1) *Supply Equations*: area allocation function, area restriction equation for quota production, yield function, farm plant products supply equation, farm animal products supply equation, processing products supply function and total supply equation, (2) *Demand Equations*: feed demand function for animal production, regional feed demand equation, human demand function for income quintiles, processing demand equations for non-tradables and tradables, seed demand equation for plant products, seed demand equation for animal products and total demand equation, (3) *Price Equations*: domestic wholesale price function, farm gate price function, effective farm gate price equation, feed cost index function and shadow price function, (4) *Other Equations*: waste equation, and net exports equation (Grethe, 2003, p.96).

All *behavioral* functions of TURKSIM are of the isoelastic type, only supply and demand elasticities are exogenous parameters. The intercepts are calibrated from base period data (Grethe, 2003, p.123). The systems of supply and demand elasticities used in the model are *synthetic* which means that they are not estimated as a system but individual elasticities from various sources such as literature, expert interviews and own estimates are used in the model. However, they are composed such that they satisfy most of the requirements of the economic theory, e.g. symmetry of cross price effects and adding up property (Grethe, 2003, p.123).

III.B.3. Common Agricultural Policy Regional Impact Analysis Model of EU (CAPRI)

CAPRI which stands for "Common Agricultural Policy Regionalized Impact analysis" is the acronym for an EU-wide quantitative agricultural sector modeling system. The purpose of the project was to analyze the impact of different elements of the Common Agricultural Policy (CAP) on EU's agriculture and environment.

The project was co-financed by EU under the *Fisheries, Agriculture, and Agro-Industrial Research* (FAIR) Program in the years 1997-1999. Total budget of the project was EUR 700,000 and the project was completed in 36 months as stated in the contract. The coordinator of the project was the Institute for Agricultural Policy (IAP) from Bonn University. The other research teams involved in the project were the research institutes from Valencia, Galway, Bologna and Montpellier (plus Research station Tänikon in Switzerland and NILP in Oslo, Norway). The first operational version of CAPRI model was released in 1999.

CAPRI covers all of EU27 (EU25 plus Bulgaria and Romania) and Norway at NUTS II regional level, which amounts to about 250 regions. The international trade model is global and covers around 40 countries or blocks. The model includes about 40 agricultural products and limited number of processed products (dairy, oils and cakes).

CAPRI is a comparative static equilibrium model. Since market and policy instruments require disaggregated modeling, a simultaneous system maximizing the sum of producer and consumer surplus for about 250 region and 40 products was infeasible. Therefore, the model structure was split-up into a *supply* and a *market* component.

The supply module consists of individual programming models for about 250 NUTS II regions. The objective functions of the supply module maximize the aggregated gross value added including the CAP premiums minus a quadratic cost function based on *Positive Mathematical Programming* (PMP). Hence, the supply side of CAPRI is represented by a structural model and calibrated by PMP as TASM and TASM-EU. In order to estimate the multi-output cost functions, CAPRI team explored the possibility to estimate multi-output quadratic cost functions based on a cross-sectional sample, building upon a Maximum Entropy based approach suggested by Paris and Howitt (1998). Later, Heckelei and Britz (1999 and 2000) improved the Maximum Entropy based PMP methodology (based on cross-sectional data) used in the CAPRI model.

The current market module of CAPRI is a global spatial multi-commodity model. An iterative process between the supply and market component results in a comparative static equilibrium. There are 12 trade blocks, each one featuring systems of supply, human consumption, feed and processing functions. The parameters of these functions are derived from elasticities borrowed from other studies and calibrated to projected quantities and prices in the simulation year (Britz, 2005, p.83). The market model is a square (number of endogenous variables equals to the number of equations) system of equations based on behavioral equations which allows to capture many interactions simultaneously. It endogenously determines the trade flows based on the Armington assumption. The interaction of the market and supply modules is depicted in Figure 7 in a simple way. Market module is responsible for simulating market clearing prices so that the prices become endogenous. However, the supply module takes the prices as given when it is solved in each steps of iteration. In this setup, the farmers react as price takers. The solution of supply module (optimal quantities with given prices) is mapped back to market module and market module calculates the equilibrium prices corresponding to these optimal quantities of supply module. This is an iterative process between the supply and market models, which ensures the convergence between the prices used in the supply model and the ones generated by the market model.

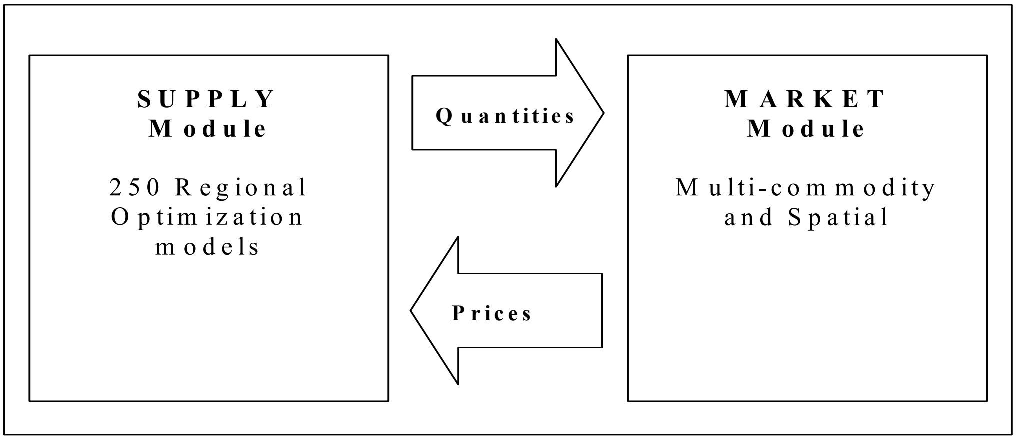

Figure 7 Simple Model Structure of CAPRI

Separation of the market-supply modules has important advantages. First, the different models, in this way, can be maintained and improved independently. Second, without this separation, it would be quite probably technically not feasible to solve the whole system as a unique model. Third, the supply side is based on explicit profit optimization under constraints. This methodology has the advantage to capture the effects of policy instruments as quotas or set-aside or to link it to engineering data or results from bio-physical models. Market side can be modeled based on behavioral functions. By this way, a broader set of restrictions coming from economic theory can easily be imposed. Demand functions can be easily formed to include cross-price effects (which is an important problem for a unique optimization model involving both market and supply modules), Armington assumptions can be easily imposed using import demand functions without loss in the solution feasibility of the model. The market model is an important complement to the regional supply module in order to assess the affect of trade policy measurements such as tariffs as well as the demand responsiveness of EU and world markets. The structure of market model follows the tradition of so-called multi-commodity modeling. Hence, the market module can be easily ameliorated without requiring changes in the other parts due to the modular approach of CAPRI.

Several reforms and reform options of the CAP have been analyzed with CAPRI model: Agenda 2000 reform, sugar reform options, dairy reform options, changes proposed with the "Mid-term review of Agenda 2000" in 2003, Luxembourg compromise. Different trade liberalization proposals in agricultural products are also analyzed using the CAPRI model, basically, the Harbinson proposal, Swiss formula, removing export subsidies, tariff rate quotas expansions, effect of changes in euro-dollar parity form the major simulations.

CHAPTER IV

MAXIMUM ENTROPY ECONOMETRICS

Entropy maximizers are sometimes accused of trying to "get something for nothing", we note that the method expresses, and has evolved from, an explicit statement of the opposite; that you cannot get something for nothing.

Jaynes, E. T. (1988)
The Evolution of Carnot's Principle

IV.A. HISTORICAL BACKGROUND

The word "*entropy*" was coined by German physicist and mathematician *Rudolf Julius Emanuel Clausius* (1822-1888). The word was first used in Clausius' work of "*Abhandlungen über die mechanische Wärmetheorie*", which is published in 1864. The first part of the word "*entropy*" refers to "*energy*" and the second part comes from Greek word "*tropos*" (*τροπή*) which means *turning point* or *transformation*. Clausius' work is the foundation stone of classical thermodynamics (Petz, 2001). A profound discussion on thermodynamic principles is well beyond the scope of this study. In order to be familiar with the concept of entropy in thermodynamics, the *first* and *second* laws of thermodynamics will be summarized.

The *first law of thermodynamics* is the “*law of conservation*”. It says that, in a closed system, energy can never be created or destroyed. It can only be transformed from one form to another. The *second law of thermodynamics* states that every time energy is transformed from one state to another, there is a loss in the amount of that form of energy, which becomes available to perform work of some kind. The *loss* in the amount of “*available energy*” is known as *entropy*. Note here that the “available energy” represents a free energy which is available for work. For example, when we burn a piece of coal, even the total amount of energy remains the same, due to the process of burning, some part of coal is transformed into sulfur-dioxide and other gases which are spread into space. The part of coal which is transformed into sulfur dioxide and other gases can not be reborn to get the some use out of them. This kind of *loss*, *wastage* or *penalty* is called *entropy*. The second law of thermodynamics states that the *total entropy* [i.e. the *total* “*unavailable energy*”] in the world is constantly increasing because of this ever repeating transformations. Rudolf Clausius says that the entropy in the world always tends towards a “*maximum*”. He further notifies that, in a closed system, energy moves from a higher level of concentration to a lower level as heat always flows from a hot to a cold body so that, ultimately, they have reached a stage where there is no longer any difference in concentration level. This point is known as “*the equilibrium state*” which represents the state where entropy has reached the maximum, i.e., where no longer “*free*” energy is available for work.

Eight years later after Clausius’ work, in 1872, *Ludwig Boltzman* proposed a probabilistic measure of the thermodynamic concept of entropy as:

$$Entropy = -k\sum_{i=1}^{n} p_i \ln p_i \tag{13}$$

where p_i is the probability of the i^{th} realization of the possible (molecular) states (named as *microstates*). This was the first *formulation* of the concept of entropy in thermodynamics, or in statistical mechanics.

Claude Shannon was a mathematician who worked on problems in signal transmission within communication systems. He was interested in communicating information across noisy channel, i.e., across channels in which some information is "*lost*" in the process of communication. Shannon's objective was to *measure* the *amount of information sent*, the *amount of information received*, and the *amount of information lost*. He, therefore, tries to find a measure of information. Since, the main purpose of providing information is to remove uncertainty, he proceeded to develop a measure of uncertainty of a probability distribution $\mathbf{p}=(p_1, p_2, \ldots, p_n)$. As a result of his intensive works, Shannon created *information theory* in 1948. He expressed the measure of information as:

$$\mathrm{S}(\mathbf{p}) = -k\sum_{i=1}^{n} p_i \ln p_i \qquad (14)$$

where k is an arbitrary positive constant.[14] He was reluctant to call it a measure of information, since the word information had many interpretations. He therefore consulted his friend, *von Neumann*, who supposedly advised him to call it "*entropy*". Many years later Shannon tells the story of the name entropy as follows (Tribus and McIrvine, 1971):

> My greatest concern was what to call it. I thought of calling it 'information', but the word was overly used, so I decided to call it 'uncertainty'. When I discussed it with *John von Neumann*, he had a better idea. Von Neumann told me, 'You should call it *entropy*, for two reasons. In the first place your uncertainty function has been used in statistical mechanics under that name, so it already has a name. In the second place, and more important, nobody knows what entropy really is, so in a debate you will always have the advantage.

[14] For properties of Shannon' Entropy measure, see Kapur and Kesavan (1992, p.24).

Thus, historically, the reason for calling the uncertainty measure in (14) a measure of entropy was simply that the measure had the same mathematical form as entropy in thermodynamics.

Three years later from Shannon's formulation, in 1951, Kullback and Leibler proposed the *directed divergence* measure for probability distributions. In 1957, E. T. Jaynes published his seminal papers about the maximum entropy formalism which was the explicit enunciation of the principle of maximum entropy.

To sum up; the concept of entropy has played an increasingly significant role in the formulation of probabilistic systems in a various disciplines. The seminal contributions in the development of maximum entropy formalism can be summed as follows. Shannon (1948)'s measure was the starting point. Then Jaynes (1957a)'s Maximum Entropy principle comes. Jaynes (1957a) proposed that Shannon's measure of uncertainty (entropy) could be used to define the values for probabilities. The other major contribution which completed the chain is Kullback's Minimum Cross Entropy (*directed divergence*) principle (1951).

IV.B. MAXIMUM ENTROPY FORMALISM (ME)

The *Maximum Entropy (ME) formalism* is founded on information theory and seeks to *recover* the most probabilistic parameter estimates of some unknown function using limited data. Below we describe the Maximum Entropy procedure derived from *information theory* based on so-called *Wallis* derivation. The *Wallis derivation* is the result of a suggestion made by Graham Wallis to E. T. Jaynes in 1962 (Jaynes, 2003). In the *Wallis* derivation of the *Maximum Entropy Principle*, *multinomial coefficients* are used.

Let us suppose that the *nature* or *society* is carrying out N trials (repetitions) of an *experiment* and that experiment has K possible *outcomes* (states).

Let $N_1, N_2,, \ldots , N_k$ be the number of times that each outcome occurs in the experiment of length N, where

$$\sum_k N_k = N, \quad N_k \geq 0 \text{ and } k=1, 2, \ldots, K \qquad (15)$$

Since there are N trials and each trail has K possible outcomes, the total number of possible combinations of outcome is K^N.

The number of ways a particular set of N_k can be realized is given by the multinomial coefficient[15]:

$$W = \frac{N!}{N_1!N_2!...N_k!} \qquad (16)$$

In addition, we can define a particular set of frequencies (p_k) for the occurrence of this particular set of N_k such as:

$$p_k = \frac{N_k}{N} \quad \text{where } k = 1, 2, 3, \ldots, K. \qquad (17)$$

From equations (16) and (17) we obtain:

$$W = \frac{N!}{N.p_1!N.p_2!...N.p_k!} \qquad (18)$$

---

[15] Ludwig Boltzmann called this as "*Thermodynamische Wahrscheinlichkeit*" in German, which means the "*Thermodynamical Probability*" of the macrostate, and he denoted the *entropy* also by the expression of S=k.log$W$. That is why the letter W is used for this multinomial coefficient expression in the entropy literature.

from which, a set of p_k can determine the value of *W*, *given N*,. Therefore, if W is maximized with respect to p_k, we obtain the set p_k (*relative frequency distribution*) that can be realized in the greatest number of ways (Golan *et al*, 1996, p.10).

Take the logarithm of W as a monotonic transformation of W,

$$ln\ W = ln\ N! - \sum_{k=1}^{K} \ln N_k ! \tag{19}$$

First term in the right hand side of (19) can be written as:

$$ln\ N! = \sum_{m=1}^{N} \ln m \quad \approx \int_{1}^{N} \ln x\, dx \quad as\ 0 < N \rightarrow \infty$$

Using integration by parts, we obtain $\int_{0}^{N} \ln x\, dx = x \ln x |_0^N - \int_{0}^{N} x \frac{dx}{x}$. Notice that *x/x*=1 in the last integral and *x.lnx* is 0 when evaluated at zero[16], so we have $\int_{0}^{N} \ln x\, dx = N \ln N - \int_{0}^{N} dx$, which gives us the *simple form* of so called *Stirling's approximation.*

$$ln\ N! = N\ ln\ N - N \qquad \text{as } 0 < N \rightarrow \infty \tag{20}$$

Use of Stirling's approximation in Equation (20) to approximate its factorial components, for large N, yields

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[16] Note that, $\lim_{x \to 0} x \ln x = 0$. That is why, $p_k.\ln p_k$ is taken to be 0 when p_k=0 in *Shannon's Entropy* measure. For details, see Kapur and Kesavan (1992, p.28).

$$ln\ W \approx N\ ln\ N - \sum_{k=1}^{K} N_k \ln N_k \tag{21}$$

Recall that the ratio $p_k = \frac{N_k}{N}$ that we stated in Equation (17) represents the frequency of the occurrence of the possible K outcomes in a sequence of length N and $\frac{N_k}{N} \to p_k$ as N→ ∞. Consequently, from (19) we have

$$ln\ W \approx -N \sum_{k=1}^{K} p_k \ln p_k \tag{22}$$

Finally, we obtain

$$N^{-1}.\ ln\ W \approx -\sum_{k=1}^{K} p_k \ln p_k = H(\mathbf{p}) \tag{23}$$

Here, $H(\mathbf{p})$ is the Shannon's *Entropy* measure where $p_k.lnp_k$ is taken to be 0 when p_k=0. The entropy (23) is maximized with maximum value *lnK*, when $p_1=p_2=...=1/K$ or, in other words, when the probabilities are *uniform*.

Consider the following linear *pure inverse problem*[17]

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} \tag{24}$$

where $\mathbf{y} = (y_1, y_2, \ldots, y_T)'$ is a *Tx1* dimensional vector of observations (data), $\boldsymbol{\beta}$ is an unobservable *Kx1* dimensional vector of unknowns (parameters) and **X** is a known *TxK* dimensional linear operator.

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[17] The problem of using observations in order to recover (estimate) unobservable parameters is called an *inverse problem*. All estimation problems are, in fact, inverse problems. Two types of inverse problems can be defined, namely *pure* and *noisy*. In a *pure inverse* problem, observable data **y** is specified without a noise (**u**) component: $\mathbf{y}=\mathbf{X}\boldsymbol{\beta}$. In a *noisy inverse* problem, observable data **y** is specified with a disturbance (or noise) term as follows: $\mathbf{y}=\mathbf{X}\boldsymbol{\beta}+\mathbf{u}$.

Let us define the unobservable *Kx1* dimensional vector of unknown parameters, **β,** as the unobservable *probabilities* $\mathbf{p}=(p_1, p_2,\ldots,p_K)'$ that represents the *data generating process* (DGP). In other words, ***p*** pointing out a *probability distribution* and, hence, fulfill the conditions $\sum_{k=1}^{K} p_k = 1$ and $p_k \geq 0$. Using this definition, Equation (24) becomes

$$\mathbf{y} = X\mathbf{p} \tag{25}$$

where, **p** is an unobservable *Kx1* dimensional vector of unknown parameters or probabilities.

Jaynes (1957a and b) suggested applying the entropy concept to recover the unknown distribution of probabilities in Equation (25). By using what Jaynes called the *Maximum Entropy Principle*, one chooses the distribution for which the information provided by the available data.

Given Equation (23), if we follow Jaynes and maximize this monotonic function of *W* subject to the limited, aggregated data given in Equation (25), we get the frequency distribution set p_k that can be realized in the greatest number of ways *consistent with what we have as information*. All information that we have in the form of data will be used, nothing more. That is, we will maximize the *measure of the amount of uncertainty, H*. Because we do not want to tell more than we know, we choose the **p** that is closest to the uniform distribution and yet consistent with the data. In other words, we want to choose the **p** that maximizes the missing information, or the amount of uncertainty.

Therefore, by the aid of the *Maximum Entropy Principle*, the problem of recovering unknown probability distributions transformed to choose the **p** that maximizes

$$H(p_1, p_2,\ldots, p_K) = -\sum_{k=1}^{K} p_k \ln p_k \tag{26}$$

subject to

$$y_t = \sum_{k=1}^{K} p_k . x_k \qquad \text{where } t=1,2,\ldots,T \tag{27}$$

$$\sum_{k=1}^{K} p_k = 1 \tag{28}$$

where *{y_1, y_2,...,y_T}* is an observed set of data (e.g. averages or aggregates) that are consistent with the distribution of probabilities *{p_1, p_2,...,p_T}*. In this maximum entropy problem setup, the Equation (27) is known as the *data* or *moment consistency* constraint whereas Equation (28) as the *normalization* or *additivity* (also, *adding-up*) constraint. Note that the problem is *ill-posed* or *undetermined* whenever T>K.

The corresponding Lagrangian function is

$$\mathscr{L} = -\sum_{k=1}^{K} p_k \ln p_k + \sum_{t=1}^{T} \lambda_t \left[y_t - \sum_{k=1}^{K} p_k . x_{tk} \right] + \mu \left[1 - \sum_{k=1}^{K} p_k \right] \tag{29}$$

The first order conditions are

$$\frac{\partial \mathscr{L}}{\partial p_k} = -\ln \hat{p}_k - 1 - \sum_{t=1}^{T} \hat{\lambda}_t x_{tk} - \hat{\mu} = 0, \; k=1,2,3\ldots K \tag{30}$$

$$\frac{\partial \mathscr{L}}{\partial \lambda_t} = y_t - \sum_{k=1}^{K} \hat{p}_k x_{tk} = 0, \; t=1, 2, 3\ldots T \tag{31}$$

$$\frac{\partial \mathscr{L}}{\partial \mu} = 1 - \sum_{k=1}^{K} \hat{p}_k = 0 \tag{32}$$

From (30), we get

$$\hat{p}_k = e^{-1-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk} - \hat{\mu}} \qquad (30)'$$

Substitution of (30)′ into (31) yields

$$\sum_{k=1}^{K} e^{-1-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk} - \hat{\mu}} . x_{tk} = y_t \qquad (31)'$$

Substitution of (30)′ into (32) produces,

$$\sum_{k=1}^{K} e^{-1-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk} - \hat{\mu}} = 1 \qquad (32)'$$

Rearranging (30)′, we obtain

$$\hat{p}_k = e^{-1-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk} - \hat{\mu}} = \underbrace{e^{-1-\hat{\mu}}}_{\text{We need this}} . e^{-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk}} \qquad (30)''$$

From (32)′, we get

$$e^{-1-\hat{\mu}} = \frac{1}{\sum_{k=1}^{K} e^{-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk}}} \qquad (32)''$$

Substituting (32)″ into (30)″, we finally obtain the *exponential distribution* expression for $\hat{p}_k$

$$\hat{p}_k^{ME} = \frac{e^{-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk}}}{\sum_{k=1}^{K} e^{-\sum_{t=1}^{T}\hat{\lambda}_t x_{tk}}} \qquad (33)$$

where

$$\Omega(\hat{\lambda}_t) = \sum_{k=1}^{K} e^{-\sum_{t=1}^{T} \hat{\lambda}_t x_{tk}} \qquad (34)$$

is a *normalization factor* and called *partition function*. The factor Ω coverts the relative probabilities to absolute probabilities. Notice that the solution given in equation (33) establishes a unique non-linear relationship between $\hat{p}_k$ and y_t through $\hat{\lambda}_t$.

The *information* carried by the data consistency constraint restricts the initial "*missing information*" and, therefore, the *ME (Maximum Entropy) formalism tries to find a solution that maximizes the missing information*. Putting another way, the ME distribution is the *most uniform* distribution compatible with the data constraint. Finally, Jaynes (1968) states that the maximum entropy distribution "*agrees with what is known, but express 'maximum uncertainty' with respect to all other matters, and thus leaves a maximum possible freedom for our final decisions to be influenced by the subsequent sample data*" (Jaynes, 1968, p.231).

IV.C. GENERALIZED MAXIMUM ENTROPY (GME)

The Maximum Entropy principle of Jaynes is only appropriate to estimate the parameters taking values within the range of [0,1] since the arguments of the Shannon's maximum entropy function are probabilities. For this reason; until 1996, the methodology had been used solely in the estimation of probability distributions in the various fields of science. In 1996 in their book, Golan *et al* (1996) proposed a *generalization* for the maximum entropy method to be used in the estimation of parameters which can take any real values. With this book, Maximum Entropy Econometrics was born.

The main advantage of Generalized Maximum Entropy estimator is that it can be used even in the case of *ill-posed* problems. A problem is *ill-posed* if there is not enough information contained in **X** and the data **y** to allow for the recovery of the desired *K*-dimensional β parameter vector by traditional estimation methods. Put it in another way, ill-posed problems referring to the cases of *Negative Degrees of Freedom*, that is, cases where the model to be solved contain more parameters than observations.

Since Golan *et al* (1996), quite a lot of econometric studies have used GME estimator and new contributions based on the use of this new estimator have been done. In 2002, *Journal of Econometrics* devoted a volume on *Information and Entropy Econometrics*[18]. This volume represents a good selection of econometric papers that use this new estimator. Other important contributions came from the field of applied economic modeling. GME estimator is suggested to be used in the estimation of *Social Accounting Matrices (SAMs)* and *behavioral parameters* of CGE models[19]. Harris (2002) proposed to use Maximum Entropy econometrics to estimate *regionalized SAMs*. Morley *et al* (1998) suggested using the new method in the estimation of *income mobilities*, and Robilliard and Robinson (1999) employed in *reconciling household surveys* and *national accounts data*.

Another important contribution came from Agricultural Sector Modeling field. Paris and Howitt (1998) suggested using GME estimator in *Positive Mathematical Programming* in order to estimate the *ill posed* quadratic cost functions. Later on, this approach was extended to more than one *cross sectional* framework by Heckelei and Britz (1999 and 2000). In the calibration of our model, we follow Heckelei and Britz (1999 and 2000). Therefore, in this section, we represent GME estimation methodology in detail.

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[18] Journal of Econometrics, 2002, Volume 107, Issue 1-2.

[19] The main studies in this field are Robinson and El-Said (1997); Robinson et al (1998); Arndt et al (1999); Robinson et al (2000); Robinson and El-Said (2000).

Consider the following *ill-posed*[20] discrete *pure* inverse problem[21]

$$\mathbf{y}=\mathbf{X}\boldsymbol{\beta} \tag{35}$$

where **y** is a *Tx1* vector of observations, **X** is the *TxK* data matrix and β is *Kx1* vector of unknown parameters. *Now assume that the elements of the unknown vector* β *are no longer representing unknown probabilities* to be recovered. In other words, this implies that β_k *must not* take the values in the interval [0,1] instead it may take *any* positive and/or negative real values.

However, because of the fact that the *arguments* of the Shannon's maximum entropy function are *probabilities*, the new defined parameters β must be written in terms of probabilities to be able to use maximum entropy formalism. Following the contributions of Golan *et al* (1996), if we define M ≥ 2 equally distanced discrete *support values*, z_{km}, as the possible realizations of β_k with corresponding probabilities p_{km}, we can specify each parameter β_k taking any real values as follows:

$$\beta_k = \sum_{m=1}^{M} z_{km} p_{km} \qquad , M \geq 2 \tag{36}$$

Let us define the *M* dimensional vector of equally distanced discrete points (*support space*) as $\mathbf{z_k}=[z_{k1}, z_{k2},\ldots, z_{kM}]'$ and associated *M* dimensional vector of probabilities as $\mathbf{p_k}=[p_{k1}, p_{k2},\ldots, p_{kM}]'$.

Now, we can rewrite β in (35) as

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[20] Recall that ill-posed problems referring to the cases of Negative Degrees of Freedom, that is, cases where the model to be solved contain more parameters than observations.

[21] See footnote 17 above.

$$\beta = \mathbf{Zp} \tag{37}$$

where

$$\boldsymbol{\beta} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ . \\ \beta_k \\ . \\ . \\ \beta_K \end{bmatrix}_{Kx1} \tag{38}$$

and

$$\mathbf{Zp} = \begin{bmatrix} \mathbf{z}_1^/ & \mathbf{0} & \mathbf{0} & \mathbf{0} & . & . & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{z}_2^/ & & & & & & \mathbf{0} \\ \mathbf{0} & & . & & & & & . \\ \mathbf{0} & & & . & & & & . \\ . & & & & \mathbf{z}_k^/ & & & \mathbf{0} \\ . & & & & & . & & \mathbf{0} \\ \mathbf{0} & & & & & & . & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & . & . & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{z}_K^/ \end{bmatrix}_{KxKM} \begin{bmatrix} \mathbf{p}_1 \\ \mathbf{p}_2 \\ . \\ . \\ \mathbf{p}_k \\ . \\ . \\ \mathbf{p}_K \end{bmatrix}_{KMx1} \tag{39}$$

where $\mathbf{Z}$ is a $KxKM$ matrix of support points with

$$\mathbf{z}_k^/ \mathbf{p}_k = \sum_{m=1}^{M} z_{km} p_{km} = \beta_k \text{ for } k=1,2,\ldots, K, m=1,2,\ldots,M \tag{40}$$

where $\mathbf{p}_k$ is a M dimensional *proper probability vector*[22] corresponding to a M dimensional vector of weights $\mathbf{z}_k$. Recall that the last vector, $\mathbf{z}_k$, defines the

[22] A *proper probability vector* is characterized by *two* properties: $p_{km} \geq 0$, $\forall$ m=1,...,M and $\sum_{m=1}^{M} p_{km} = 1$

support space of β_k**.** By this way, each parameter is converted from the real line into a well-behaved set of proper probabilities defined over the supports.

As can be seen, the implementation of the maximum entropy formalism allowing for *unconstrained parameters* starts by *choosing* a set of discrete points by researcher based on his *a priori* information about the value of parameters to be estimated, where these sets of discrete points are called the *support space* for all parameters. In most cases, where researchers are uninformed as to the sign and magnitude of the unknown β_k, they should specify a support space that is uniformly symmetric around zero with end points of large magnitude, say $\mathbf{z_k}=[-C, -C/2, 0, C/2, C]'$ for M=5 and for some scalar C (Golan *et al,* 1996, p.77).

As a result of these formulations, the reparameterized discrete pure inverse problem allowing for *unconstrained parameters* becomes:

$$\mathbf{y} = \mathbf{XZp} \tag{41}$$

We now consider the problem of information recovery in the case of ill-posed *inverse problems with noise* where the relationships relating sample data to unknown parameters are not necessarily exact. Here, the unobservable *noise* or *disturbance* vector, **u**, may results from one or more sources of noise in the observed system, including sample and non-sample errors in the data, randomness in the behavior of the agents in the economy, and specification or modeling errors. In this case, the indirect observations are no longer assumed to be free of measurement errors or other disturbances.

In this case, suppose that we observe a T-dimensional vector **y** of noisy indirect observations on an unknown and unobservable K-dimensional parameter vector **β**, where **y** and **β** are related through the following linear model relationship

$$\mathbf{y}=\mathbf{X}\boldsymbol{\beta}+\mathbf{u} \tag{42}$$

Note that, here, **X** is a *TxK* known matrix, and **u** is a *T*-dimensional *noise vector* representing the *noise* in the relationship between **y** and **β**.

Using the terminology of *Information Theory*, our objective is to simultaneously *recover* the *signal* (parameter) **β** and the *noise* (unknown error distribution) **u** where both are unknown.

Similar to **β**, *assuming that* **u** *is a random variable such like* **β**, we can also transform the *noises* as follows (Golan *et al*, 1996, p.87):

$$u_t = \sum_{j=1}^{J} v_{tj} w_{tj} \qquad , J \geq 2 \tag{43}$$

Notice that by this conversation, Golan *et al* (1996) propose a transformation of the possible outcomes for $\mathbf{u_t}$ to the interval [0,1] by defining a set of discrete support points $\mathbf{v_t}$=[v_{t1}, v_{t2},…, v_{tJ}]′ which is distributed uniformly and evenly around zero (such that v_{t1}=-v_{tJ} for each *t* if we assume that the error distribution is symmetric and centered about **0**) [23] and a vector of corresponding unknown probabilities $\mathbf{w_t}$=[w_{t1}, w_{t2},…, w_{tJ}]′ where $J \geq 2$.

Now, we can rewrite **u** in (41) as

$$\mathbf{u} = \mathbf{Vw} \tag{44}$$

where

[23] Note that $J \geq 2$ points may be used to express or recover additional information about u_t (e.g. skewness or kurtosis). For example if we assume that the noise distribution is skewed such that $u_t \sim \chi^2(4)$, then v=[$-\sqrt{2}$, $2\sqrt{2}$] can be used as support space for noise representing the skewness. See Golan et al (1996, p.121).

$$\mathbf{u} = \begin{bmatrix} u_1 \\ u_2 \\ . \\ . \\ u_t \\ . \\ . \\ u_T \end{bmatrix}_{Tx1} \tag{45}$$

and

$$\mathbf{Vw} = \begin{bmatrix} \mathbf{v}_1^/ & \mathbf{0} & \mathbf{0} & \mathbf{0} & . & . & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{v}_2^/ & & & & & & \mathbf{0} \\ \mathbf{0} & & . & & & & & . \\ \mathbf{0} & & & . & & & & . \\ . & & & & \mathbf{v}_t^/ & & & \mathbf{0} \\ . & & & & & . & & \mathbf{0} \\ \mathbf{0} & & & & & & . & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & . & . & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{v}_T^/ \end{bmatrix}_{TxTJ} \begin{bmatrix} \mathbf{w}_1 \\ \mathbf{w}_2 \\ . \\ . \\ \mathbf{w}_t \\ . \\ . \\ \mathbf{w}_T \end{bmatrix}_{TJx1} \tag{46}$$

with

$$\mathbf{v}_t^/\mathbf{w}_t = \sum_{j=1}^{J} v_{tj}x_{tj} = u_t \qquad \text{for } t\text{=1,2,…, } T \text{ and } j\text{=1,2,…,}J \tag{47}$$

In (40) and (47) the support spaces $\mathbf{z_k}$ and $\mathbf{v_t}$ are chosen to span the relevant parameter spaces for each $\{\beta_k\}$ and $\{u_t\}$, respectively. As Golan et al (1996, p.88) point out the choice of **V** clearly depends on the properties of **u**. As an example, they state that *Chebychev's inequality* may be used as a conservative means of specifying sets of error bounds.

Under this reparameterization, the inverse problem with noise given in (42) may be written as

$$\mathbf{y}=\mathbf{X}\boldsymbol{\beta}+\mathbf{u} = \mathbf{XZp} + \mathbf{Vw} \qquad (48)$$

For example, when modeling transition probabilities from aggregate response data it is natural to have the β_k constrained to be nonnegative and contained in the set [0,1] and the parameter space z_{km} can be defined over [0,1] along with the relevant set of adding up conditions (Golan *et al,* 1997, p.16).

Jaynes (1957a) demonstrates that *entropy is additive for independent sources of uncertainty*. In order to show that, following Kapur and Kesavan (1992, pp.30-31), let $\mathbf{p}=(p_1, p_2,...,p_M)$ and $\mathbf{w}=(w_1, w_2, ...,w_J)$ be two independent probability distributions of two random variables, X and Y, so that

$$P(X=x_m)=p_m, \quad \text{and} \quad P(Y=y_j)=w_j, \qquad (49)$$

and

$$P(X=x_m, Y=y_j)= P(X=x_m).\ P(Y=y_j)=p_m w_j \qquad (50)$$

For the joint distribution of x and y, there are $M.J$ possible outcomes with probabilities $p_m w_j$ for m=1, 2,…,M; and j=1, 2,…,J so that for the joint probability distribution, which we shall now denote by **p*w**, the entropy is given by

$$H_{MJ}(\mathbf{p}*\mathbf{w}) = -\sum_{M=1}^{M}\sum_{j=1}^{J} p_m w_j \ln(p_m w_j) = -\sum_{m=1}^{M} p_m \ln p_m - \sum_{j=1}^{J} w_j \ln w_j$$

$$H_{MJ}(\mathbf{p}*\mathbf{w}) = H_M(\mathbf{p}) + H_J(\mathbf{w}) \qquad (51)$$

Hence, for two independent distributions, the entropy of the joint distribution is the sum of the entropies of the two distributions, which is called the *additivity property* of the measure of entropy.

Therefore, assuming the unknown weights on the parameter and the noise supports for the linear regression model are independent, we can jointly recover the unknown parameters and disturbances (noises or errors) by solving the constrained optimization problem of *Max* $H(\mathbf{p},\mathbf{w})=-\mathbf{p}'\ln\mathbf{p}-\mathbf{w}'\ln\mathbf{w}$ subject to $\mathbf{y}=\mathbf{XZp}+\mathbf{Vw}$.

Hence, given the reparameterization in (48) where $\{\beta_k\}$ and $\{u_t\}$ are transformed to have the properties of probabilities, in scalar notation the GME formulation for a noisy inverse problem may be stated as

$$\max_{\mathbf{p},\mathbf{w}} H(\mathbf{p},\mathbf{w}) = -\sum_{k=1}^{K}\sum_{m=1}^{M} p_{km}.\ln p_{km} - \sum_{t=1}^{T}\sum_{j=1}^{J} w_{tj}.\ln w_{tj} \qquad (52)$$

subject to the constraints

$$\sum_{k=1}^{K}\sum_{m=1}^{M} x_{tk} z_{km} p_{km} + \sum_{j=1}^{J} w_{tj} v_{tj} = y_t, \qquad \text{for } t=1, 2,\ldots,T. \qquad (53)$$

$$\sum_{m=1}^{M} p_{km} = 1, \qquad \text{for } k=1, 2,\ldots,K. \qquad (54)$$

$$\sum_{j=1}^{J} w_{tj} = 1, \qquad \text{for } t=1, 2,\ldots,T. \qquad (55)$$

where (53) is the data (or, consistency) constraint whereas (54) and (55) provide the required adding-up constraints for probability distributions of $\{p_{km}\}$ and $\{w_{tj}\}$, respectively.

Notice that in order to obtain the values of β_k's and u_t's, we will have recourse to the following definitions

$$\beta_k = \sum_{m=1}^{M} z_{km} p_{km} \qquad \text{for } k=1,2,\ldots,K \text{ and}$$

$$u_t = \sum_{j=1}^{J} v_{tj} w_{tj} \qquad \text{for } t=1,2,\ldots T \tag{56}$$

The corresponding *Lagrangian* is defined as

$$\begin{aligned}\mathscr{L} = &-\sum_{k=1}^{K}\sum_{m=1}^{M} p_{km}.\ln p_{km} - \sum_{t=1}^{T}\sum_{j=1}^{J} w_{tj}.\ln w_{tj} \\ &+\sum_{t=1}^{T}\lambda_t \left[y_t - \sum_{k=1}^{K}\sum_{m=1}^{M} x_{tk} z_{km} p_{km} - \sum_{j=1}^{J} w_{tj} v_{tj} \right] \\ &+\sum_{k=1}^{K}\gamma_k \left[1 - \sum_{m=1}^{M} p_{km} \right] + \sum_{t=1}^{T}\delta_t \left[1 - \sum_{j=1}^{J} w_{tj} \right]\end{aligned} \tag{57}$$

The first order conditions are

$$\frac{\partial \mathscr{L}}{\partial p_{km}} = -\ln \hat{p}_{km} - 1 - \sum_{t=1}^{T} \hat{\lambda}_t z_{km} x_{tk} - \hat{\gamma}_k = 0, \text{ for } k=1,2,\ldots,K \text{ and } m=1,2,\ldots,M \tag{58}$$

$$\frac{\partial \mathscr{L}}{\partial w_{tj}} = -\ln \hat{w}_{tj} - 1 - \hat{\lambda}_t v_{tj} - \hat{\delta}_t = 0, \text{ for } t=1,2,\ldots,T \text{ and } j=1,2,\ldots,J \tag{59}$$

$$\frac{\partial \mathscr{L}}{\partial \lambda_t} = y_t - \sum_{k=1}^{K}\sum_{m=1}^{M} x_{tk} z_{km} \hat{p}_{km} - \sum_{j=1}^{J} \hat{w}_{tj} v_{tj} = 0, \text{ for } t=1,2,\ldots,T \tag{60}$$

$$\frac{\partial \mathscr{L}}{\partial \gamma_k} = 1 - \sum_{m=1}^{M} \hat{p}_{km} = 0, \text{ for } k=1,2,\ldots K \tag{61}$$

$$\frac{\partial \mathscr{L}}{\partial \delta_t} = 1 - \sum_{j=1}^{J} \hat{w}_{tj} = 0, \text{ for } t=1,2,\ldots T \tag{62}$$

From (58) we obtain

$$\hat{p}_{km} = e^{-1-\sum_{t=1}^{T}\hat{\lambda}_t z_{km} x_{tk} - \hat{\gamma}_k} \qquad (58)'$$

Rearranging (58)′ one can get

$$\hat{p}_{km} = \underbrace{e^{-1-\hat{\gamma}_k}}_{\text{we need this}} .e^{-\sum_{t=1}^{T}\hat{\lambda}_t z_{km} x_{tk}} \qquad (58)''$$

In order to obtain an expression for $e^{-1-\hat{\gamma}_k}$, we can insert (58)′ into (61) and solve for $e^{-1-\hat{\gamma}_k}$

$$e^{-1-\hat{\gamma}_k} = \frac{1}{\sum_{m=1}^{M} e^{-\sum_{t=1}^{T}\hat{\lambda}_t z_{km} x_{tk}}} \qquad (61)'$$

Thus, we can substitute (61)′ into (58)″ to obtain the solution for $\hat{p}_{km}$

$$\hat{p}_{km}^{GME} = \frac{e^{-\sum_{t=1}^{T}\hat{\lambda}_t z_{km} x_{tk}}}{\sum_{m=1}^{M} e^{-\sum_{t=1}^{T}\hat{\lambda}_t z_{km} x_{tk}}} \qquad (63)$$

Similarly, from (59) we get

$$\hat{w}_{tj} = e^{-1-\hat{\lambda}_t v_{tj} - \hat{\delta}_t} \qquad (59)'$$

Rearranging (59)′ yields

$$\hat{w}_{tj} = \underbrace{e^{-1-\hat{\delta}_t}}_{\text{we need this}} .e^{-\hat{\lambda}_t v_{tj}} \qquad (59)''$$

In order to obtain an expression for $e^{-1-\hat{\delta}_t}$, we can insert (59)′ into (62) and solve for $e^{-1-\hat{\delta}_t}$

$$e^{-1-\hat{\delta}_t} = \frac{1}{\sum_{j=1}^{J} e^{-\hat{\lambda}_t v_{tj}}} \tag{62$'$}$$

Thus, we can substitute (62)′ into (59)″ to obtain the solution for $\hat{w}_{tj}$

$$\hat{w}_{tj}^{GME} = \frac{e^{-\hat{\lambda}_t v_{tj}}}{\sum_{j=1}^{J} e^{-\hat{\lambda}_t v_{tj}}} \tag{64}$$

Substituting the solutions of $\hat{p}_{km}$ and $\hat{w}_{tj}$ into (56) produces the *GME estimators* of β_k and u_t, as

$$\hat{\beta}_k^{GME} = \sum_{m=1}^{M} \hat{p}_{km} z_{km}, \quad \text{for } k=1,2,\ldots,K \tag{65}$$

and

$$\hat{u}_t^{GME} = \sum_{j=1}^{J} \hat{w}_{tj} v_{tj}, \quad \text{for } t=1,2,\ldots,T \tag{66}$$

As can be seen, the GME estimates depend on the optimal Lagrange multipliers $\hat{\lambda}_t$ for the model constraints. There is no closed-from solution for $\hat{\lambda}_t$, and hence *no closed form solution* **p**, **w**, **β** and **u**. Thus numerical optimization techniques should be used to obtain the solutions and solutions must be found numerically.

CHAPTER V

POSITIVE MATHEMATICAL PROGRAMMING (PMP)

These schools, however, had an unfortunate and rather naïve belief in something like a "Theory-free" observation. "Let the facts speak for themselves". The impact of these schools on the development of economic thought was therefore not very great, at least not directly. Facts that speak for themselves, talk in a very naïve language.

Ragnar Frisch (17 June 1970)
(from Nobel Lecture, p.16)[24]
1969 Nobel Prize in Economics

V.A. POSITIVE MATHEMATICAL PROGRAMMING (PMP)

Positive mathematical programming (PMP) was created in order to overcome overspecialization problems in positive optimization models. Models calibrated with PMP methodology yield smooth responses to exogenous changes (Howitt 1995a, p. 329). PMP is a method to calibrate models of agricultural production and resource use using *non-linear yield* or *cost* functions. The main idea of PMP is to add a number of non-linear relationships to the objective function of

[24] Frisch was also the *editor* of the very first volume of *Econometrica* which is issued in 1933.

the model in order to calibrate the model exactly to the base year data in terms of output, input use, objective function values and dual values on model constraints using the information contained in the data set (Howitt 1995a, p. 332).

Three propositions form the core of the PMP theory. Following Howitt (1995a, pp. 339-341) these are:

Proposition 1: *Given an agent maximizing multi-output profit subject to linear constraints on some inputs or outputs, if the number of nonzero non-degenerate production activity levels observed (n) exceeds the number of binding constraints (m), then a necessary and sufficient condition for profit maximization at the observed levels is that the profit function be nonlinear (in outputs) in some of the (n) production activities.*[25]

First proposition, known as *nonlinear calibration proposition*, states that if the model does not calibrate to observed production levels with the full set of general linear constraints, a necessary and sufficient condition for profit maximization is that the objective function be nonlinear in at least one of the activities (Howitt, 1995a, pp.331-332).

Proposition 2: *A necessary condition for the exact calibration of a nx1 vector* $\mathbf{q}$ *is that the objective function associated with the (n-m)x1 vector of independent variables* $\mathbf{q}^{\mathbf{p}}$ *contain at least (n-m) linearly independent instruments that change the first derivatives of* $\boldsymbol{f}(\mathbf{q}^{\mathbf{p}})$*.* [26]

Proposition 2 above is supported by the following corollary:

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[25] For the proof of this proposition, see Howitt (1995a, pp.339-340).

[26] For the proof of this proposition, see Howitt (1995a, pp.340-341).

Corollary *The number of calibration terms in the objective function must be equal or greater than the number of independent variables to be calibrated* (Howitt, 1995a, p.341).

Second proposition, named as *calibration dimension proposition*, implies that calibrating the model with complete accuracy depends on the number of nonlinear terms that can be independently calibrated (Howitt, 1995a, p.332).

Consider the following problem:

Maximize	$\mathbf{f}(\mathbf{q})$	
Subject to	$\mathbf{Aq}=\mathbf{b}$	(I)
	$\hat{\mathbf{A}}\mathbf{q} < \hat{\mathbf{b}}$	(II)
	$\mathbf{Iq} = \bar{\mathbf{q}}$	(III)

where $\mathbf{q}$ is a *nx1* matrix, $\mathbf{A}$ is a *mxn* matrix, $\hat{\mathbf{A}}$ is a *(l-m)xn* matrix, $\bar{\mathbf{q}}$ is a *nx1* matrix with *n>m*, $\mathbf{I}$ is a *nxn* matrix, $\mathbf{b}$ is a *mx1* matrix and finally $\hat{\mathbf{b}}$ is a *(l-m)x1* matrix. Note that $\bar{\mathbf{q}}$ is an *nx1* vector of activities that are observed to be nonzero in the base year data: *n>m* implies that there are more nonzero activities to calibrate than the number of binding resource constraints (I). Assume that $\mathbf{f}(\mathbf{q})$ is monotonically increasing in $\mathbf{q}$ with the first and second derivatives at all points and that the problem given above is not primal or dual degenerate.

Third proposition below implies that the *perturbation* of the calibration constraints of a maximization problem, which is not primal or dual degenerate, preserves the primal and dual.

Proposition 3: *There exists a nx1 vector of perturbations* $\boldsymbol{\varepsilon}$ ($\boldsymbol{\varepsilon} > \mathbf{0}$) *of the values* $\bar{\mathbf{q}}$ *such that* *(a) The constraint set (I) is decoupled from the constraint set (III), in the sense that the dual values associated with constraint set (I) do not depend on constraint set (III);*

(b) The number of binding constraints in constraint set (III) is reduced so that the problem is no longer degenerate; and

(c) The binding constraint set (I) remains unchanged. [27]

To conclude, given the three propositions presented above, linear and nonlinear optimization problems can be calibrated by the addition of a specific number of nonlinear terms.

Major stages of a "*standard*" PMP methodology can be represented following Howitt (1995a). [28]

Suppose the following optimization problem of a typical farm frequently used in applied agricultural policy modeling at the farm or at the more aggregate level*:*

$$\begin{aligned} &\underset{\mathbf{x}}{Max} \quad Z = \mathbf{p'q} - \mathbf{c'q} \\ &\mathbf{Aq} \le \mathbf{b} \quad \text{with dual variable vector of } \boldsymbol{\pi} \\ &\mathbf{q} \ge \mathbf{0} \end{aligned} \qquad (67)$$

where Z is objective function value, $\mathbf{p}$ is a (n×1) vector of product prices, $\mathbf{q}$ is a (n×1) vector of production activity levels, $\mathbf{c}$ is a (n×1) vector of variable cost per unit of activity, $\mathbf{A}$ is a (m×n) matrix of coefficients in resource constraints, $\mathbf{b}$ is a (m×1) vector of available resource quantities, and π is a (m×1) vector of dual variables associated with the resource constraints.

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[27] For the proof of this proposition, see Howitt (1995a, pp.341-342).

[28] Standard PMP calibration using *cost functions*.

The solution of this problem does not, in general, reproduce the observed allocations of fixed resources to the production activities. In other words, the solutions of these models are generally quite different from real ones. The farmer may produce a mix of agricultural products such as, 15 ha of wheat, 10 ha of barley and 12 ha of maize. The model's solution may result in producing only maize to maximize the profit given the cost structure incorporated in the model. This solution is true in the normative sense, if the model structure fully reflects the conditions that the farmer is operating in. However, if we assume that the farmers are rational decision makers, the results do not provide the necessary modeling structure for the policy impact analysis.

The basic idea of Positive Mathematical Programming (PMP) is to use the information contained in dual variables of a LP or NLP problem bounded to observed activity levels by *calibration constraints* (*Step 1*), to be able to specify a non-linear objective function such that observed activity levels, which can be represented by the matrix of $\bar{\mathbf{q}}$, are reproduced by the optimal solution of the new programming problem without bounds (*Step 2*) (Heckelei, 1997, p.3).

As the *First step* of this procedure we rewrite the previous problem as follows:

$$\underset{\mathbf{q}}{Max} \quad Z = \mathbf{p}'\mathbf{q} - \mathbf{c}'\mathbf{q}$$

subject to

$$
\begin{aligned}
&\text{(I)} \quad \mathbf{Aq} \le \mathbf{b} && \text{with dual variable vector of } \boldsymbol{\pi} \\
&\text{(II)} \quad \mathbf{q} \le \bar{\mathbf{q}} + \boldsymbol{\varepsilon} && \text{with dual variable vector of } \boldsymbol{\lambda} \\
&\text{(III)} \quad \mathbf{q} \le \mathbf{0} && \qquad (68)
\end{aligned}
$$

here λ are dual variables associated with the calibration constraints**,** $\bar{\mathbf{q}}$ is a (n×1) vector of observed production activity levels and ε is a (n×1) vector of *perturbations* (small positive numbers) which are introduced to prevent degenerate solutions.

The addition of the *calibration constraints* (II) will force the optimal solution of the LP model in (68) to give the observed base year activity levels $\bar{\mathbf{q}}$, given that the specified resource constraints allow for this solution (which they should if the data are consistent). The observed base year activity levels will be obtained within the range of the small positive numbers ε (positive perturbations) of the calibration constraints.

Now, we will partition the vector $\mathbf{q}$ into two sub-vectors, an *(n-m)x1* vector of "*preferable*" activities denoted by $\mathbf{q^p}$ which are constrained by *calibration constraints*, and a *(mx1)* vector of "*marginal*" activities denoted by $\mathbf{q^m}$ which are constrained by the *resource constraints*. For the sake of notational simplicity and without loss of generality, we assume that all elements in $\bar{\mathbf{q}}$ are non zero and all resource constraints are binding**.** Applying the same partitioning for the other vectors as well, the model in (68) can be rewritten as

$$\underset{\mathbf{x}}{Max} \quad Z = \begin{bmatrix} \mathbf{p^{p\prime}} & \mathbf{p^{m\prime}} \end{bmatrix} . \begin{bmatrix} \mathbf{q^p} \\ \mathbf{q^m} \end{bmatrix} - \begin{bmatrix} \mathbf{c^{p\prime}} & \mathbf{c^{m\prime}} \end{bmatrix} . \begin{bmatrix} \mathbf{q^p} \\ \mathbf{q^m} \end{bmatrix}$$

subject to

$$\begin{bmatrix} \mathbf{A^p} & \mathbf{A^m} \end{bmatrix} . \begin{bmatrix} \mathbf{q^p} \\ \mathbf{q^m} \end{bmatrix} \leq \mathbf{b} \quad \text{with dual variables vector of } \boldsymbol{\pi}$$

$$\begin{bmatrix} \mathbf{q^p} \\ \mathbf{q^m} \end{bmatrix} \leq \begin{bmatrix} \bar{\mathbf{q}}^\mathbf{p} \\ \bar{\mathbf{q}}^\mathbf{m} \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varepsilon}^\mathbf{p} \\ \boldsymbol{\varepsilon}^\mathbf{m} \end{bmatrix} \quad \text{with dual variables vector of } \begin{bmatrix} \boldsymbol{\lambda}^\mathbf{p} \\ \boldsymbol{\lambda}^\mathbf{m} \end{bmatrix}$$

$$\begin{bmatrix} \mathbf{q^p} \\ \mathbf{q^m} \end{bmatrix} \geq \mathbf{0} \qquad (69)$$

Let us construct the *Lagrangian* function in order to derive the Kuhn-Tucker conditions.

$$\mathscr{L} = \mathbf{p^{p\prime}q^{p}} + \mathbf{p^{m\prime}q^{m}} - \mathbf{c^{p\prime}q^{p}} - \mathbf{c^{m\prime}q^{m}} + \boldsymbol{\pi}'\left[\mathbf{b} - \mathbf{A^{p}q^{p}} - \mathbf{A^{m}q^{m}}\right]$$
$$+\boldsymbol{\lambda}^{\mathbf{p}\prime}\left[\overline{\mathbf{q}}^{\mathbf{p}} + \boldsymbol{\varepsilon}^{\mathbf{p}} - \mathbf{q^{p}}\right] + \boldsymbol{\lambda}^{\mathbf{m}\prime}\left[\overline{\mathbf{q}}^{\mathbf{m}} + \boldsymbol{\varepsilon}^{\mathbf{m}} - \mathbf{q^{m}}\right] \qquad (70)$$

The corresponding Kuhn-Tucker conditions are:

$$\left.\begin{array}{l}(i)\ \dfrac{\partial\mathscr{L}}{\partial\mathbf{q^{p}}} = \mathbf{p^{p}} - \mathbf{c^{p}} - \mathbf{A^{p\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{p}} \le \mathbf{0} \\ (ii)\ \mathbf{q^{p\prime}}.\dfrac{\partial\mathscr{L}}{\partial\mathbf{q^{p}}} = \mathbf{q^{p\prime}}\left[\mathbf{p^{p}} - \mathbf{c^{p}} - \mathbf{A^{p\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{p}}\right] = \mathbf{0}\end{array}\right\}\Rightarrow$$

We know that $\mathbf{q^{p}} > \mathbf{0}$, thus *(i)* and *(ii)* becomes:

(1) $\mathbf{p^{p}} - \mathbf{c^{p}} - \mathbf{A^{p\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{p}} = \mathbf{0}$

$$\left.\begin{array}{l}(iii)\ \dfrac{\partial\mathscr{L}}{\partial\mathbf{q^{m}}} = \mathbf{p^{m}} - \mathbf{c^{m}} - \mathbf{A^{m\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{m}} \le \mathbf{0} \\ (iv)\ \mathbf{q^{m\prime}}.\dfrac{\partial\mathscr{L}}{\partial\mathbf{q^{m}}} = \mathbf{q^{m\prime}}\left[\mathbf{p^{m}} - \mathbf{c^{m}} - \mathbf{A^{m\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{m}}\right] = \mathbf{0}\end{array}\right\}\Rightarrow$$

It is know that $\mathbf{q^{m}} > \mathbf{0}$, thus *(iii)* and *(iv)* becomes:

(2) $\mathbf{p^{m}} - \mathbf{c^{m}} - \mathbf{A^{m\prime}}\boldsymbol{\pi} - \boldsymbol{\lambda}^{\mathbf{m}} = \mathbf{0}$

$$\left.\begin{array}{l}(v)\ \dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\pi}} = \mathbf{b} - \mathbf{A^{p}q^{p}} - \mathbf{A^{m}q^{m}} \ge \mathbf{0} \\ (vi)\ \boldsymbol{\pi}'.\dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\pi}} = \boldsymbol{\pi}'\left[\mathbf{b} - \mathbf{A^{p}q^{p}} - \mathbf{A^{m}q^{m}}\right] = \mathbf{0}\end{array}\right\}\Rightarrow$$

We know that $\boldsymbol{\pi} > \mathbf{0}$, hence from *(v)* and *(vi)*, we get

(3) $\mathbf{b} - \mathbf{A^{p}q^{p}} - \mathbf{A^{m}q^{m}} = \mathbf{0}$

$$\left.\begin{array}{l}(vii)\ \dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\lambda}^{\mathbf{p}}} = \overline{\mathbf{q}}^{\mathbf{p}} + \boldsymbol{\varepsilon}^{\mathbf{p}} - \mathbf{q^{p}} \ge \mathbf{0} \\ (viii)\ \boldsymbol{\lambda}^{\mathbf{p}\prime}.\dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\lambda}^{\mathbf{p}}} = \boldsymbol{\lambda}^{\mathbf{p}\prime}\left[\overline{\mathbf{q}}^{\mathbf{p}} + \boldsymbol{\varepsilon}^{\mathbf{p}} - \mathbf{q^{p}}\right] = \mathbf{0}\end{array}\right\}\Rightarrow$$

We know that $\mathbf{q^{p}} = \overline{\mathbf{q}}^{\mathbf{p}} + \boldsymbol{\varepsilon}^{\mathbf{p}}$, so we get

(4) $\overline{\mathbf{q}}^{\mathbf{p}} + \boldsymbol{\varepsilon}^{\mathbf{p}} - \mathbf{q^{p}} = \mathbf{0}, \textit{and}$
$\boldsymbol{\lambda}^{\mathbf{p}} \ne \mathbf{0}$

$$\left.\begin{array}{l}(ix)\ \dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\lambda}^{\mathbf{m}}} = \overline{\mathbf{q}}^{\mathbf{m}} + \boldsymbol{\varepsilon}^{\mathbf{m}} - \mathbf{q^{m}} \ge \mathbf{0} \\ (x)\ \boldsymbol{\lambda}^{\mathbf{m}\prime}.\dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\lambda}^{\mathbf{m}}} = \boldsymbol{\lambda}^{\mathbf{m}\prime}\left[\overline{\mathbf{q}}^{\mathbf{m}} + \boldsymbol{\varepsilon}^{\mathbf{m}} - \mathbf{q^{m}}\right] = \mathbf{0}\end{array}\right\}\Rightarrow$$

We know that $\mathbf{q^{m}} < \overline{\mathbf{q}}^{\mathbf{m}}$, so given that $\boldsymbol{\varepsilon}^{\mathbf{m}} > \mathbf{0}$, $\dfrac{\partial\mathscr{L}}{\partial\boldsymbol{\lambda}^{\mathbf{m}}} > \mathbf{0}$. Thus,

(5) $\boldsymbol{\lambda}^{\mathbf{m}\prime} = \mathbf{0}\ \ or\ \ \boldsymbol{\lambda}^{\mathbf{m}} = \mathbf{0}$

Combining the information from *(1)-(4)*, we obtain that $\boldsymbol{\lambda}^{\mathbf{p}} = \mathbf{p}^{\mathbf{p}} - \mathbf{c}^{\mathbf{p}} - \mathbf{A}^{\mathbf{p}\prime}\boldsymbol{\pi}$. From *(5)* we have, $\boldsymbol{\lambda}^{\mathbf{m}} = \mathbf{0}$. Lastly, from *(5)* and *(2)*; $\mathbf{p}^{\mathbf{m}} - \mathbf{c}^{\mathbf{m}} - \mathbf{A}^{\mathbf{m}\prime}\boldsymbol{\pi} - \underbrace{\boldsymbol{\lambda}^{\mathbf{m}}}_{0} = \mathbf{0}$, hence $\mathbf{A}^{\mathbf{m}\prime}\boldsymbol{\pi} = \mathbf{p}^{\mathbf{m}} - \mathbf{c}^{\mathbf{m}}$ which results in $\boldsymbol{\pi} = \left(\mathbf{A}^{\mathbf{m}\prime}\right)^{-1}\left(\mathbf{p}^{\mathbf{m}} - \mathbf{c}^{\mathbf{m}}\right)$.

Therefore, the Kuhn-Tucker conditions imply that

(KT-I) $$\boldsymbol{\lambda}^{\mathbf{p}} = \mathbf{p}^{\mathbf{p}} - \mathbf{c}^{\mathbf{p}} - \mathbf{A}^{\mathbf{p}\prime}\boldsymbol{\pi} \tag{71}$$

(KT- II) $$\boldsymbol{\lambda}^{\mathbf{m}} = \mathbf{0} \tag{72}$$

(KT-III) $$\boldsymbol{\pi} = \left(\mathbf{A}^{\mathbf{m}\prime}\right)^{-1}\left(\mathbf{p}^{\mathbf{m}} - \mathbf{c}^{\mathbf{m}}\right) \tag{73}$$

As can be seen, the dual values of the calibration constraints are zero for marginal activities, $\boldsymbol{\lambda}^{\mathbf{m}}$. The dual values of the calibration constraints ($\boldsymbol{\lambda}^{\mathbf{p}}$) are equal to the difference of *price* and *marginal cost* for preferable activities given by the sum of variable cost per activity unit ($\mathbf{c}^{\mathbf{p}}$) and the marginal cost of using fixed resources ($\mathbf{A}^{\mathbf{p}\prime}\boldsymbol{\pi}$). The dual values of the resource constraints ($\boldsymbol{\pi}$) depend only on the parameters in the objective function and the coefficients of marginal activities.

In *second step* of the procedure, **λ's** are used to specify the non-linear portion of the objective function such that the marginal cost of the preferable activities are equal to their respective revenues at the base year activity levels $\bar{\mathbf{x}}$. Given that the implied variable cost function has the right curvature properties (convex in activity levels) the solution to the resulting programming problem without the calibration constraints will replicate to the primal result of (68).

Any non-linear convex cost function with first derivatives correctly calibrated will reproduce the base year solution. In principle, any type of nonlinear function with the required properties is convenient for this step. For simplicity and lacking strong arguments for other type of functions, a quadratic cost function is usually employed. Hence, suppose that we have the following general version of a quadratic total variable cost function:

$$\mathbf{TVC} = \mathbf{d'q} + \frac{1}{2}\mathbf{q'Tq} \tag{74}$$

which implies the following marginal cost function in matrix form:

$$\mathbf{MC} = \mathbf{d} + \mathbf{Tq} \tag{75}$$

where **d** is a (N×1) vector of parameters associated with the linear term and, **T** is a (N×N) symmetric[29] positive definite[30] matrix and **q** is a (Nx1) vector of activity levels.

For calibration of the model, PMP methodology of Howitt (1995a) proposes to equate this marginal cost to the *sum* of *observed* variable cost (**c**) plus *dual values* (λ) associated with the calibration constraints[31] at the *observed base year activity levels*, $\bar{\mathbf{q}}$. In this case, marginal cost relation becomes $\mathbf{MC} = \mathbf{d} + \mathbf{T}\bar{\mathbf{q}} = \mathbf{c} + \boldsymbol{\lambda}$. Here, note that the **d** vector has N unknowns and the symmetric **D** matrix has $N.(N+1)/2$ different unknown parameters whereas **c** and λ vectors has only N known values. In the "*standard*" PMP methodology, the problem of estimating $N + [N.(N+1)/2]$ parameters from 2N known values is usually solved by equating **d** to **c** and setting all off-diagonal elements of **T** to zero. Then, the N diagonal elements of **T** matrix can be calculated as $t_{ii}=\lambda_i/\bar{q}_i \quad \forall\ i$.

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[29] Notice that the second cross derivatives of the total variable cost function, TVC, are symmetric by *Young's theorem*. Hence, **T** matrix ($T_{ij} = T_{ji}\ \forall$ i,j) is symmetric.

[30] Mathematically, given the profit function of π(q)=Pq-TC(q), profit maximization requires π'(q)=Pq-MC(q)=0 and π''(q)=-MC'(q)<0. Hence, marginal cost must be increasing.

[31] For details, see Howitt (1995a).

Another solution involves setting the vector **d** of the quadratic cost function to be equal to zero, which yields: $t_{ii} = (\lambda_i + c_i)/\overline{q}_i$ and $d_i = 0$ for $\forall$ *i*. A different calibration rule called the *average cost approach* equates the accounting cost vector **c** to the average cost vector of the quadratic cost function, which produces: $t_{ii} = 2\lambda_i/\overline{q}_i$ and $d_i = c_i - \lambda_i$ for $\forall$ *i*. Exogenous *supply elasticities* ε_{ii} are also used to derive the parameters of the quadratic cost function as in Çakmak and Kasnakoğlu (2002) and in Helming *et al.* (2001): $t_{ii} = \overline{p}_i/\varepsilon_{ii}\overline{q}_i$ and $d_i = c_i + \lambda_i - t_{ii}\overline{q}_i$ for $\forall$ *i*. Provided that equation $\mathbf{MC} = \mathbf{d} + \mathbf{T}\overline{\mathbf{q}} = \mathbf{c} + \boldsymbol{\lambda}$ is verified, all these specifications would result in exact calibration to the observed values but with different simulation responses to changes in exogenous variables.

The final nonlinear programming problem that is exactly calibrated to base year activity levels is as follows

$$\begin{aligned}
&\underset{\mathbf{x}}{\text{Max}}\, Z = \mathbf{p}'\mathbf{q} - \mathbf{c}'\mathbf{q} - \frac{1}{2}\mathbf{q}'\mathbf{T}\mathbf{q} \\
&\textit{subject to} \\
&\mathbf{Aq} \le \mathbf{b} \qquad\qquad [\pi] \\
&\mathbf{q} \ge \mathbf{0}
\end{aligned} \tag{76}$$

In order to estimate these $n + [n.(n+1)/2]$ parameters of **d** and **T** matrices, Paris and Howitt (1998) suggest using ME estimation. Their approach is then extended by Heckelei and Britz (1999 and 2000) to use cross sectional sample information. Our model follows Heckelei and Britz (1999 and 2000) using maximum entropy approach to PMP based on cross sectional sample. In the next section we will review the Generalized Maximum Entropy estimation and then present the Positive Mathematical Approach with Maximum Entropy based on cross sectional sample.

V.B. MAXIMUM ENTROPY BASED POSITIVE MATHEMATICAL PROGRAMMING (ME-PMP)

As stated before, deriving the $n+[n.(n+1)/2]$ parameters of **T** and **d** matrices given in equation (75) with only *2n* pieces of information coming from **c** and λ is an *ill-posed* problem. In order to estimate these $n+[n.(n+1)/2]$ parameters of **d** and **T** matrices, in their seminal paper, Paris and Howitt (1998) suggested using Maximum Entropy (ME) econometrics following Golan *et al* (1996). In this section we will first review the contribution of Paris and Howitt (1998) and then pass to the multiple data point PMP with (generalized) maximum entropy (Heckelei and Britz, 1999 and 2000). This second version is what our model uses supply calibration.

V.B.1. Basic ME-PMP Version

In order to recover the marginal cost function given by $\mathbf{MC}=\mathbf{d}+\mathbf{T}\overline{\mathbf{q}}=\mathbf{c}+\boldsymbol{\lambda}$, Paris and Howitt (1998) suggested using Maximum Entropy econometrics since the problem is *ill-posed*. The cost function is hypothesized to be a quadratic functional form in output quantities such as $C(\mathbf{q})=\mathbf{q}'\mathbf{T}\mathbf{q}/2$, where **T** matrix is symmetric and positive semi definite. To achieve the symmetric positive semi-definiteness of the **T** matrix, the following Cholesky decomposition is proposed:

$$\mathbf{T}=\mathbf{LDL}' \qquad (77)$$

where $\mathbf{L}$ is a unit lower triangular matrix[32], and $\mathbf{D}$ is a diagonal matrix. The Cholesky factorization always exists for symmetric positive semi-definite matrices. It can be shown that $\mathbf{LDL}'$ is a positive semi-definite matrix provided that all the diagonal elements of **D** are non-negative (Paris and Howitt, 1998, p.128). To recover the marginal cost function based on maximum entropy formalism, the Cholesky parameters of **L** and **D** matrices are regarded as expected values of associated probability distributions defined over a set of known K discrete *support points*. Hence, it is assumed that for each (i,t) parameter

$$L_{it} = \sum_{k=1}^{K} ZL_{itk} PL_{itk} \quad \text{with } i,t = 1, \ldots, N \tag{78}$$

$$D_{ii} = \sum_{k=1}^{K} ZD_{iik} PD_{iik} \quad \text{with } i = 1, \ldots, N \tag{79}$$

where **ZL** and **ZD** are the matrices of the known support points for the probability distribution of **L** and **D** matrices, respectively, while **PL** and **PD** represent the corresponding probability matrices of the generalized maximum entropy problem, respectively.

Given that there are NxN parameters of the **T** matrix and given that each parameter is specified with K support points, the **ZL** and **ZD** matrices are specified as follows:

$$for\ \ i = t \qquad ZD_{itk} = \frac{mc_i}{\bar{x}_i}.WD_k \qquad k = 1,\ldots,K;\ i,t = 1,\ldots,N \tag{80}$$

$$for\ \ i \neq t \qquad ZD_{itk} = 0 \qquad k = 1,\ldots,K;\ i,t = 1,\ldots,N \tag{81}$$

$$for\ \ i > t \qquad ZL_{itk} = \frac{mc_i}{\bar{x}_i}.WL_k \qquad k = 1,\ldots,K;\ i,t = 1,\ldots,N \tag{82}$$

[32] A unit lower triangular matrix is a square matrix with unit elements on the main diagonal and zero elements above it (Paris and Howitt, 1998, p.128, fn.3)

$$for\ \ i = t \qquad ZL_{itk} = 1 \qquad k = 1,...,K;\ i,t = 1,...,N \tag{83}$$

$$for\ \ i < t \qquad ZL_{itk} = 0 \qquad k = 1,...,K;\ i,t = 1,...,N \tag{84}$$

where **WD** and **WL** are *Kx1* vectors of suitable *weights*.[33] The mc_i is the i^{th} *marginal cost* measured in the *LP stage of the PMP* while the $\bar{x}_i$ is the realized output level of the i^{th} activity. In this formulation, Equation (80) defines the support space for the diagonal elements of the **D** matrix, Equation (81) imposes a zero restriction on all the off-diagonal elements of the **D** matrix, Equation (82) define the support space for the lower triangular elements of the **L** matrix and finally Equations (83) and (84) impose a unit and zero restriction, respectively, on the diagonal and upper triangular elements of the **L** matrix.

The formulation of the ME recovery problem is to find matrices **PL** and **PD** with elements $PL_{itk} >> 0$ and $PD_{iik} >> 0$ such that:

$$\max_{\mathbf{P,L,D}} \quad H(PL_{itk}, PD_{itk}) = -\sum_{i=1}^{N}\sum_{t=1}^{N}\sum_{k=1}^{K} PL_{itk}\log(PL_{itk}) - \sum_{i=1}^{N}\sum_{t=1}^{N}\sum_{k=1}^{K} PD_{itk}\log(PD_{itk}) \tag{85}$$

subject to

$$\sum_{j=1}^{N}\sum_{t=1}^{i} L_{it}D_{tt}L_{jt}\bar{q}_j = c_i + \lambda_i \qquad i,t,j = 1,...,N,\ \forall\ i \tag{86}$$ [34]

$$\sum_{t=1}^{i} L_{it}D_{tt}L_{jt} = t_{ij} \qquad \forall\ i < j\text{, Cholesky decomposition of } \mathbf{T} \tag{87}$$

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[33] The weights for the diagonal elements of the **D** matrix (**WD**) should be non-negative to ensure the positive semi definiteness of the resulting **T** matrix. In their article, they use the following two alternative sets of **WD** such as (0, 0.66, 1.33, 2.00, 2.66) and (0, 1, 2, 3, 4). On the other hand, the alternative weights for the off-diagonal elements of the **L** matrix (**WL**) are as follows (-1.0, -0.5, 0.0, 0.5, 1.0) and (-2, -1, 0, 1, 2).

[34] L_{jt} = 0 when $j<t$ since **L** is a lower triangular matrix.

$$\sum_{t=1}^{j} L_{it} D_{tt} L_{jt} = t_{ij} \qquad \forall\ i > j \text{, Cholesky decomposition of } \mathbf{T} \qquad (88)$$

$$\sum_{t=1}^{i} L_{it} D_{tt} L_{it} = t_{ii} \qquad \forall i = j \text{, Cholesky decomposition of } \mathbf{T} \qquad (89)$$

$$t_{ij} = t_{ji} \qquad \forall\ i, j \text{, Symmetry of } \mathbf{T} \text{ matrix} \qquad (90)$$

$$\sum_{k=1}^{K} PL_{itk} = 1 \qquad i,t,j = 1,...,N \text{, Adding up property} \qquad (91)$$

$$\sum_{k=1}^{K} PD_{itk} = 1 \qquad i,t,j = 1,...,N \text{, Adding up property} \qquad (92)$$

$$L_{it} = \sum_{k=1}^{K} ZL_{itk} PL_{itk} \qquad i,t,j = 1,...,N,\ \forall\ i,t \text{, Lower triangular matrix} \qquad (93)$$

$$D_{tt} = \sum_{k=1}^{K} ZD_{ttk} PD_{ttk} \qquad i,t,j = 1,...,N,\ \forall\ t \text{, Diagonal matrix} \qquad (94)$$

V.B.2. Multiple Data Point ME-PMP (Cross Sectional)

The multiple data point maximum entropy based PMP algorithm of Heckelei and Britz (1999 and 2000) is represented here. This version further enriches and develops Paris and Howitt (1998). As stated before, it is the algorithm used in our model and, therefore, takes on greater importance for this study.

Our objective here is to estimate a quadratic cost function with cross cost effects (full **T**-matrix) between *crop production activities* and the intercept matrix of **d** Suppose one can generate *R* (1×n) vectors of marginal costs from a set of R regional programming models by applying the first step of *PMP*. In order to exploit this information for the specification of quadratic cost functions for all regions, we need to define appropriate restrictions on the parameters across regions, since otherwise no informational gain is achieved. Consider the following suggestion for a "*scaled*" regional vector of marginal cost applied to crop production activities:

$$\mathbf{MC}_r = \mathbf{d}_r + \mathbf{T}_r \overline{\mathbf{q}}_r \;\; \forall\, r, \qquad (95)$$

$$\mathbf{T}_r = (cpi_r)^g \mathbf{S}_r \mathbf{B} \mathbf{S}_r^{/} \;\; \forall\, r, \qquad (96)$$

where $\mathbf{d}_r$ is a (Nx1) vector of linear cost function parameters in region r, $\mathbf{T}_r$ represents a (NxN) matrix of quadratic cost term parameters in region r, cpi_r stands for a regional "*crop profitability index*" defined as regional average revenue per hectare relative to average revenue per hectare over all regions such as $cpi_r = AR_r / AR$ with $AR_r = \sum_{i=1}^{M} \overline{q}_{ir} p_i yl_{ir} \Big/ L_r$ and $AR = \sum_{r=1}^{R} AR_r \Big/ \sum_{r=1}^{R} L_r$. Note that $\overline{q}_{ir}$ is observed activity levels of crop i in region r in base year, p_i denotes the price of crop i, yl_{ir} represents the yield of crop i in region r, and L_r is the total arable land in region r. The parameter g is the exponent of crop profitability index to be estimated and it determines the influence of crop profitability index. Lastly, s_{rii} represent the elements of (NxN) diagonal scaling matrices $\mathbf{S_r}$ and it is given by $s_{rii} = \sqrt{1/\overline{q}_{ir}}$.

This algorithm involves two important elements which improves the Maximum Entropy based PMP of Paris and Howitt (1998). First one is *crop profitability index* and the second one is the *scaling mechanism*. The crop profitability index for each region is estimated separately reflecting the regional differences in the production of associated crop. The inclusion of the exponent of crop profitability index in the calculation of marginal cost matrix is important since it captures the economic effect of differences in soil, climatic conditions etc for each regions. Second, scaling mechanism improves the responses of the model to the changes in acreage of any crop. To stress the effect of scaling, Heckelei and Britz (1999 and 2000) give an example for two regions with identical total area but different shares of crop land. According to the example, assume that there is 10 ha increase in the acreage of a crop. If the total acreage of this crop in region one is 1 ha and 100 hectares in region two prior to the change of the acreage, then 10 hectare increase in the acreage of this crop would imply 1000 percent relative increase for the first region but only 10 percent for the second region. Hence, the scaling of B matrix assures the same marginal cost increases in both regions for the same percentage increase in crop acreage. Using this scaling mechanism it is possible to take into account this difference in the calculation of marginal costs depending on the differences in crop acreage for different regions.

To ensure that the PMP model converges to a stable solution the second order conditions require that the *Hessian* of the cost function is *negative definite*. This condition implies that $\mathbf{T_r}$ matrices, and therefore, **B** matrix should be *positive (semi) definite*. This is known as *curvature restriction*. In order to ensure the positive definiteness, as we stated in the previous section, Paris and Howitt (1998, p.128) suggested using Cholesky decomposition. The Cholesky decomposition is defined as the following product of **L** and **D** matrices:

$$\mathbf{B} = \mathbf{LDL}' \tag{97}$$

where $\mathbf{L}$ is a unit lower triangular matrix, and $\mathbf{D}$ is a diagonal matrix with all positive elements. As long as it is guaranteed that all the diagonal elements of D matrix is positive, $\mathbf{LDL}'$ product will always produce a positive (semi) definite matrix. However, Heckelei and Britz (1999, p.10) states two main disadvantages of this procedure. First, the results for **B** depend on the order of rows in the matrix. Second, recall from the previous section that, instead of defining support points for **B** directly, the approach of Paris and Howitt (1998) proposes using support points for the estimation of **L** and **D** matrices. They centre the elements of **D** around the value for the diagonal elements of **T** which would satisfy the marginal cost condition and the elements of **L** around zero. At this point, Heckelei and Britz (2000, p.35) rightly point out that due to the complex (and even order-dependent, as stated in the first disadvantage) relationship between the matrices **L**, **D** and **T**, this procedure impose severe *a priori* expectations for the parameters of recovered **T** matrix since the nonzero cross cost effects of activities will be merely based on this technically motivated choice of support points. In order to overcome these problems with the $\mathbf{LDL'}$ decomposition of Paris and Howitt (1998), Heckelei and Britz (2000, p.36) propose a solution to the same curvature problem which allows the definition of support points for the actual parameters to be estimated by incorporating a "*classic*" Cholesky decomposition[35] of the form $\mathbf{LL'}$ as direct constraints of the estimation problem. In other words, their suggestion implies that the Cholesky decomposition of the form $\mathbf{LL'}$ is used *indirectly* as an additional constraint to the ME problem. Their approach does not involve defining support points for the elements of Cholesky decomposition matrices, instead does involve defining direct support points only for the parameters to be estimated using the *a priori* information coming from data and from the first step of PMP modeling.

Below we obtain the constraints of the "classical" $\mathbf{LL'}$ Cholesky decomposition following their suggestion. For this purpose, consider the following *3x3* **B** matrix:

$$\mathbf{B} = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \tag{98}$$

The Cholesky decomposition is

$$\mathbf{L} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \tag{99}$$

and

[35] The two different forms of the Cholesky decomposition are related in the following manner: Replacing the "ones" on the diagonal triangular matrix **L** of $\mathbf{T} = \mathbf{LDL'}$ with the square roots of the corresponding diagonal elements of **D** produces $\mathbf{T} = \mathbf{LL'}$. (Heckelei and Britz, 2000, p.39)

$$\mathbf{B} = \mathbf{L}.\mathbf{L}' = \begin{bmatrix} l_{11}l_{11} & l_{11}l_{21} & l_{11}l_{31} \\ l_{21}l_{11} & l_{21}l_{21} + l_{22}l_{22} & l_{21}l_{31} + l_{22}l_{32} \\ l_{31}l_{11} & l_{31}l_{21} + l_{32}l_{22} & l_{31}l_{31} + l_{32}l_{32} + l_{33}l_{33} \end{bmatrix} \tag{100}$$

This final expression yields the following two sets of equations, in *general form*, for the *off-diagonal* and *diagonal* elements of **B** matrix, respectively:

$$b_{ji} = \begin{cases} \sum_{h=1}^{i} l_{jh} l_{ih} & when \quad i < j \\ \sum_{h=1}^{j} l_{jh} l_{ih} & when \quad i > j \end{cases} \tag{101}$$

$$b_{ii} = \sum_{h=1}^{i} l_{ih}^2 \tag{102}$$

From these equations and setup, the following constraints for the diagonal and off-diagonal elements of **L** matrix are obtained:

$$l_{ii} = \sqrt{b_{ii} - \sum_{h=1}^{i-1} l_{ih}^2} \quad \forall i, j\ . \tag{103}$$

$$l_{ji} = \frac{b_{ji} - \sum_{h=1}^{i-1} l_{jh} l_{ih}}{l_{ii}} \quad \forall i, j \ \text{ where } j>i. \tag{104}$$

$$l_{ji} = 0 \quad \forall i, j \ \text{ where } j<i. \tag{105}$$

Notice also that since **B** is supposed to be a symmetric and positive (semi) definite matrix, the l_{ii} must always be positive and real,

$$l_{ii} > 0 \tag{106}$$

Now, we can write the general formulation of the corresponding *Maximum Entropy* recovery problem as follows:

$$\underset{\mathbf{p},\mathbf{B},\mathbf{d},g}{\text{Max}} \quad H(\mathbf{p}) = -\sum_{k=1}^{K}\sum_{i=1}^{N}\sum_{r=1}^{R} pd_{kir} \ln pd_{kir} - \sum_{k=1}^{K}\sum_{i=1}^{N}\sum_{j=1}^{N} pb_{kij} \ln pb_{kij} - \sum_{k=1}^{K} pg_k \ln pg_k \tag{107}$$

subject to

$$d_{ir} + cpi_r^g \cdot \sum_{j=1}^{N} s_{rii} s_{rjj} \;\; b_{ij} \;\; \overline{q}_{ir} = c_{ir} + \lambda_{ir}, \;\; \forall\, i,r \text{ , Data constraint}^{36} \tag{108}$$

$$d_{ir} = \sum_{k=1}^{K} pd_{kir} zd_{kir} \;\; , \;\; \forall\, i,r \;\; \text{, Marginal cost intercept term.} \tag{109}$$

$$b_{ij} = \sum_{k=1}^{K} pq_{kij} zb_{kij} \;\; , \;\; \forall\, i \;\; and \;\; j \ge i \text{ , Marginal cost slope term.} \tag{110}$$

$$b_{ij} = b_{ji}, \;\; \forall\, i < j \text{ , Symmetry of } \mathbf{B} \text{ matrix.} \tag{111}$$

$$g = \sum_{k=1}^{K} pg_k zg_k \text{ , Exponent of crop profitability index.} \tag{112}$$

$$\sum_{k=1}^{K} pd_{kir} = 1, \;\; \forall\, i,r \text{ , Adding up property.} \tag{113}$$

$$\sum_{k=1}^{K} pb_{kij} = 1, \;\; \forall\, i \;\; and \;\; j \ge i \text{ , Adding up property.} \tag{114}$$

$$\sum_{k=1}^{K} pg_k = 1 \text{ , Adding up property.} \tag{115}$$

$$l_{ii} = \sqrt{b_{ii} - \sum_{h=1}^{i-1} l_{ih}^2} \quad \forall i,j \text{ . Cholesky decomposition restriction.} \tag{116}$$

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[36] Information from first phase of PMP, and cross sectional (regional) information from base year data.

$$l_{ji} = \frac{b_{ji} - \sum_{h=1}^{i-1} l_{jh} l_{ih}}{l_{ii}} \quad \forall i, j \,;\; j>i \text{ Cholesky decomposition restriction.} \tag{117}$$

$$l_{ji} = 0 \quad \forall i, j \,;\; j<i \text{ Cholesky decomposition restriction.} \tag{118}$$

$$l_{ii} > 0 \tag{119}$$

For the support points for the exponent *c* of the crop profitability index *cpi*, Heckelei and Britz (1999, p.11) propose the following so that the index cover the range from $1/cpi_r^2$ to cpi_r^2: $\mathbf{zc} = (-2, -2/3, 2/3, 2)$. The linear terms **d** represent marginal costs when all production activity levels **q** are zero, so an interpretation in terms of economic theory is hard, therefore they suggest for the spread of the support points **zd** an *ignorance prior*, in other words, it is set to a very wide interval around the observed costs. The spread is 180 times the national average in revenue per hectare:

$$\mathbf{zd} = \mathbf{c_r} + (-90, -30, 30, 90).AR \tag{120}$$

where *AR* represents the national average in revenue per hectare.

Finally, the support points for **B** matrix are suggested to be defined as follows:

$$\mathbf{zb}_{\mathrm{ij}} = \mathbf{zbs}_{\mathrm{ij}}\, \mathbf{amc}_{\mathrm{ij}} \tag{121}$$

where

$$\mathbf{zb}_{\mathrm{ij}} = \begin{cases} (0.001,\ 3.3,\ 6.66, 10) & \forall\, i = j \\ (-2, -2/3, 2/3, 2) & \forall\, i \neq j \end{cases} \tag{122}$$

and $\mathbf{amc}_{\mathrm{ij}} = 1/2(\overline{\mathrm{MC}}_{\mathrm{i}} + \overline{\mathrm{MC}}_{\mathrm{j}})$. Here, $\overline{\mathrm{MC}}_{\mathrm{i}}$ represents the land weighted average of marginal cost for activity *i* across regions.

CHAPTER VI

TURKISH AGRICULTURAL SECTOR MODEL (TAGRIS)

All models are wrong; but some are useful.

Box, G. E. P. (1976).
"Science and statistics",
Journal of the American Statistical Association,
71, pp. 791-799.

The purpose of this chapter is to provide a comprehensive representation of the Turkish Agricultural Sector model (TAGRIS). The chapter has three main sections. In the first section, the structure of the model is explained. The basic features of the model, input output structure of production, demand and supply interaction, trade and regional structure are summarized. Data requirements and major data sources are described. The second section is reserved to explain the calibration processes in detail. In the calibration of demand, an elasticity based approach is followed. The domestic supply calibration follows Heckelei and Britz (1999 and 2000) and uses maximum entropy based PMP with multiple data points. The supply calibration also involves the exports, which is a novel aspect of the study. For the calibration of export supply, elasticity based PMP approach is used. The estimation methodology for the estimation of the annual yield growth rates can be found in the last section. This is a crucial step since the model is used to analyze the impacts of future policy scenarios. Prior to the implementation of policy scenarios, the model is projected to the future. In this projection, an information set concerning possible yield growths until the projection year seems essential. A hybrid two-step estimation process consisting of Generalized Maximum Entropy (GME) and Ordinary Least Square (OLS) estimations is proposed for this purpose.

VI.A. STRUCTURE OF THE MODEL

The structure of the model permits a comprehensive analysis of the crop and livestock production and use. The model is a non-linear programming model. It maximizes the *Marshallian surplus* (consumer plus producer surplus).

VI.A.1. Overview of the Model's Structure

The model used in this study represents the *third* generation of policy impact analysis using sector models, following TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002).

The basic features of the model may be summarized as:

i) The production side of the model is disaggregated into four regions for the exploration of interregional comparative advantage in policy impact analysis. These are: *Coastal Anatolia*, *Central Anatolia*, *East Anatolia*, and *GAP*[37] Regions.
ii) The crop and livestock sub-sectors are integrated endogenously, i.e., the livestock sub-sector gets inputs from crop production.

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[37] Southeastern Anatolia Project (Turkish acronym is *GAP*).

iii) Foreign trade is allowed in *raw* and in *raw equivalent* form for processed products and trade is differentiated for the *EU*, *USA* and the rest of the world (*ROW*).

The model contains more than 200 activities to describe the production of about 52 commodities with approximately 250 equations and 350 variables. The agricultural products of our model cover 96.3 % of Turkey's total harvested area (2003-2005 average). The products included in the model can be grouped as follows:

(1) *CEREALS*: Common wheat, Durum wheat, Barley, Corn, Rice, Oats, Rye, Spelt, Millet.
(2) *PULSES*: Chick pea, Dry bean, Lentil.
(3) *INDUSTRIAL CROPS*: Tobacco, Sugar beet, Cotton.
(4) *OILSEEDS*: Sesame, Sunflower, Peanut, Soybean.
(5) *VEGETABLES*: Melon-Watermelon, Cucumber, Eggplant, Fresh Tomato, Processing Tomato, Green Pepper.
(6) *TUBERS*: Onion, Potato.
(7) *FRUITS AND NUTS*: Apple, Apricot, Peach, Table Olive, Oil Olive, Citrus, Pistachio, Hazelnut, Dry Fig, Table Grape, Raisin Grape, Tea.
(8) *FODDER CROPS*: Cow vetch, Wild vetch, Alfalfa, Sainfoin.
(9) *LIVESTOCK AND POULTRY PRODUCTS*: Beef and Veal, Mutton and Lamb, Goat Meat, Poultry Meat, Cow Milk, Sheep Milk, Goat milk, Egg, Cow hide, Sheep Hide, Goat Hide, Wool, Hair.

Each production activity defines a yield per hectare for crop production, and a yield per head for livestock and poultry production. Crop production activities use fixed proportion of labor, tractor power, fertilizers, and seeds or seedlings. The livestock and poultry activities are defined in terms of dry energy requirements. The input-output structure used in the production of the model is sketched in Figure 8.

Crop production activities are divided into three categories: crop yield for human consumption, crop yield for animal consumption and crop by-product yield[38] for feed. Five groups of input are incorporated for the crop production. These include land, labor, tractor power, fertilizer and seed. Land is classified into four classes: (1) Dry and (2) Irrigated land for short cycle activities, (3) Tree land for long cycle activities, and (4) Pasture land includes range-land and meadow.

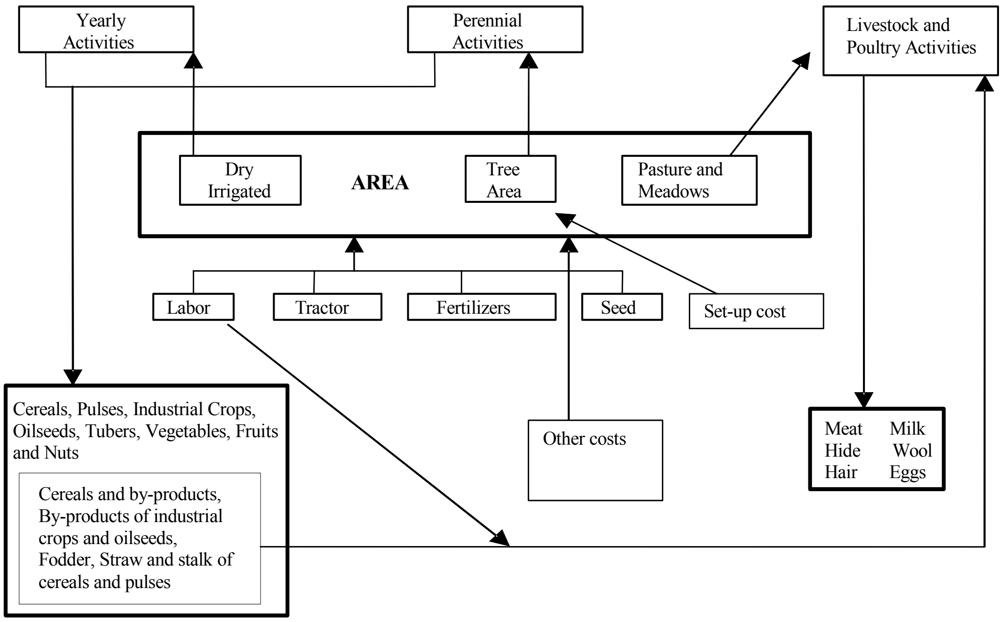

Figure 8 Input Output Structure in Production

Labor and tractor power requirements are specified quarterly. The labor input is measured in man-hour equivalents and shows actual time required on the field or per livestock unit. The tractor hours correspond to the usage of tractors in actual production and transportation related activities. Two types of fertilizers, namely nitrogen and phosphate, are measured in terms of nutrient contents. They are considered to be traded goods and are not restricted by any physical limit. The costs of labor, tractor and fertilizer, seed and seedlings (for

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[38] Forage, straw, milling by-products, oil seed, cotton and sugar beet processing by-products.

vegetables and tobacco) are included as production costs for annual crops. Fixed investment costs are assigned for perennial crops.

Livestock production is an integrated part of the model. In fact, it is difficult to incorporate livestock production in a static sector model because of its dynamic character. Static models, however, can throw light on a number of interesting questions related to the links with the production of feed crops and to alternative equilibrium states of the livestock sub-sector due to policy changes.

The feed supply is provided from the crop production sector, and disaggregated into six categories: (1) Direct or raw equivalent commercial feed consumption of cereals[39], (2-3) Two categories of processing by-products: milling by-products[40] and oil seed by-products[41], (4) Straw or stalk by-products from the crop production[42], (5) Fodder crops[43], and (6) Range land and meadow.

The model makes sure that the minimum feed composition requirements are fulfilled. The explicit production cost for animal husbandry is labor. The outputs of the livestock and poultry production activities are expressed in terms of kg/head. On the demand side, consumer behavior is regarded as price dependent, and thus market clearing commodity prices become endogenous to the model. Demand, supply and policy interactions at the national level are sketched in Figure 9.

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[39] Wheat, barley, corn, rye, oats, millet and spelt.

[40] Wheat, rice, sugar beet.

[41] Cotton, sunflower, groundnut, and soybean.

[42] Wheat, barley, corn, rye, oats, millet, spelt, rice, chickpea, dry bean, lentil.

[43] Alfalfa, cow vetch, wild vetch, and sainfoin.

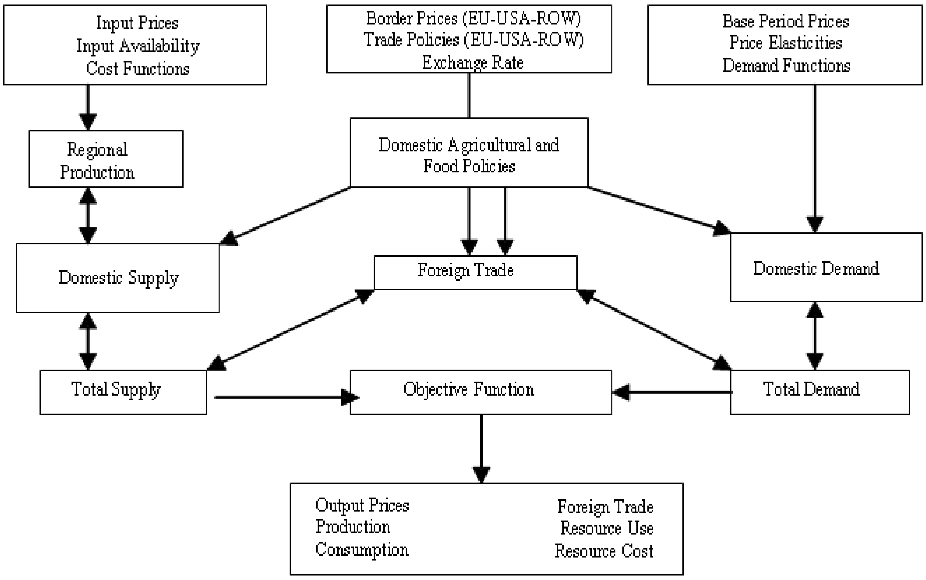


Figure 9 Demand and Supply Interaction

VI.A.2. Model Regions and Regional Structures

In order to explore the interregional comparative advantage in policy impact analysis the production side of the model is disaggregated into four regions: Coastal, Central, Eastern, and GAP Regions (Figure 10).

The Central Anatolia region consists of 23 provinces. It covers approximately 35 percent of Turkey, with a surface area of 27.5 million hectares (Table 10). It is the largest region defined in the model. In 2000, the total cultivated land in the region amounted to 12.2 million hectares, corresponding to 46 percent of total cultivated land in Turkey. Although the region has 35 percent of the irrigated land in Turkey, the agricultural production is highly dependent on rainfall since only one tenth of region's cultivated land is irrigated. According to the 2000 census, the region had 17 million inhabitants representing 25 percent of the total population.

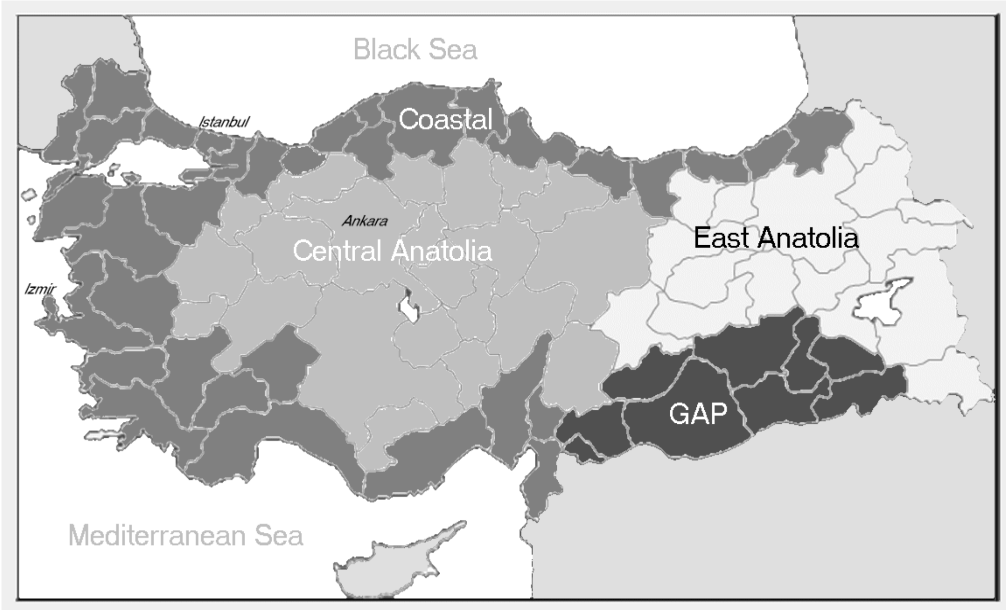


Figure 10 Regions in the Model

The Coastal region is formed by 33 provinces on the coastal line of Turkey. The Region with a surface area of 26.9 million hectares covers approximately 35 percent of the total area of Turkey. It is the second largest region in the model. The total cultivated land in the region adds up to 8.1 million hectares, representing 31 percent of total cultivated land in Turkey. The Region's share in irrigated area is 40 percent with 1.5 million hectares. The population of the Region reaches 38 million with a population density of 1.4 inhabitants per hectare (Table 11).

East Anatolia is the mountainous region of Turkey. The Region covers 20 percent of the surface area, but has only 11 percent of cultivated land. Apart from the other 3 regions in the model, it has also border with Georgia, Armenia, Iran and Iraq. The East Anatolia region has about 6.5 million inhabitants corresponding to 9 percent of the total population. It has the lowest population density with 0.4 inhabitants per hectare (Table 11).

Table 10 Regional Indicators

	Central Anatolia		Coastal Region		East Anatolia		GAP Region		Turkey
	Quantity	% [a]	Quantity	% [a]	Quantity	% [a]	Quantity	% [a]	Quantity
Total Population [1]	16,972,453	25	37,801,130	56	6,421,725	9	6,608,619	10	67,803,927
Surface Area (ha) [2]	27,462,800	35	26,935,700	35	15,558,700	20	7,535,800	10	77,493,000
Irrigated area (ha) [b,3]	1,287,416	35	1,475,244	40	631,304	17	267,264	7	3,661,228
Cultivated Land (ha) [c,4]	12,154,202	46	8,052,188	31	2,786,551	11	3,386,126	13	26,379,067
Field Crop Area (ha) [4]	11,566,230	50	5,897,149	26	2,648,615	11	2,920,698	13	23,032,692
Vegetable Land (ha) [4]	192,501	24	499,974	63	25,478	3	75,104	9	793,057
Fruit Land (ha) [4]	395,471	15	1,655,065	65	112,458	4	390,324	15	2,553,318

Notes: [a] share in Turkey, [b] does not include private irrigations, [c] sum of field crop area, vegetable and fruit lands.
Sources: Author's calculations from [1]Turkstat (2000b), [2]GCM (1999), [3]SHW (2003), [4]Turkstat (2000a).

The Southeastern Anatolia Project (GAP) region which consists of 9 provinces covering 7.5 million hectares accounts for 10 percent of the total land in Turkey. Its population was 6.6 million in 2000, which represents about 10 percent of the total population. The current irrigated land in the region is only about 0.3 million hectares (Table 10) corresponding to only 7 percent of total irrigated area of Turkey. However, the Southeastern Anatolia Project (GAP) is one of the largest integrated regional development projects in the world and upon completion of the project; it is planned that nearly 1.8 million hectares of land will be irrigated. In addition to the construction of irrigation infrastructure, the project includes further development in power production, mining, education, health, tourism, communication, transportation and manufacturing sectors.

The *share of population living in the villages* is 35 percent in Turkey (Table 11). In this respect, all regions except Coastal zone are above Turkey's average. A similar pattern is seen in terms of *percentage of households engaged in agriculture to total households*; this indicator takes its lowest value (60.2 percent) in the Coastal region, which is the only region below Turkey' average, and its highest value (75.1 percent) is reported for East Anatolia. Furthermore, the *average village population* is highest in the Coastal region and lowest in East Anatolia. Coastal region is relatively more urban with more populated villages and the East Anatolia Region is just the opposite.

Table 11 Structures and Means of Production

INDICATORS	Central	Coastal	Eastern	GAP	TURKEY
Population Density (Inhabitant per ha) [1,2]	0.62	1.4	0.41	0.88	0.87
Village Population/Total Population (%) [1]	36.6	31.9	47.4	37.3	35.1
Average Village Population [1]	631	834	467	579	678
Households engaged in agriculture/Total Households (%) [5]	72.7	60.2	75.1	74.7	66.4
Field crop area per inhabitant (ha) [4]	0.68	0.12	0.41	0.44	0.34
Field crop area per household engaged in agriculture (ha) [4,5]	9.9	2.3	5.5	9.4	5.6
Field crop area per agricultural worker (ha) [4,5]	2.8	0.7	1.6	2.7	1.6
Irrigated land/Field crop area (%) [3,4]	11.1	25.0	23.8	9.2	15.9
Field crop area per tractor (ha/tractor) [4]	32.8	12.3	51.1	61.5	24.5
Fertilizers per cultivated land (kg/ha) [4]	64.2	207.7	31.7	63.2	77.7

Sources: Author's calculations from [1]Turkstat (2000b), [2]GCM (1999), [3]SHW (2003), [4]Turkstat (2000a), and [5]Turkstat (2001).

Field crop area per inhabitant in Central Anatolia is 0.68 hectare which is exactly twice the overall average. The same figure reaches its lowest value in the Coastal region with only 0.12 hectare per head. Furthermore, *field crop area per household engaged in agriculture* is highest in Central Region with 9.9 hectare and smallest in Coastal region with 2.3 hectare per agricultural household (Table 11).

While *the share of irrigated land in total field crop area* is highest in the Coastal region with 25.02 percent, this indicator takes its lowest value (9.2 percent) in the GAP region. However, as it is stated above, upon the completion of Southeastern Anatolia Project, GAP region is expected to register the highest regional share (probably over 50 percent). Central Anatolia region with 11.1 percent also falls behind Turkey's average (15.9 percent).

Field crop area per tractor takes the lowest value in the Coastal zone representing region's relative intensity in terms of tractor use compared to the other regions. Coastal zone's field crop area per tractor is about one half of Turkey's average.

Fertilizer use per[44] *cultivated land* in Coastal region is about three fold of Turkey's average (77.7 kg/ha) with 207.7 kilogram per hectare. This figure is lowest in East Anatolia with only 31.7 kilogram per hectare. In Central Anatolia and GAP regions, this figure is 64.2 and 63.2 kilogram per hectare, respectively. All regions, except Coastal zone, are below Turkey's average in terms of fertilizer use per hectare.

Table 12 reports the ranking of agricultural products in terms of cultivated land according to the regions of our model. Soft wheat production dominates in all regions. The second widespread product is barley and is followed by durum wheat in cereals. Cotton, corn and chick peas are also leading agricultural products of Turkey. Other regional principal products are; sunflower and hazelnut in Coastal region; sugar beet and potatoes in Central Anatolia; apricot, sugar beet and dry been in East Anatolia; lentil, pistachio and grape (table grape) in the GAP region.

Table 12 Ranking of Agricultural Products in Terms of Cultivated Land

Rank	Coastal	Central	Eastern	GAP	Turkey
1	Common Wheat	Common Wheat	Common wheat	Common wheat	Common wheat
2	Corn	Barley	Barley	Barley	Barley
3	Barley	Durum wheat	Apricot	Cotton	Durum wheat
4	Sunflower	Chick pea	Sugar beet	Lentil	Cotton
5	Cotton	Sugar beet	Chick pea	Pistachio	Corn
6	Hazelnut	Potatoes	Dry bean	Grape (Table)	Chick pea

Source: Author's calculations from Turkstat (2005)

[44] *Nutrient based* sum over: 21 % Nitrogenous, 16 % Phosphorous, 48 % Potash.

VI.A.3. Data sources

The data set used in the model can be divided into two main groups. These are; (1) micro level data for production coefficients which form the core of the model, and (2) regional and national data for production, prices, trade, consumption etc.

The data sources are Turkish Statistical Institute (Turkstat)[45], State Planning Organization (SPO), Agricultural Economics Research Institute (AERI), Undersecretary of Foreign Trade (UFT), Food and Agricultural Organization of UN (FAO), and the World Bank. The data from AERI (2005) is used to complement the livestock production data. The input and output coefficients of production are calculated from Koral and Artun (2000) and AERI (2001). All the data obtained from various sources is processed and combined as a unique consistent data set.

The main data categories can be stated as follows: regional production, regional areas, regional number of animals for each type of activity, domestic farm-gate prices, export and imports quantities, export and import prices, import tariffs and export subsidies, income and price elasticities, regional resource availabilities, prices of inputs, annualized investment costs for perennial crops, exchange rate, input-output coefficients for the crop and livestock activities, nutrient content of the crops and crop by products.

In the model, trade is included as raw and raw equivalent form. Therefore the preparation of trade data requires further emphasis and data processing. The trade of processed products is converted into raw equivalents. This conversion is necessary to balance the commodity balance accounting. For example, if there are exports of macaroni, sufficient quantities of durum wheat should be

[45] Formerly known as State Institute of Statistics (SIS)

used to produce the macaroni that is exported. This will, in turn, decrease the availability of durum wheat to the country. Hence, the macaroni exports should be converted to its durum wheat equivalents in order to reflect the decrease in the durum wheat availability for domestic consumption due to the exportation of macaroni.

In order to convert the trade of processed products to raw equivalent quantities, the *technical conversion factors* from Turkstat (2003a) and FAO (2005b) are used. The technical conversion factors give the amount of raw material used in the production of one unit of processed product. They express the percentage of the input (raw material) retained after the processing operation has been carried out. The raw equivalent import and export quantities are calculated using the 12 digit Harmonized System trade data for averages between 2002 and 2004.

VI.B. CALIBRATION OF THE MODEL

TAGRIS is a partial equilibrium agricultural sector model with endogenous prices. Its partiality stems from the fact that it considers the income formation and factor use within the agricultural sector. The objective function of the model is given by the *Marshallian* surplus (sum of consumers' and producers' surplus). The calibration of demand follows an elasticity based approach. The calibration of supply follows Heckelei and Britz (1999 and 2000) and uses a *Maximum Entropy* integrated PMP method. Model is written in GAMS (Brooke et al, 1998) and solved using the non-linear programming solver *CONOPT 3*. The GAMS Program Code of the model is provided in Appendix, A4.

Demand and supply calibration methodologies of the model are presented in the following two sub-sections.

VI.B.1. Calibration of Demand

Assume that the demand function has the following simple linear form:

$$p_d = a - b.q_d \tag{123}$$

Recall that the demand elasticity is given by

$$\eta_d = \frac{\partial q / q}{\partial p / p} = \frac{\partial q}{\partial p}\frac{p}{q} \tag{124}$$

Hence, if the elasticity of demand and base period equilibrium quantity and prices are known, then the slope of the demand curve can be obtained. Denote the elasticity of demand by $\overline{\eta}$, and the base period equilibrium quantities and prices by $\overline{q}$ and $\overline{p}$, respectively; the Equation (124) can then be rewritten as follows:

$$\overline{\eta} = \frac{\partial q}{\partial p}\frac{\overline{p}}{\overline{q}} = \frac{1}{b}\frac{\overline{p}}{\overline{q}} \tag{125}$$

which yields

$$b^* = \frac{1}{\overline{\eta}}\frac{\overline{p}}{\overline{q}} \tag{126}$$

and the corresponding intercept term is $a^* = \overline{p} - b^*\overline{q}$. The resulting calibrated demand curve which will give a price of $\overline{p}$ at the quantity of $\overline{q}$ and a point elasticity of $\overline{\eta}$ has the following form:

$$p_d = a^* - b^* . q_d \tag{127}$$

This is the most popular demand calibration methodology used in the optimization based price endogenous partial equilibrium agricultural sector models. For further details see Hazel and Norton (1986, p.176) and McCarl and Spreen (2005, Chapter 13, pp.16-18).

This formulation of demand takes into account only the own-price effects. The cross price effects are ignored. To include the cross-price effects in the demand function, the inverse of the original demand functions should exist. This requirement is known as the *integrability condition.* Zusman (1969) illustrated that a solution is possible only if *symmetry* of the demand functions is assumed, that is, only if the *matrix of cross price terms is symmetric* (Hazel and Norton, 1986, p.168). This is a strong requirement in terms of demand theory since, as McCarl and Spreen (2005, Chapter 13, pp.16-17) rightly pointed out, the Slutsky decomposition reveals that for the demand functions, the cross price derivatives consist of a symmetric substitution effect and income effect. Hence the integrability condition (symmetry of cross price effects) requires that the income effect to be identical across all pairs of products or to be zero.

McCarl and Spreen (2005, Chapter 13, p.17) state that there are mainly two solutions to handle the asymmetry of the cross-price effects of demand function. First, one can formulate the model in such a way that both price and quantity equilibrium conditions are imposed on the primal problem (Plessner and Heady, 1965). Second, one can use the *linear complementarity programming* instead of quadratic programming (Takayama and Judge, 1971). However, in this case the objective function no longer represents the Marshallian surplus. Besides, to our knowledge, there is no application of PMP methodology using these algorithms, at least in the big scale models like TAGRIS, in the literature. Our preliminary trials show that the solution burden of the model increases drastically if the asymmetric cross-price effects are imposed for about 50 products. In addition, the symmetry assumption of cross-price effects in the demand function imposes severe restrictions on cross-price responses of the model without any empirical justification. Hence we have preferred to use simple linear demand functions and calibrate them with the methodology based on own-price elasticities.

VI.B.2. Calibration of Supply

For the presentation of calibration of domestic supply, let us write the simplified first step (discussed in section V.B) version of the model:

$$\text{Max } Z = \mathbf{Q}'\mathbf{\Theta} - \frac{1}{2}\mathbf{Q}'\mathbf{\Psi}\mathbf{Q} - \mathbf{P^m M} + \mathbf{P^x X} - \mathbf{c}'\mathbf{q} \qquad (128)$$

$$\mathbf{Q} \le \mathbf{q} + \mathbf{M} - \mathbf{X} \qquad \text{(Commodity balance)} \qquad (129)$$

$$\mathbf{Aq} \le \mathbf{b} \qquad \text{(Resource constraint)} \qquad (130)$$

$$\mathbf{Iq} = \bar{\mathbf{q}} + \varepsilon \qquad \text{(Calibration constraint)} \quad [\boldsymbol{\lambda}] \qquad (131)$$

$$\mathbf{q} \ge \mathbf{0} \qquad \text{(Non negativity constraint)} \qquad (132)$$

where Z is the objective function, $\mathbf{Q}$ is the matrix of quantities consumed, $\mathbf{\Theta}$ is the matrix of demand intercepts, $\mathbf{\Psi}$ is the matrix of demand slopes, $\mathbf{c}$ is the matrix of all observed variable costs, $\mathbf{q}$ is the matrix of production activities, $\mathbf{P^m}$ is the matrix of import prices, $\mathbf{M}$ is the matrix of activity import levels, $\mathbf{P^x}$ is the matrix of export prices, $\mathbf{X}$ is the matrix of activity export levels, $\mathbf{A}$ is the matrix of input-output coefficients, $\mathbf{b}$ is the right hand side of resource equations, $\bar{\mathbf{q}}$ is the matrix of base period levels of the production activities, $\boldsymbol{\lambda}$ are the dual values of calibration constraints, and ε is the perturbation factor to prevent degenerate solution.

The dual values of the calibration constraints provide the missing information about the marginal costs of activities. Assume the following form for the total variable cost function:

$$\mathbf{TVC} = \mathbf{d}'\mathbf{q} + \frac{1}{2}\mathbf{q}'\mathbf{T}\mathbf{q} \tag{133}$$

which implies the following marginal cost function:

$$\mathbf{MC} = \mathbf{d} + \mathbf{T}\mathbf{q} \tag{134}$$

where **d** is a vector of parameters associated with the linear term and, **T** is a symmetric positive definite matrix and **q** is a (Nx1) vector of activity levels.

In the PMP methodology, the marginal cost of production should be equal to the sum of observed variable cost (**c**) plus dual values (λ) associated with the calibration constraints (131) at the observed base period activity levels. So, we have $\mathbf{MC} = \mathbf{d} + \mathbf{T}\overline{\mathbf{q}} = \mathbf{c} + \boldsymbol{\lambda}$. In order to estimate the parameters of **d** and **T** matrices, following Heckelei and Britz (1999 and 2000), cross section maximum entropy estimation method (see section V.C.2) is applied to obtain

$$\mathbf{MC}_r = \mathbf{d}_r + \mathbf{T}_r\overline{\mathbf{q}}_r \;\; \forall\, r, \tag{135}$$

$$\mathbf{T}_r = (cpi_r)^g \mathbf{S}_r \mathbf{B} \mathbf{S}_r^{/} \;\; \forall\, r, \tag{136}$$

where $\mathbf{d}_r$ is the matrix of linear cost function parameters in region *r*, $\mathbf{T}_r$ represents the matrix of quadratic cost term parameters in region *r*, cpi_r is the crop profitability index, $\mathbf{S}_r$ is the scaling matrices for region *r*, $\mathbf{B}$ is the parameter matrix to be estimated by maximum entropy and *g* is the exponent of the crop profitability index to be estimated by maximum entropy.

Thus, the cost functions are obtained from the production decisions of the producers in the base period. In the second step, the cost functions are incorporated into the model and calibration constraints (131) are removed. Then the final form of the model is obtained:

$$\text{Max } Z = \mathbf{Q}'\mathbf{\Theta} - \frac{1}{2}\mathbf{Q}'\mathbf{\Psi}\mathbf{Q} - \mathbf{P}^{\mathbf{m}}\mathbf{M} + \mathbf{P}^{\mathbf{x}}\mathbf{X} - (\mathbf{d}'\mathbf{q} + \frac{1}{2}\mathbf{q}'\mathbf{T}\mathbf{q}) \quad (137)$$

$$\mathbf{Q} \leq \mathbf{q} + \mathbf{M} - \mathbf{X} \quad \text{(Commodity balance)} \quad (138)$$

$$\mathbf{A}\mathbf{q} \leq \mathbf{b} \quad \text{(Resource constraint)} \quad (139)$$

$$\mathbf{q} \geq \mathbf{0} \quad \text{(Non negativity constraint)} \quad (140)$$

The final model is consistent with economic theory and it replicates the base year production and prices without the calibration constraints.

Usually, in optimization based agricultural sector models, exports of certain products may decline or expand drastically as a result of changes in border prices. However, drastic changes in exports necessitate accompanied changes in their costs, usually related to the changes in marketing and transportation costs. Hazel and Norton (1986, p.263) remark that, marketing costs are roughly similar for exports and domestic products, and if the exports are at the producer-level commodity balances, those costs would not be taken into account. Hence incremental costs for export should be included in the objective function in this case.

To overcome this difficulty, the PMP approach has been used both to calibrate the exports and to estimate these incremental costs. Export supply elasticities are used for the PMP calibration of the model. The export supply elasticities are taken as unity following Aydın *et al* (2004). After carrying out the export supply calibration, the model in (137)-(140) can be rewritten as:

$$\text{Max } Z = \mathbf{Q}'\mathbf{\Theta} - \frac{1}{2}\mathbf{Q}'\mathbf{\Psi}\mathbf{Q} - \mathbf{P}^{\mathbf{m}}\mathbf{M} + \mathbf{P}^{\mathbf{x}}\mathbf{X} - (\mathbf{d}'\mathbf{q} + \frac{1}{2}\mathbf{q}'\mathbf{T}\mathbf{q}) \quad (141)$$

$$\mathbf{Q} \leq \mathbf{q} + \mathbf{M} - \mathbf{X} \quad \text{(Commodity balance)} \quad (142)$$

$$\mathbf{A}\mathbf{q} \leq \mathbf{b} \quad \text{(Resource constraint)} \quad (143)$$

$$\mathbf{X} = \overline{\mathbf{X}} + \varepsilon \quad \text{(Calibration constraint)} \quad [\boldsymbol{\delta}] \quad (144)$$

$$\mathbf{q}, \mathbf{X} \geq \mathbf{0} \quad \text{(Non negativity constraint)} \quad (145)$$

where $\bar{\mathbf{X}}$ is the observed base period export level for activities and $\boldsymbol{\delta}$ are the dual values of calibration constraints. As in the calibration of domestic production, the dual values of the calibration constraints provide the missing information about the marginal costs of exports. Hence, the intercept and slope terms of the marginal cost functions of exports are estimated by using the prevailing export pattern in the base period.

The slope terms are dependent on the gross revenue and the export levels:

$$\Omega_k = -\frac{1}{\bar{\gamma}_k}\frac{\bar{P}_k^X}{\bar{X}_k} \tag{146}$$

where k denotes the commodity, Ω_k is the slope term of export supply function, $\bar{\gamma}_k$ represents the supply elasticity, $\bar{P}_k^X$ is the observed export price of product k at base period, $\bar{X}_k$ is the observed export level of the product k.

The intercept terms are found by using the dual values of the calibration constraints and the slope terms are found as follows:

$$\Phi_k = -\delta_k - \Omega_k \bar{X}_k \tag{147}$$

where Φ_k is the intercept term of the export supply function, and δ_k denotes the dual value of the calibration constraint in (144).

Hence, the export cost functions are obtained taking into account the export performance of the sectors in the base period. In the second step, as in the case of the calibration of domestic supply, the cost functions are incorporated in the model and calibration constraints are removed. The general structure of the final model is as follows:

$$
\begin{aligned}
Max \quad Z = & \mathbf{Q}'\mathbf{\Theta} - \frac{1}{2}\mathbf{Q}'\mathbf{\Psi}\mathbf{Q} - \mathbf{P}^{\mathbf{m}}\mathbf{M} + \mathbf{P}^{\mathbf{x}}\mathbf{X} \\
& - (\mathbf{d}'\mathbf{q} + \frac{1}{2}\mathbf{q}'\mathbf{T}\mathbf{q}) + (\mathbf{\Omega}'\mathbf{X} + \frac{1}{2}\mathbf{X}'\mathbf{\Phi}\mathbf{X})
\end{aligned} \tag{148}
$$

$$\mathbf{Q} \le \mathbf{q} + \mathbf{M} - \mathbf{X} \qquad \text{(Commodity balance)} \tag{149}$$

$$\mathbf{Aq} \le \mathbf{b} \qquad \text{(Resource constraint)} \tag{150}$$

$$\mathbf{q}, \mathbf{X} \ge \mathbf{0} \qquad \text{(Non negativity constraint)} \tag{151}$$

where $\mathbf{\Omega}$ is the matrix of export supply intercepts, and $\mathbf{\Phi}$ is the matrix of export supply slopes. As before, the model is consistent with microeconomic theory and it exactly replicates the base year export levels without calibration constraints.

VI.C. GME ESTIMATES FOR PRODUCT YIELDS IN 2015

In order to obtain healthier simulation results for the projected year of 2015, the model incorporates the yield growth estimates for the products covered in the model.

A special two-stage procedure has been used to estimate the annual growth of product yields. The estimation process is a *hybrid* procedure, combining OLS and GME estimations. OLS is a pure *frequentist* approach and hence, there is no room for the use of any *a priori* information in the OLS estimation. For small sample sizes OLS is the best linear unbiased estimator (BLUE) and for large sample sizes the estimator is *consistent* and *asymptotically efficient* (Greene, 1997, p.271-278). On the other hand, GME estimator uses *a priori* information in the estimation process. In addition, Golan *et al* (1996, pp.117-123) report that GME performs better than OLS with small samples, particularly for sample sizes smaller than ten (Eruygur, 2005).

The process used in the estimation of the yield growth involves two steps. Long historical data from 1961 to 2005 about the yields of the products covered in the model are obtained from FAOSTAT (2006). Trend terms are estimated using OLS in the first stage.

The yields seem to be stagnated in the last decade in Turkey. Hence, the long-term trend is not expected to be valid in the next decade. It has been decided to use OLS estimates as the center points for the support spaces of GME estimation and use the data of last ten years. The main advantage of this procedure can be explained with an example. Suppose that Turkey's yields of commodity X decreases after 1995, but was growing at high rates prior to 1995. Hence, if the data after 1995 is used to estimate the growth with OLS, then, the estimation result will most likely illustrate very high decays in the yield levels of this commodity. The opposite may also be valid. It is not very plausible to estimate very high growths for yields of a product by only looking to the recent data since the historical data can show quite opposite trends. Thus, in order to get rid of exaggerated yield growth estimates, the two-step procedure has been preferred.

In both stages, the growths are estimated using the log-linearized exponential growth equation given below:

$$y_t = \beta_0 . e^{\beta_1 t + u_t} \tag{152}$$

where y_t denotes *yield*, t denotes *year*, and u_t is the *disturbance term*. The estimated regression coefficient, β_1, reports growth rates. Estimated annual growth rates are reported in Table 13.

Table 13 Annual Yield Growth Rate Estimates

	Yield Growth Rate, %	Prob. values
Common Wheat	0.69	0.011
Durum Wheat	0.69	0.011
Barley	0.81	0.015
Corn	0.78	0.016
Rice	1.56	0.010
Rye	0.90	0.019
Chick Pea	*-0.08*	0.010
Dry Bean	0.32	0.012
Lentil	0.78	0.015
Tobacco	*-0.44*	0.013
Sugarbeet	0.88	0.012
Cotton	1.77	0.016
Sesame	0.03	0.010
Sunflower	0.56	0.014
Groundnut	1.44	0.011
Soybean	0.00	-
Onion (dry)	0.94	0.015
Potato	1.05	0.010
Melon and Watermelon	0.29	0.012
Cucumber	0.62	0.018
Eggplant	0.10	0.014
Fresh Tomato	*-0.04*	0.011
Processing Tomato	*-0.04*	0.011
Green Pepper	0.60	0.010
Apple	0.32	0.011
Apricot	0.74	0.016
Peach	0.65	0.014
Table Olive	0.74	0.011
Oil Olive	0.74	0.011
Citrus	1.49	0.018
Pistachio	0.32	0.011
Hazelnut	0.79	0.012
Dry Fig	*-0.16*	0.010
Table Grape	0.56	0.018
Sultana Grape	0.56	0.018
Tea	1.10	0.022
Sheep Meat	0.22	0.020
Sheep Milk	1.29	0.022
Sheep Wool	0.00	-
Sheep Hide	0.00	-
Goat Meat	0.13	0.010
Goat Milk	0.34	0.010
Goat Hair	0.00	-
Goat Hide	0.00	-
Cow Meat	1.50	0.021
Cow Milk	1.78	0.010
Cow Hide	0.00	-
Poultry Meat	2.56	0.010
Hen Egg	3.27	0.010
Fodder (Vetche)	*-1.46*	0.011

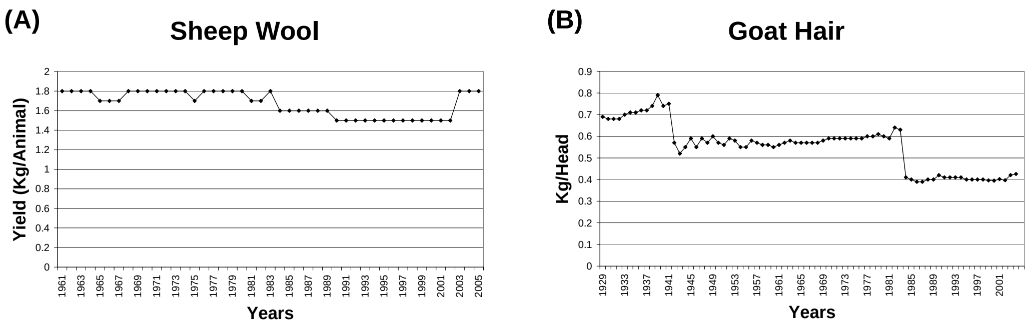
Notes: The figures in "Prob. values" column show the statistical significance levels of (pseudo[46]) t values of the corresponding GME estimates for annual growth rates. The estimations were done using Shazam© for Windows 10.0.
Source: Author's calculations from FAOSTAT (2006)

The data of the products in the shaded rows points out statistically significant per annum yield decays.

[46] See Mittelhammer *et al* (2002) for details.

Some special cases occurred after the estimation results were obtained. These were treated as exceptions after evaluating the estimation results together with the production levels. Soybean is one of them. Data showed a notable upward trend in soybean production yields of Turkey, particularly after 1980's. However, after 1987, there were considerable decreases both in the harvested soybean area and production. Hence the increases in the soybean yields were caused by the reallocation of the soybeans to the fertile lands and it seems that this caused a notable but misleading upward trend in the soybean yields. In addition, soybean is a commodity which has not been inserted in the crop rotation due to marketing difficulties of the farmers despite the efforts of policy makers. Soybean area and production are still very low compared to any crop production in Turkey. For this reason, no yield improvement has been imposed on soybean.

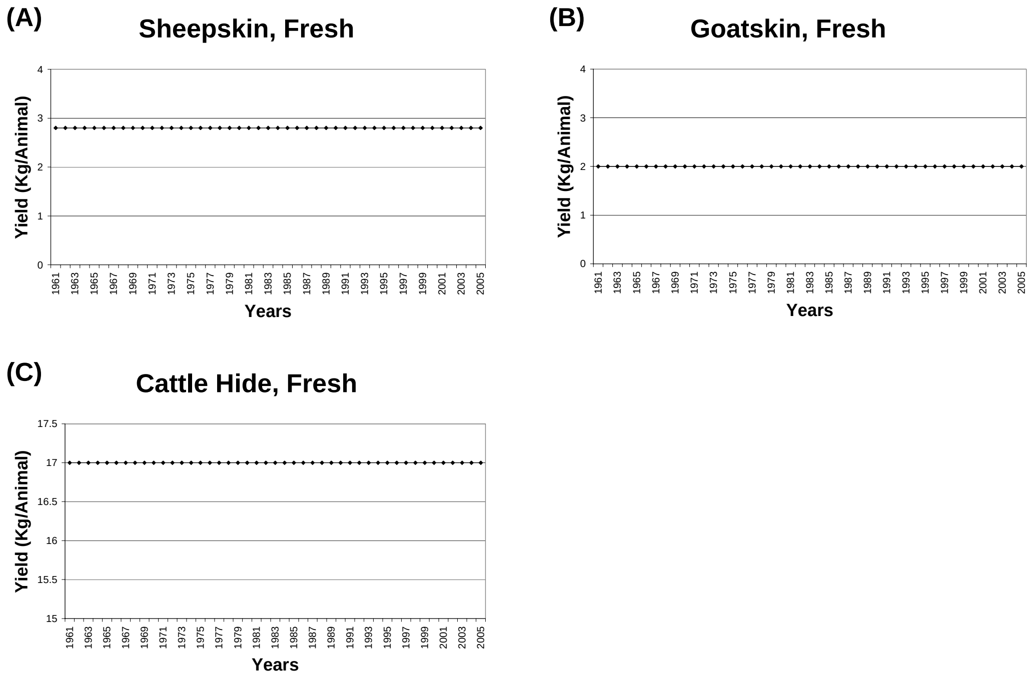
Taking into account the behaviors of sheep wool and goat hair series, we preferred not to assign any growth for the yields of these products.



Source: FAOSTAT (2006)

Figure 11 Sheep Wool and Goat Hair Yields

Finally, because there were no variation in sheep, goat and cow hides' yields statistical estimation was not needed and not applicable.



Source: FAOSTAT (2006)

Figure 12 Sheep, Goat and Cow Hide Yields

CHAPTER VII

SCENARIOS AND SIMULATIONS

Models are to be used, not believed.

Henri Theil (1971)
Principles of Econometrics, p. vi.

Using Turkish Agricultural Sector model, two sets of scenarios are defined and analyzed for their impacts in the year 2015. The first group is named as *Non-EU Scenarios*. This set includes two simulations. EU-OUT simulation describes non membership situation in which it is assumed that there will be no changes in the current agricultural and trade policies of Turkey until 2015. This is also the baseline simulation[47]. WTO simulation is the same as EU-OUT except that it assumes a 15 percent decrease in Turkey's binding WTO tariff commitments in 2015. The second group is *EU Scenarios*. This set includes three simulations. EU-CU simulation assumes that Turkey is not a member of EU but extends the current Customs Union agreement with the EU to

[47] The *baseline scenario* is a projection of the model to a predetermined period under the assumption that there is no change in the current agricultural policy. The baseline scenario incorporate plausible changes in exogenous parameters such as population, income, import and export prices, input prices, yields and resource endowments. The principal value of the baseline projection is that, apart from the base period, it provides an additional benchmark for the evaluation of the changing policy environment.

agricultural products. EU-IN1 simulation describes the situation that Turkey is a member of EU in 2015. The last simulation, EU-IN2, is the same as EU-IN1 simulation but the yield growths in EU-IN2 are higher than the other simulations.

The structure of scenarios can be *summarized* as follows:

(1) Non-EU Scenarios

a. EU-OUT (Baseline scenario)
b. WTO (15 % decrease in WTO binding tariff commitments of Turkey)

(2) EU Scenarios

a. EU-CU (Customs Union with the EU is extended to agricultural products)
b. EU-IN1 (Turkey is a member of EU)
c. EU-IN2 (Turkey is a member of EU, higher yield growth is assumed until 2015)

The *base period* of the model is the average of 2002, 2003 and 2004. Import tariffs, export subsidies and deficiency payments for crops reflect period averages.

The exogenous parameters of the model are projected to 2015 for all simulations. Turkish annual population growth rate is determined according to the FAOSTAT (2005) estimates and thereby a 1.4 percent annual population growth rate is imposed. GDP per capita series with 1987 prices from TCMB[48] are used to estimate per capita annual real GDP growth for Turkey. Using a simple trend regression, annual real GDP growth rate is estimated as 1.3 percent. Trade prices in 2015 are obtained from the estimates of FAPRI (2005) with the necessary FOB and CIF adjustments. It is assumed that irrigated area in the GAP region will increase by 150,000 ha and by 60,000 ha in the rest of

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[48] Central Bank of the Republic of Turkey (CBRT).

Turkey by 2015. The level and the coverage of deficiency payments in 2015 are assumed to be the same as in 2005. Area restrictions on tea, tobacco and hazelnut are assumed to remain unchanged. A Similar assumption is made for the quantity restriction on sugar beet production.

In order to reflect the technological improvements until 2015, the implied yield growths until 2015 by the *annual yield growth rate* estimates of section VI.C are applied. However, in all scenarios except for EU-IN2, we preferred to use more *conservative* estimates about the yield growths and therefore *half values* of the implied yield growths until 2015 are imposed. Only in EU-IN2, which is our *optimistic* scenario, estimated values of annual yield growth rates of section VI.C are used.

VII.A. NON-EU SCENARIOS

The first simulation (EU-OUT) reflects the *status quo.* The policy environment is the same as in 2005; however, the exogenous parameters on population, income, yields, border prices and quality of land are adjusted according to the estimates for 2015. The negotiations about the renewal of the WTO-Agreement of Agriculture are under way. The WTO simulation intends to evaluate the possible impact of tariff reduction in agricultural products on agriculture in Turkey. In this simulation, it is assumed that Turkey is not a member of the EU, since the commitments of Turkey will be consolidated to the EU, in case of membership by 2015. Before the WTO simulation, basic principles and functions of WTO will be reviewed. Uruguay Round Agreement on Agriculture and ongoing Doha Development Agenda Round will be briefly summarized.

VII.A.1. Baseline (2015) Simulation: EU-OUT

EU-OUT is designed as the *baseline* scenario for 2015 simulations. It, therefore, assumes no changes in policies. It only involves estimated changes in production yields, in world prices, total irrigated area, population and real per capita income growths. EU-OUT scenario is designed to give us the insights about *what would likely happen in Turkish agriculture until 2015* if there were no changes in the main polices.

The general results for baseline simulation are presented in Table 14. Total, producer and consumer surplus measures are the aggregate welfare measures used to evaluate the impact of various scenarios including baseline scenario. Producer surplus roughly indicates the return from all production factors excluding variables costs to producers. Consumer surplus, on the other hand, represents the additional benefits to non marginal consumers.

As can be seen from Table 14, the total surplus is expected to increase by 4.4 percent in 2015. More than half of the increase can be attributed to the growth in income and increase in the productivity. We observe 1.7 percent increase in producer surplus and 34.2 percent in consumer surplus in 2015.

The figures of production and consumption in Table 14 are calculated in two different ways: First with the 2002-2004 prices, and second with the model's prices. Both values are in US dollars and the impact of inflation is limited with the depreciation of the US dollars. The *volumes* calculated with *constant prices* correspond to changes in the quantities. The *values* are found by multiplying the model's prices with the corresponding quantities, and reflect the changes in both quantities and prices.

Table 14 General Results for Baseline Simulation (2015)

	2002-04	2015	
	BASE	EU-OUT	EU-OUT/BASE (%)
Total Surplus (Index)	**100.0**	**104.4**	**4.4**
Producers' Surplus	100.0	101.7	1.7
Consumers' Surplus	100.0	134.2	34.2
Total Production			
Volume [a]	33,997	40,406	18.9
Value	33,997	44,341	30.4
Direct Payments	-	-	
Crop Production			
Volume [a]	23,191	28,054	21.0
Value	23,191	29,275	26.2
Livestock Production			
Volume [a]	10,806	12,352	14.3
Value	10,806	15,066	39.4
Total Consumption			
Volume [a]	29,441	35,827	21.7
Value	29,441	39,055	32.7
Crop Consumption			
Volume [a]	18,368	23,082	25.7
Value	18,368	23,528	28.1
Livestock Consumption			
Volume [a]	11,073	12,745	15.1
Value	11,073	15,527	40.2
Net Exports	**2,264**	**2,860**	**26.3**
Crop Products	2,537	3,336	31.5
Livestock Products	-273	-476	74.4
Price Index (Laspeyres)	**100.0**	**109.9**	**9.9**
Crop Products	100.0	102.5	2.5
Livestock Products	100.0	122.2	22.2

Notes: See text for the scenario definitions.
[a] Model results at base period prices
Source: Author's calculations.

Both the volume and the value of agricultural production rise in 2015 (Table 14). Volume of total Turkish agricultural production increases by 18.9 percent while the increases in total crop, and livestock products are 21.0 and 14.3 percents, respectively. Increases in values are higher than increases in the volumes since the former reflects also the rise in product prices. Indeed, the total price index (Laspeyres) shows that there will be approximately a 10 percent rise in overall dollar price level. The main source of this price increase is 22.2 percent rise in the livestock & poultry product prices. The increase in the overall price level of crop products seems negligible (with only 2.5

percent). The main reason of the high increase in the overall price level of livestock & poultry sector is that the shift in demand that happens due to the real per capita income and population growth could not be compensated by a corresponding expansion in supply. Since the tariff rates of Turkey for these products are notably high, the increase in demand can not be satisfied by imports as well, and consequently domestic prices tend to move up significantly.

The livestock & poultry product consumption volume increases by 15.1 percent, but the consumption volume of crop products moves up by 25.7 percent. All these result in a 21.7 percent expansion in total consumption.

There is deterioration in the net trade position of Turkey in livestock and poultry products, but the improvement in the net trade position in crop products increases the total net exports of Turkey from USD 2,264 million to USD 2,860 million in 2015. Net exports of crop products soar to USD 3,336 million from USD 2,537 million. The net imports of Turkey in livestock & poultry products increase by 74.4 percent and reach to USD 476 million from USD 273 million. The imports of hides, wool and hair are the major sources of the expansion in the net livestock and poultry product imports of Turkey (See Table 18).

Table 15 reports the changes in production volumes by main product groups. According to the EU-OUT simulation the highest increase in production volume is observed in vegetables with 29.5 percent. The second highest increase is observed in oilseeds. This mainly results from considerable increase in the volume of sunflower and groundnut production at about 35 percent (Table A3.A.1. in the Appendix). However, sesame and soybean production volumes decline by 18.1 and 48.7 percents, respectively. Third highest increase is observed in tubers with 27.2 percent. Onion (dry) and potato constitute this category and their production volumes increase by 31.0 and 25.7 percents, respectively. Pulses and Fruits & Nuts rank as fourth and fifth in terms of increase in production volumes. Among the groups of crop products, the lowest increases in production volume are observed in industrial crops and cereals. However, contrary to cereals, value of industrial crop production goes up by 42.2 percent because of the corresponding high price increases in this sector (Table 16). Although the production volume of cereals moves up by only 13.8 percent, production volume of rice expands by 35.9 percent and this is the highest figure within all products covered in our model (Table A3.A.1. in Appendix). The lowest increase in production volume among the product groups is seen in Hide, Wool and Hair sector with 2.9 percent. The highest increase in production volume among the livestock & poultry sectors is observed in poultry sector by 18.6 percent and then milk sector comes with 17.5 percent. Meat sector experiences a 10.5 percent increase in its volume of production. Overall, Table 15 shows that total production volume of Turkish agricultural sector will increase by about 19 percent in 2015.

Table 15 Production Volumes for Baseline Simulation (USD million at 2002-04 prices)

	BASE	EU-OUT	% CHANGE
	2002-04	2015	EU-OUT/BASE
CROP PRODUCTS	***23,191***	***28,054***	***21.0***
CEREALS	6,509	7,408	13.8
PULSES	942	1,170	24.2
INDUSTRIAL CROPS	2,370	2,686	13.4
OILSEEDS	558	722	29.3
TUBERS	1,511	1,921	27.2
VEGETABLES	4,854	6,287	29.5
FRUITS AND NUTS	6,448	7,859	21.9
LIVESTOCK & POUL.	***10,806***	***12,352***	***14.3***
MEAT	4,777	5,281	10.5
MILK	3,482	4,091	17.5
HIDE, WOOL & HAIR	249	256	2.9
POULTRY	2,297	2,724	18.6
TOTAL	***33,997***	***40,406***	***18.9***

Note: See text for the scenario definitions.
Source: Author's calculations.

Table 16 reports the changes in production values by main product groups. The first striking point is the high increase in the values of livestock & poultry products due to the remarkable rise in their prices. The value of total livestock and poultry products increases by 39.4 percent although the increase in volume is only 14.3 percent as we stated above. The expansion in the value of crop products is 26.2 percent since the increase in their prices are moderate compared to livestock and poultry products. Overall, the value of total Turkish agricultural products moves up by 30 percent although the increase in volume is estimated only as 19 percent. Table 16 shows that, in 2015, the total value of Turkish agricultural production will expand to USD 44,341 million from USD 33,997 million. The increase of about USD 4,000 million will come from the rise in the price level.

Table 17 shows the price indices for main product groups. The price levels of oilseeds, tubers and vegetables are expected to decrease by 6.8, 9.3 and 0.8 percents, respectively. There is a slight rise in the overall price level of crop products at around 2.5 percent.

Table 16 Value of Production for Baseline Simulation (USD million)

	BASE	EU-OUT	% CHANGE
	2002-04	2015	EU-OUT/BASE
CROP PRODUCTS	***23,191***	***29,275***	***26.2***
CEREALS	6,509	7,576	16.4
PULSES	942	1,215	29.1
INDUSTRIAL CROPS	2,370	3,370	42.2
OILSEEDS	558	699	25.2
TUBERS	1,511	1,743	15.4
VEGETABLES	4,854	6,237	28.5
FRUITS AND NUTS	6,448	8,436	30.8
LIVESTOCK & POUL.	***10,806***	***15,066***	***39.4***
MEAT	4,777	6,650	39.2
MILK	3,482	4,918	41.2
HIDE, WOOL & HAIR	249	300	20.5
POULTRY	2,297	3,198	39.2
TOTAL	***33,997***	***44,341***	***30.4***

Note: See text for the scenario definitions.
Source: Author's calculations.

The highest price increase within the category of crop products is seen in industrial products. Tobacco prices will go up by 37.6 percent since its supply curve shifts inward due to the decline in yields (see Table 13) whereas its demand curve shifts rightward with the expansion in population and per capita real income. Cotton prices go up by 35.3 percent because of the high expansion in its net exports. The lowest price increase is observed in cereals with 1.1 percent and then pulses come with 4.0 percent. The highest decline in price level is seen in rice prices by 14.0 percent. There is a 22.2 percent expansion in the price level of livestock & poultry products group, which is considerably high, compared to the crop products category.

Table 17 reports that the highest price increase within livestock & poultry products category will likely be experienced in the meat group with 26 percent. Second highest rise can happen in milk group with about 20 percent. Prices of both the poultry products and the hide, wool and hair products rise by 17.4 percent. Table A3.A.4 given in Appendix shows that sheep and goat meat prices will increase by 35.0 and 36.6 percents respectively. The reason is that there is almost no growth in the yields of sheep and goat meat productions since 1988. Our model, taking into account these low yield growth performances, reports high price increases for these products. The producer price of sheep meat is already high in Turkey. According to 2002 figures (FAOSTAT), Turkey's sheep meat price is 2.5 fold of New Zealand, which is the biggest sheep meat exporter of the world with a 40.7 percent share in total world exports (FAOSTAT, 2002-2004 averages). However, New Zealand's yield is only 13.3 percent higher than Turkey. Hence, apart from yields, there should be other factors increasing the prices of sheep meat in our country.

Table 17 Price Indices for Baseline Simulation (USD/Ton)

BASE=100	EU-OUT	% CHANGE
	2015	EU-OUT/BASE
CROP PRODUCTS	***102.5***	***2.5***
CEREALS	101.1	1.1
PULSES	104.0	4.0
INDUSTRIAL CROPS	121.2	21.2
OILSEEDS	93.2	-6.8
TUBERS	90.7	-9.3
VEGETABLES	99.2	-0.8
FRUITS AND NUTS	107.5	7.5
LIVESTOCK & POUL.	***122.2***	***22.2***
MEAT	126.4	26.4
MILK	120.3	20.3
HIDE, WOOL & HAIR	117.4	17.4
POULTRY	117.4	17.4
TOTAL	***109.9***	***9.9***

Note: See text for the scenario definitions.
Source: Author's calculations.

Here, of course the quality of the product in question is also important and can change the entire picture. For example, Spain's sheep meat production yield (FAOSTAT, 2002-2004 average) is well below that of Turkey and its sheep meat producer price (FAOSTAT, 2002 figure) is about 17 percent higher. Spain is the sixth biggest sheep meat importer of the world with a 2.3 percent share in total world imports but Turkey ranks sixty-fourth in the same list (FAOSTAT, 2002-2004 average). This highlights the importance of product quality. According to the model simulation, the lowest price increase within meat group is seen in Cow meat (beef and veal). This is, in fact, the reflection of a relatively good yield performance in beef and veal production (Table 13). Figures show that beef and veal yield growth performance is relatively better than that of sheep and goat meat, but unfortunately this is not enough since Turkey significantly lagged behind the world in terms of production yields. According to 2002-2004 averages, Turkey is below the world average (198 kg/head) with 182 kg per head (FAOSTAT). Turkey's cow meat production yield is 60 percent of Germany (307 kg/head).

The second highest price increase within livestock & poultry product category is seen in milk group with about 20 percent. The increase in the price of cow milk is relatively lower compared to sheep and goat milk. This is plausible since almost no change had been observed in the yield of sheep and goat milk production between 1961 and 2002. Fortunately, in the last three years (after 2002) there are upward movements in the yields of these products. In cow milk yield, on the other hand, there is a gradual improvement after 1989. According to 2002-2004 averages (FAOSTAT), the cow milk yield of Germany, which is the biggest cow milk exporter of the world with 36.1 percent share, is 3.5 fold of Turkey's cow milk yield. The goat milk yield of France is about 7.7 fold of that of Turkey. The sheep milk production yields of France and Spain are about 3.1 fold of Turkish sheep milk production yield. All these numbers are considerably high and point out that Turkey should improve the production technologies of these products even though the production environment in Turkey provides relatively lower stimulus for livestock production. In this framework, if there can be no improvement in these technologies; EU-OUT simulation points out remarkable price increases for these products in 2015 (Table A3.A.4 in Appendix).

Table 18 shows the effects of EU-OUT simulation on net exports. Under "status quo", the net exports in *crop products* are expected to record a 32 percent increase in 2015, from USD 2,537 million to USD 3,336 million. Posting the largest percentage growth seems to be *tuber crops* (dry onion and potato), with 50 percent, and *vegetables*, with 45 percent. Table 18 reports that the net exports of *fruits & nuts* by reaching to USD 2,672 million from USD 2,064 million increase around 29 percent.

Table 18 Net Exports for Baseline Simulation (USD million)

	2002-04	EU-OUT (2015)				% CHANGE
	TOTAL	USA	EU	ROW	TOTAL	EU-OUT/BASE
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***31.5***
CEREALS	-240	-233	-81	-8.0	-322	34.2
PULSES	190	1.4	45	190	237	24.4
INDUSTRIAL CROPS	615	69	551	103	724	17.6
OILSEEDS	-747	-632	2.9	-293	-922	23.4
TUBERS	55	0.0	4.1	79	83	49.7
VEGETABLES	598	59	354	451	864	44.5
FRUITS AND NUTS	2064	132	1734	807	2672	29.4
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***74.4***
MEAT	11	0.0	0.0	1.8	2	-84.4
MILK	-14	0.5	0.5	20	21	-252.8
HIDE, WOOL & HAIR	-290	7.0	-250	-275	-517	78.6
POULTRY	19	0.0	0.0	19	19	-0.4
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***26.3***

Note: See text for the scenario definitions.
Source: Author's calculations.

On the other hand, the net imports of *cereals* move up by 34 percent and increase to USD 322 million from USD 240 million. *Oilseed* net imports expand approximately by 23 percent and reach to USD 922 million from USD 747 million. Net imports of livestock products rise by 74 percent, thereby expanding from USD 273 million in base period to USD 476 million in 2015. The main source of this expansion is *hide, wool and hair* products that post a

79 percent expansion in their net imports rising to USD 517 million from USD 290 million. This expansion is reasonable since for about 45 years the yield improvement in these products was rather minimal. Increasing demand, due to the growths in real per capita income and population, coupled with non-growing yields produces notable expansions in net imports of *hide, wool and hair* products (around 79 percent).

Net sheep meat export shrinks from USD 9 million to USD 1 million (Table A3.A.5 in appendix) and the net cow meat exports almost disappear. Regarding milk, it seems that the recent upward trend in cow milk production yields shows its positive effects on the net trade position of Turkey for milk. The net milk import of about USD 14 million disappears and a net milk export worth of USD 21 million arises. This is an important example for the effectiveness of even a small technological improvement in some cases. However, this should not be considered enough since this result is also supported by the application of about 150 percent tariffs in Turkey. This means that without high tariff protections, milk sector remains still vulnerable and open to high level of net imports. Regarding the poultry sector, Table 18 indicates that if the current status quo goes on, the net exporter position of poultry sector will be preserved in 2015.

Before finishing the analysis of net trade, we want to draw attention to the state of three important products of Turkey. These are *common wheat, corn, sugar beet*. Table A3.A.5 (In appendix) shows that the net *common wheat* imports will expand by 56 percent and reach to USD 84 million. Common wheat is the main product of agricultural sector as a “grande culture”. Although there are improvements in the Turkish wheat yields, it seems that this progress is inadequate for the competitiveness of the Turkish common wheat in the world. Hence, according to the results of our analysis, common wheat production needs more attention despite the expected improvement in the yields by 2015. Various investment and R&D policies seem to be necessary to improve the level and variability of the wheat yields. The following information is provided to put the wheat yield of Turkey in comparison with some selected countries. According to 2002-2004 averages (FAOSTAT), the yield level of Turkish wheat production (2.1 ton/ha) is far below the world average (2.8 ton/ha). It is about 27 percent of UK's yield level (7.9 ton/ha), 29 percent of Germany's yield level (7.2 ton/ha) and 30 percent of France's yield level (7.1 ton/ha).

According to Table A3.A.5 (In appendix), Turkey may become a major net importer of *corn*. Net corn import enlarges from USD 183 million to USD 250 million representing an upward shift of about 37 percent. This basically results from higher domestic prices. Table A3.A.5 (In appendix) reports that the 2002-2004 average corn price in Turkey is about USD 211/ton. According to 2002-2004 averages (FAOSTAT), the average world export unit value of corn is USD 125/ton. The export unit value of USA, which is the biggest corn exporter in the world with about 40 percent share in the world trade, is USD 116/ton and the corn producer price of USA is USD 93/ton (FAOSTAT, 2002 figure). The producer prices of France, Italy, Argentina and Brazil are USD 107/ton, USD 137/ton, USD 78/ton and USD 52/ton, respectively (FAOSTAT, 2002 figures). These are notably low figures compared to the high domestic corn price of Turkey. According to 2002-2004 averages (FAOSTAT), Turkey's average corn yield level (4.5 ton/ha) is slightly below the world average (4.6 ton/ha). It is 50 percent of the average corn yield of USA (9.0 ton/ha). The yield levels of France, Italy and Argentina are 8.4 ton/ha, 8.8 ton/ha and 6.4 ton/ha, which are 1.9, 2.0, and 1.4 folds of Turkey's average corn yield.

Another important deterioration in the net trade position of Turkey occurs in sugar which is expressed as sugar beet equivalent in the model. Table A3.A.5 reveals that the net exports of sugarbeet of about USD 69 million decline by 150 percent and, as a result, Turkey becomes a net importer of sugarbeet of about USD 35 million. Table A3.A.4 shows that 2002-2004 average domestic price of sugarbeet is USD 56/ton in Turkey. Taking into account that the producer prices of Germany and France (which are the fifth and sixth biggest sugarbeet exporters of the world with 6.3 and 4.8 percent shares) are USD

41/ton and USD 31/ton (FAOSTAT, 2002-2004 averages), respectively; it becomes plausible to perceive the 150 percent decline in the net sugarbeet exports of Turkey. Indeed, the main net importer is reported as EU in Table A3.A.5 with USD 94 million. According to 2002-2004 averages (FAOSTAT), Turkish sugarbeet production suffers from the low yield problem since Turkey's average sugarbeet yield (42.4 ton/ha) is under the world average (42.8 ton/ha). If we compare Turkey with France and Germany on this basis, we see that France's sugarbeet production yield (76.3 ton/ha) is about 1.8 fold, and Germany's sugarbeet production yield (57.8 ton/ha) is about 1.4 fold of that of Turkey.

Our model may provide clues about the regional effects of the scenarios at least for the crop production since the crop production is disaggregated into four regions in the model, whereas the livestock production is at the national level. In this framework, Table 19 shows the regional effects of EU-OUT baseline simulation.

Table 19 Regional Effects for Baseline Simulation (USD million)

	BASE	EU-OUT	% CHANGE
	2002-04	2015	EU-OUT/BASE
Crop Production Volume	***23,191***	***28,054***	***21.0***
Coastal Region	12,710	15,835	24.6
East Anatolia	1,021	1,133	10.9
Central Anatolia	6,599	7,731	17.2
GAP Region	2,861	3,355	17.3
Crop Production Value	***23,191***	***29,275***	***26.2***
Coastal Region	*12,710*	*16,547*	*30.2*
East Anatolia	*1,021*	*1,162*	*13.8*
Central Anatolia	6,599	7,858	*19.1*
GAP Region	*2,861*	*3,708*	*29.6*

Note: See text for the scenario definitions.
Source: Author's calculations.

Compared to the base period figures, the production levels in all regions are increasing. If the current status quo goes on, in 2015, the highest increase in total crop production volume is expected to take place in the Coastal region with about 25 percent. GAP and Central Anatolia regions rank as second and third, with 17.3 and 17.2 percents, respectively. The poorest performance is expected to happen in East Anatolia. According to the EU-OUT simulation results, the production volume of East Anatolia enlarges only by 11 percent.

In terms of the increases in values of production, we observe the same ranking. The only difference is that GAP region (29.6 percent increase) comes closer to Coastal region (30.2 percent increase) in values. The least increase is expected to happen in East Anatolia region with 13.8 percent.

The regional results of the model ratify the comparative advantage of the Coastal region. Particularly East Anatolia is lagging behind the others because of its comparative disadvantages in the production due to the inadequacy of its natural resources and its low productivity (see Table 10 and Table 11)

Table 20 shows the national and regional percentage changes in the use of inputs for the crop production, but for the livestock production only national changes are reported since the livestock production in the model is at the national level.

Table 20 Impacts on Input Use in Baseline Simulation (USD million)

BASE=100	2015	% CHANGE
	EU-OUT	EU-OUT/BASE
Machinery	**109.2**	**9.2**
Coastal	107.8	7.8
Central	111.9	11.9
Eastern	99.6	-0.4
GAP	110.7	10.7
Labor	**104.2**	**4.2**
Livestock Prod.	***104.33***	***4.33***
Vegetable Prod.	***104.1***	***4.1***
Coastal	105.2	5.2
Central	107.2	7.2
Eastern	79.9	-20.1
GAP	106.7	6.7
Fertilizer	**107.9**	**7.9**
Coastal	108.9	8.9
Central	107.6	7.6
Eastern	98.9	-1.1
GAP	108.7	8.7

Note: See text for the scenario definitions.
Source: Author's calculations.

While the use of all inputs is diminishing in East Anatolia, the input uses are expanding in all other regions. In East Anatolia, the largest decline in input use is expected to happen in labor, with 20 percent. So, provided that there will be no decline in region's labor productivity if the current status quo goes on, the agricultural employment in East Anatolia will likely shrink in 2015. Furthermore, if this trend in crop production of East Anatolia is coupled with some improvements in labor productivity, the decline in the employment of crop production in East Anatolia will likely boost. Of course, in this case, productivity enhancement can push the demand for labor with increasing production volume. Another remark is that, in all regions the labor intensity in crop production decreases. In other words, the percentage increases in the machinery and fertilizer use in Coastal, GAP and Central Anatolia is always higher than the percentage increase in the labor use. In East Anatolia, since the percentage declines in the machinery and fertilizer use are quite lower compared to the percentage decrease in the labor use, the same pattern is observed as well. Examining the overall agricultural sector we can note that the highest expansion is seen in the machinery use by 9.2 percent which is followed by the fertilizer use with 8 percent. The sharpest rise in machinery and labor use in the crop production will likely happen in Central Anatolia whereas the biggest expansion in fertilizer use is expected to be seen in the Coastal region of Turkey.

VII.A.2. WTO Simulation

The end date of the new WTO-Agreement on Agriculture may coincide with the possible membership of Turkey to the EU. The WTO simulation intends to shed some light on the potential effects of the reduction in the tariff commitments on the agricultural sector in Turkey.

VII.A.2.1. The WTO and Its Policies

The Bretton Woods Conference in 1944 proposed the formation of an International Trade Organization (ITO) in order to establish the rules and regulations for international trade. Negotiations on the charter of such an organization were concluded successfully in 1948 in Havana. However, the foundation of the ITO was blocked by the USA. Meanwhile, the General Agreement on Tariffs and Trade (GATT) was negotiated in 1947 by 23 countries[49] - 12 industrial and 11 developing - before the ITO negotiations ended. Since the ITO never came into being, GATT is seen as the only concrete result of the negotiations. Seven rounds of negotiations took place under GATT before the Uruguay Round.[50] By the end of the Uruguay Round (1994), 128 countries had joined the GATT. The Uruguay Round concluded in Marrakech on April 15, 1994 and the ministers signed the final act establishing the WTO. The WTO entered into force on January 1, 1995. The major events in the movement from GATT to WTO can be seen in Table 21.

[49] The founding parties to the GATT were Australia, Belgium, Brazil, Burma, Canada, Ceylon, Chile, China, Cuba, Czechoslovakia, France, India, Lebanon, Luxembourg, Netherlands, New Zealand, Norway, Pakistan, Southern Rhodesia, Syria, South Africa, the United Kingdom and the United States. China, Lebanon, and Syria subsequently withdrew.
[50] Geneva (1947), Annecy (1949), Torquay (1951), Geneva (1956), Dillon Round (1960-1961), Kennedy Round (1964-1967), Tokyo Round (1973-1979), Uruguay Round (1986-1994).

Table 21 From GATT to WTO: Major Events

Date	Events
1947	The GATT is drawn up to record the results of tariff negotiations among 23 countries. The agreement enters into force on January 1, 1948.
1948	The GATT provisionally enters into force. Delegations from 56 countries meet in Havana, Cuba, to consider the final draft of the International Trade Organization (ITO) agreement; in March 1948, 53 countries sign the Havana Charter establishing an ITO.
1950	China withdraws from the GATT. The U.S. administration abandons efforts to seek congressional ratification of the ITO.
1955	A review session modifies numerous provisions of the GATT. The United States is granted a waiver from GATT disciplines for certain agricultural policies. Japan accedes to the GATT.
1965	Part IV (on trade and development) is added to the GATT, establishing new guidelines for trade policies of and toward developing countries. A Committee on Trade and Development is created to monitor implementation.
1974	The Agreement Regarding International Trade in Textiles, better known as the Multifibre Arrangement (MFA), enters into force. The MFA restricts export growth in clothing and textiles to 6 percent per year. It is renegotiated in 1977 and 1982 and extended in 1986, 1991, and 1992.
1986	The Uruguay Round is launched in Punta del Este, Uruguay.
1994	In Marrakech, on April 15, ministers sign the final act establishing the WTO and embodying the results of the Uruguay Round.
1995	The WTO enters into force on January 1.
1999	Ministerial meeting in Seattle fails to launch a new round.
2001	A new round of trade talks (the Doha Development Agenda) is agreed on in Doha, Qatar.

Source: Hoekman (2002).

a. The WTO: Functions and Basic Principles

The WTO is a global international organization. As of December 11, 2005, WTO has 149 members with Saudi Arabia being the latest to join.

The main functions of the WTO are listed as follows: (1) Administering WTO trade agreements, (2) Providing a forum for trade negotiations, (3) Handling trade disputes, (4) Monitoring national trade policies, (5) Providing technical assistance and training for developing countries, and (6) Cooperating with other international organizations (WTO, 2006).

For the exploration of the main principles of WTO, we basically follow Hoekman (2002). Hoekman (2002, p.42) stresses the importance of five principles in understanding the pre-1994 GATT and the WTO: *nondiscrimination*, *reciprocity*, *enforceable commitments*, *transparency* and *safety valves*.

The *nondiscrimination* principle has two major components: the *most favored nation (MFN) rule* (expressed in Article I of GATT) and the *national treatment* principle (expressed in Article III of GATT). The MFN rule requires that a product made in one member country be treated no less-favorable than a similar product coming from any other member country. Hence, if the best treatment granted a trading partner is a 5 percent tariff, this rate must be applied to all other WTO members in the trade of this product. The national treatment principle ensures that liberalization commitments are not offset through the imposition of domestic taxes and similar measures. A fundamental element of the negotiating process is *reciprocity* principle, wherein nations acceding to the WTO must commit to equivalent obligations as those undertaken by the existing members. The third principle is the binding and *enforceable commitments*. Hoekman (2002, p.43) stresses the fact that liberalization commitments and agreements to abide by certain rules of the game have little value if they can not be enforced. The tariff commitments of WTO members in a multilateral trade negotiation and on accession are enumerated in schedules (lists) of concessions. These schedules establish "*ceiling bindings*": the related member cannot increase tariffs above bound levels without negotiating compensation with the principle suppliers of the products concerned. The MFN rule then ensures that such compensation – usually reductions in other tariffs- extend to all other WTO members, enlarging the cost of reneging. Enforcement of commitments requires access to information on trade regimes that are pursued by member countries. This is the fourth principle, which is known as *transparency*. The principle of transparency is a basic pillar of the WTO, and it is a legal obligation (Article X of the GATT and Article III of GATS). According to this principle, WTO members are bound to publish their trade regulations, to setup and maintain institutions allowing for the review of administrative decisions affecting trade, to respond to requests for information by other WTO members, and to notify changes in trade policies to the WTO (Hoekman, 2002, p.44). The final principle embodies in the WTO is that, in specific circumstances, governments should be able to restrict trade. This is known as the *safety valves* principle.

Three main reasons can be stated in this respect. First, governments should have the right to step in when competition becomes so vigorous as to injure domestic competitors. Second, governments should have the right to impose countervailing duties on imports that have been subsidized and antidumping duties on imports that have been dumped (sold at prices below that charged in the home market). Finally, governments can interfere in trade for economic reasons such as the serious balance of payments difficulties or supporting an infant industry (Hoekman, 2002, p.44).

Hoekman (2002, p.49) states that, under the post-Uruguay Round experience and thinking, trade policy should be made more central to the development process and development strategies. This is a requirement at both the national and international levels. At the national level it is necessary to ensure that governments have a basis on which to resist efforts to negotiate agreements in an area. *Governments must be able to identify what types of rules will promote development and what types would lead to an inappropriate use of scarce resources of the country*.

b. Uruguay Round Agreement on Agriculture

In this section, we will discuss the concessions and commitments that WTO members have to undertake on market access, domestic support and export subsidies according to the Uruguay Round Agreement on Agriculture.
In the Agreement on Agriculture, member countries agreed on the following items in the area of *market access (tariffs)*.[51]

(1) Non-tariff border measures are replaced by tariffs that provide the same level of protection.

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[51] WTO, Summary of Final Act of Uruguay Round.
Accessible online: http://www.wto.org/english/docs_e/legal_e/ursum_e.htm

(2) Tariffs resulting from this "*tariffication*" process, as well as other tariffs on agricultural products, are to be reduced by an average 36 per cent in the case of developed countries and 24 per cent in the case of developing countries, with minimum reductions for each tariff line being required. Reductions are to be undertaken over 6 years in the case of developed countries and over 10 years in the case of developing countries. Least-developed countries are not required to reduce their tariffs.

In terms of *Domestic support*, the following items were agreed on:

(1) Domestic support measures that have, at most, a minimal impact on trade ("*green box*" policies[52]) are excluded from reduction commitments[53]. In addition to the green box policies, other policies that need not be included in the Total Aggregate Measurement of Support (Total AMS) reduction commitments are direct payments under production-limiting programs, certain government assistance measures to encourage agricultural and rural development in developing countries and other support which makes up only a low proportion[54] of the value of production of individual products or, in the case of non-product-specific support, the value of total agricultural production.
(2) The Total AMS covers all support provided on either a product-specific or non-product-specific basis that does not qualify for exemption and is to be reduced by 20 per cent (13.3 per cent for developing countries with no reduction for least-developed countries) during the implementation period.

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[52] In WTO terminology, subsidies in general are defined by "*boxes*" which are given the colors of *traffic lights*: *green* (permitted), *amber* (slow down- i.e. be reduced), *red* (forbidden). The Agriculture Agreement has no red box. (WTO, Domestic Support in Agriculture: The Boxes). Accessible online: http://www.wto.org/english/tratop_e/agric_e/agboxes_e.pdf)

[53] Such policies include general government services, for example in the areas of research, disease control, infrastructure and food security. It also includes direct payments to producers, for example certain forms of "decoupled" (from production) income support, structural adjustment assistance, direct payments under environmental programs and under regional assistance programs.

[54] Five percent in the case of developed countries and ten percent in the case of developing countries.

As for the *export subsidies*, the following items were agreed on:

(1) Members are required to reduce the value of mainly direct export subsidies to a level 36 per cent below the 1986-90 base period level over the 6 year implementation period, and the quantity of subsidized exports by 21 per cent over the same period. In the case of developing countries, the reductions are *two-thirds* those of developed countries over a 10 year period (with no reductions applying to the least-developed countries).

The summary of the reductions required according to the Uruguay Round Agreement on Agriculture can be found in Table 22.

Table 22 Uruguay Round Agreement on Agriculture: Reductions

	Developed Countries (1995-2000)	**Developing Countries (1995-2005)**
Tariffs		
Average cut for all agricultural products	36 %	24 %
Minimum cut per product	15 %	10 %
(base period 1986-1988)		
Domestic support		
Total agriculture support cut	20 %	13 %
(base period 1986-1988)		
Export subsidies		
Value of subsidies	36 %	24 %
Subsidized quantities	21 %	14 %
(base period 1986-1990)		

Source: WTO

c. Doha Development Agenda Round

The Doha Round of WTO negotiations began in November 2001. This round is mandated to accord particular priority to the needs of developing countries. On 31 July 2004, the WTO's 147 Member Governments approved a Framework Agreement. The Framework Agreement affirms that: "Agriculture is of critical importance to economic development of developing country Members and they must be able to pursue agricultural policies that are supportive of their development goals, poverty reduction strategies, food security and livelihood concerns (FAO, 2005a, p.28; from WTO, 2004, Annex A, paragraph 2). Furthermore, having regard to their rural development, food security and/or livelihood security needs, special and differential treatment for developing countries will be an integral part of all elements of the negotiation (FAO, 2005a, p.28; from WTO, 2004, Annex A, paragraph 39). The document refers to special and differential treatment in the area of domestic support, export competition and market access to be used for the benefit of developing countries. There is a commitment to the identification of "sensitive products" and "special products", which will be eligible for more flexible treatment and to a "special safeguard mechanism" for developing countries. The Framework Agreement provides some flexibility for developed countries but reaffirms their commitment to reform. With reference to the Doha Ministerial Declaration, which calls for "substantial reductions in trade-distorting domestic support", the Agreement states that "there will be a strong element of harmonization in the reductions made by developed Members. Specifically, higher levels of permitted trade-distorting support will be subject to deeper cuts." A timeline for the elimination of export subsidies is to be established and as a guiding principle for further negotiations on market access the Agreement indicates that "*substantial overall tariff reductions will be achieved as a final result from negotiations*" (FAO, 2005a, p.29).

The Doha Development Agenda (DDA) round of trade negotiations continued, with a discussion on agriculture based on the framework accepted in 2004 (OECD, 2006b, p.11). The methodology to calculate *ad valorem* tariff-equivalents was agreed and concrete proposals were made. In December 2005, negotiations at the Hong Kong Ministerial ended with an agreement to ensure the parallel removal of all forms of export subsidies and disciplines on all export measures with equivalent effect by the end of 2013. This issue is subject to agreement on the DDA more generally. Important issues related to trade distortionary forms of domestic support and to improving market access, *particularly rates of tariff cuts*, have not been solved yet. The July 2006 negotiations in Geneva failed to reach an agreement about reducing farming subsidies and lowering import taxes.

VII.A.2.2. WTO Simulation and Results

In the model tariffs of 30 products are bounded by WTO commitments of Turkey according to the 2002-2004 averages. This implies that any WTO agreement to reduce tariff commitments will directly affect the tariff protection of these products. The applied tariffs and the WTO commitments of Turkey are presented in Table 23.

In the WTO simulation, we try to analyze the possible impacts of a new WTO agreement on the Turkish agricultural sector. For this purpose, it is hypothesized that the new agreement will lead to a *15 percent reduction in all tariff line commitments of WTO members in agricultural products by 2015*.

Table 24 summarizes the general results of WTO simulation. Total surplus index reveals that if Turkey implements these reductions there will be no change in total welfare compared to the baseline scenario (EU-OUT). However, the implications of the WTO simulation for consumers' and producers' surpluses are different. The WTO simulation brings a 1.2 percent increase in consumers' surplus in contrast to a 0.1 percent decline in producers' surplus over the baseline. Hence, assuming that the prevailing policies remain intact, a 15 percent reduction in all tariff rate commitments will be beneficial to consumers with a small negative effect on the welfare of producers.

Table 23 Turkey's Tariff Schedules and WTO Commitments

	2002-2004 Average	2006	Turkey's Commitments
Soft Wheat	0.40	1.30	1.80
Durum Wheat	0.30	1.00	1.80
Barley	0.85	1.00	1.80
Corn	0.50	1.30	1.80
Rice	**0.45**	**0.45**	**0.45**
Rye, Oats, Spelt, Millet	0.47	1.07	1.80
Chickpea	**0.20**	**0.19**	**0.20**
Dry Bean	**0.20**	**0.19**	**0.20**
Lentil	**0.20**	**0.19**	**0.20**
Tobacco	0.25	0.25	0.45
Sugarbeet	**0.20**	**0.19**	**0.19**
Cotton	0.00	0.00	0.06
Sesame	**0.24**	**0.23**	**0.23**
Sunflower	0.15	0.26	0.26
Groundnut	**0.33**	**0.32**	**0.32**
Soybean	0.00	0.00	0.23
Onion	**0.50**	**0.50**	**0.50**
Potato	**0.20**	**0.19**	**0.19**
Melon & Watermelon	**0.87**	**0.86**	**0.86**
Cucumber	**0.30**	**0.30**	**0.30**
Eggplant	**0.20**	**0.20**	**0.20**
Fresh Tomato	**0.49**	**0.49**	**0.49**
Processing Tomato	**0.49**	**0.49**	**0.49**
Pepper	**0.20**	**0.20**	**0.20**
Apple	**0.61**	**0.60**	**0.60**
Apricot	**0.55**	**0.55**	**0.56**
Peach	**0.55**	**0.55**	**0.56**
Table Olive	**0.20**	**0.39**	**0.39**
Oil Olive	**0.20**	**0.20**	**0.20**
Citrus	**0.55**	**0.54**	**0.54**
Pistachio	**0.44**	**0.43**	**0.43**
Hazelnut	**0.44**	**0.43**	**0.43**
Fig	**0.46**	**0.46**	**0.46**
Table Grape	**0.56**	**0.55**	**0.55**
Raisin Grape	**0.56**	**0.55**	**0.55**
Tea	1.45	1.45	1.68
Sheep Meat	**2.27**	**2.25**	**2.25**
Sheep Milk	1.50	1.50	1.80
Sheep Wool	0.00	0.00	0.08
Sheep Hide	0.00	0.00	0.36
Goat Meat	**2.27**	**2.25**	**2.25**
Goat Milk	1.50	1.50	1.80
Goat Hair	0.00	0.00	0.24
Goat Hide	0.00	0.00	0.36
Cow Meat	**2.27**	**2.25**	**2.25**
Cow Milk	1.50	1.50	1.80
Cow Hide	0.00	0.00	0.16
Poultry Meat (Chicken)	0.65	0.65	0.87
Egg	**0.77**	**0.77**	**0.77**

Source: UFT (2006), TRAINS (2006)

The increase in consumers' surplus stems from the decrease in prices. The reported price index illustrates that, the 15 percent reductions in tariff commitments will cause a 2 percent decline in the overall price level compared to the baseline scenario. The main price decrease is likely to happen in the livestock products with 4 percent. On the other hand, the drop in crop prices is expected to be rather small. Table 24 illustrates that the relatively large decrease in the price level of livestock products seems to result from the 53 percent expansion in their total net imports. Net imports of livestock products increase to USD 727 million from baseline value of USD 476 million. The figure is reported as USD 273 million for the base period. Impact of the 15 percent reductions in Turkey's binding WTO tariff commitments on the net exports of crop products is small.

Table 24 General Results for WTO Scenario (USD million)

	2002-04	2015			
	BASE	EU-OUT	WTO	WTO/BASE (%)	WTO/EU-OUT (%)
Total Surplus (Index)	**100.0**	**104.4**	**104.4**	**4.4**	**0.0**
Producers' Surplus	100.0	101.7	101.5	1.5	-0.1
Consumers' Surplus	100.0	134.2	135.9	35.9	1.2
Total Production					
Volume [a]	33,997	40,406	40,305	18.6	-0.2
Value	33,997	44,341	43,601	28.2	-1.7
Crop Production					
Volume [a]	23,191	28,054	28,038	20.9	-0.1
Value	23,191	29,275	29,207	25.9	-0.2
Livestock Production					
Volume [a]	10,806	12,352	12,268	13.5	-0.7
Value	10,806	15,066	14,394	33.2	-4.5
Total Consumption					
Volume [a]	29,441	35,827	36,390	23.6	1.6
Value	29,441	39,055	39,081	32.7	0.1
Crop Consumption					
Volume [a]	18,368	23,082	23,095	25.7	0.1
Value	18,368	23,528	23,496	27.9	-0.1
Livestock Consumption					
Volume [a]	11,073	12,745	13,295	20.1	4.3
Value	11,073	15,527	15,585	40.8	0.4
Net Exports	**2,264**	**2,860**	**2,595**	**14.6**	**-9.3**
Crop Products	2,537	3,336	3,321	30.9	-0.4
Livestock Products	-273	-476	-727	166.1	52.6
Price Index (Laspeyres)	**100.0**	**109.9**	**108.0**	**8.0**	**-1.7**
Crop Products	100.0	102.5	102.3	2.3	-0.2
Livestock Products	100.0	122.2	117.5	17.5	-3.9

Notes: See text for the scenarios.
[a] Model results at the base period prices.
Source: Author's calculations.

From Table 24, it can be seen that the effects of the WTO simulation on total production volume is small (0.2 percent decline) compared to baseline scenario. The impact on crop production is even smaller with 0.1 percent.

However, the livestock production seems to be the most affected since it declines by 0.7 percent compared to the EU-OUT scenario. As the values reflect also the changes in the price level, the percentage changes in values are higher than the volumes. With a 4 percent decrease in the price level of livestock products, the value of the total livestock production is likely to decline by about 4.5 percent (compared to baseline). The impact of the simulation on the value of crop production is negligible. The value of total agricultural production is expected to decrease by 1.7. The simulation results for the production volumes and values of all products are given in Tables A3.C.1 and A3.C.2, respectively, at the appendix.

Table 25 shows the per capita consumption effects of the WTO simulation. Per capita meat consumption in the WTO simulation is expected to increase by 7 percent although under baseline situation (EU-OUT) it is expected to decrease by 3.7 percent.

Table 25 Per Capita Consumption Effects of WTO Simulation (Index)

BASE=100	EU-OUT	WTO	% CHANGE
	2015	2015	WTO/BASE
CROP PRODUCTS	***109.1***	***109.2***	***9.2***
CEREALS	103.4	103.5	3.5
PULSES	111.0	111.0	11.0
INDUSTRIAL CROPS	100.0	100.3	0.3
OILSEEDS	117.2	117.3	17.3
TUBERS	110.4	110.4	10.4
VEGETABLES	113.2	113.2	13.2
FRUITS AND NUTS	110.4	110.4	10.4
LIVESTOCK & POUL.	***99.9***	***104.2***	***4.2***
MEAT	96.3	107.1	7.1
MILK	100.9	99.9	-0.1
HIDE, WOOL & HAIR	111.9	111.9	11.9
POULTRY	103.2	103.2	3.2
TOTAL	***105.7***	***107.3***	***7.3***

Note: See text for the scenario definitions.
Source: Author's calculations.

The only decrease in per capita consumption is expected in milk consumption which is about 1 percentage point when compared to the baseline. There will be no significant effect on the per capita consumptions of the other products. Table A3.C.3 in appendix reports these impacts for all the products.

Table 26 reports the impacts on price effects for the main product groups. While the meat prices are expected to increase by 26 percent in baseline, this increase reduces to 15 percent in the WTO scenario. Hence, compared to baseline (EU-OUT), the highest decline in prices is seen in the group of meat products, which is around 9 percent.

Table A3.C.4 in appendix reports the effects of WTO simulation on the prices for all products. Consulting to this table, we see that with 15 percent reductions in binding tariffs of Turkey, the prices of cow, sheep and the goat meat in 2015 are expected to be USD 5,711, USD 6,473 and USD 6,231 per ton, respectively. Without reductions in tariffs, it is estimated that their prices will be around USD 6,269, USD 7,191 and USD 6,813 per ton, respectively. Hence, the effects of WTO simulation on meat prices are notable.

Table 26 Prices in WTO Scenario (USD/Ton)

BASE=100	EU-OUT	WTO	% CHANGE
	2015	2015	WTO/BASE
CROP PRODUCTS	***102.5***	***102.3***	***2.3***
CEREALS	101.1	100.8	0.8
PULSES	104.0	103.8	3.8
INDUSTRIAL CROPS	121.2	120.0	20.0
OILSEEDS	93.2	93.0	-7.0
TUBERS	90.7	90.7	-9.3
VEGETABLES	99.2	99.1	-0.9
FRUITS AND NUTS	107.5	107.5	7.5
LIVESTOCK & POUL.	***122.2***	***117.5***	***17.5***
MEAT	126.4	114.6	14.6
MILK	120.3	121.4	21.4
HIDE, WOOL & HAIR	117.4	117.4	17.4
POULTRY	117.4	117.4	17.4
TOTAL	***109.9***	***108.0***	***8.0***

Note: See text for the scenario definitions.
Source: Author's calculations.

Table 27 reports the results of the WTO simulation on net exports for all product groups. In comparison with the baseline simulation, the largest expansion in net imports will likely be seen in meat. Net meat imports stand at USD 245 million with 15 percent reduction in tariff commitments. However, in the baseline projection, meat trade records net exports of USD 2 million, in sharp contrast to net imports of USD 246 million in the WTO simulation. Table A3.C.5 in Appendix gives the detailed results on the net exports of all products. It reports that with 15 percent reductions in meat tariff lines, the net imports of cow, sheep and goat meat enlarge to USD 120 million, USD 111 million and USD 15 million, respectively, from almost nil in baseline. These imports will likely originate from ROW.

In addition, Table A3.C.5 shows that, rice imports from ROW and USA increase by USD 2 million and 1 million, respectively. In addition, sugarbeet imports from EU (most probably from France) expand by USD 5 million and sesame imports from ROW rise by USD 5 million.

Table 27 Net Exports in WTO Simulation (USD million)

	2002-04	EU-OUT (2015)				WTO (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***-605***	***2605***	***1322***	***3321***
CEREALS	-240	-233	-81	-8.0	-322	-235	-81	-11	-326
PULSES	190	1.4	45	190	237	1.4	45	190	237
INDUSTRIAL CROPS	615	69	551	103	724	69	546	103	719
OILSEEDS	-747	-632	2.9	-293	-922	-632	2.9	-298	-927
TUBERS	55	0.0	4.1	79	83	0.0	4.1	79	83
VEGETABLES	598	59	354	451	864	59	354	451	864
FRUITS AND NUTS	2064	132	1734	807	2672	132	1734	807	2672
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***7.4***	***-249***	***-485***	***-727***
MEAT	11	0.0	0.0	1.8	2	0.0	0.0	-246	-246
MILK	-14	0.5	0.5	20	21	0.5	0.5	20	20
HIDE, WOOL & HAIR	-290	7.0	-250	-275	-517	7.0	-250	-277	-519
POULTRY	19	0.0	0.0	19	19	0.0	0	19	19
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***-598***	***2356***	***837***	***2595***

Notes: See text for the scenario definitions.
Source: Author's calculations.

VII.B. EU SCENARIOS

EU is a major trading partner of Turkey in agricultural products. Therefore, further economic integration with the EU would imply changes in the structure of production in Turkey and the structure of trade flows with the EU and the rest of the world. The agricultural components of agro-food products are excluded in the current customs union agreement between EU and Turkey. The possible results of the abolition of trade barriers between EU and Turkey in agriculture have the outmost importance for the policy makers both in the EU and Turkey. The impacts of the shift in policy structure coupled with trade implications will be crucial both in the determination of the exceptions and derogations in agriculture during the membership negotiation process, and eventually in the estimation of the net burden of Turkey's membership on the EU budget.

The main research question of this section is "*what are the potential effects of Turkey's EU membership in 2015 on agricultural production and trade in Turkey?*" The results of the simulations provide updated estimates about the possible CAP costs of Turkish agriculture to the EU Budget. The ongoing agricultural policy reform processes both in the EU and Turkey imply that most of the domestic supports will shift to less price-distortionary income payments. However, trade and to a limited extent domestic intervention may still remain as the major policy tools.

TAGRIS is used to discuss the consequences of three different EU simulations: (1) The first simulation is the one in which Turkey extends the current Customs Union agreement with EU to agricultural products (*EU-CU* scenario), (2) In the second simulation Turkey is assumed to be a member of EU in 2015 (*EU-IN1* scenario) and (3) In the last simulation Turkey is still a member of EU in 2015 but the yield growth until 2015 is the double of what we have assumed in the other simulations including the EU-OUT (*EU-IN2* scenario).

In section VII.B.1, we review the Common Agricultural Policy (CAP) of the EU with a detailed representation of the 2003 CAP reforms. The details of EU simulations and model results are provided in section VII.B.2.

VII.B.1. Common Agricultural Policy (CAP) of EU

The CAP was initiated during the reconstruction period of Europe after the World War II. It was based on the Treaty of Rome (Notably Article 39 of the Treaty of Rome, also articles 38 and 40-47) signed in the early 1060s. Its main objective was to promote higher productivity in food products mainly due to food security reasons and to establish a viable European agricultural sector that would provide the consumers with stable and affordable food supply. CAP offered subsidies and guaranteed prices to farmers to encourage the agricultural production. These subsidies developed into a comprehensive body of "Common Market Organizations" (CMOs) for several agricultural products including livestock. From the mid 1960s and throughout the 1970s, the CAP program developed. It provided financial assistance for the restructuring of Europe's farming system. It supported farm investments to ensure the development of farms in size, management and technology.

The CAP was successful in meeting its objective of moving the EU towards self-sufficiency, and even it caused to occur in EU almost permanent surpluses of the major farm commodities. Some of these surpluses were exported with the help of CAP export subsidies, but the rest had to be stored or disposed of within the EU. Obviously, these policy measures brought very high budgetary burden and also distorted some world markets. The CAP measures did not always serve to the interests of farmers because of the distortionary effects on the market. Due to its high budgetary costs and distortionary effects on some world markets, CAP became quite unpopular among the European consumers, taxpayers and foreign countries. [55]

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[55] CAP leaflet: The common agricultural policy – A policy evolving with the times http://ec.europa.eu/agriculture/publi/capleaflet/cap_en.pdf .

In 1992, the *Mac Sharry Reforms* (named after the then Commissioner for Agriculture, Ray Mac Sharry), which involved reducing support prices and providing farmer compensations in the form of direct aid payments, were adopted. The reform measures reduced the surpluses using the production limits. Farmers had to start becoming more market oriented and more flexible in responding to the changing priorities of the public. To compensate for the reductions in support prices farmers were receiving direct income supports. In addition, Mac Sharry reforms introduced several rural development measures to promote the environment friendly farming.

In the heart of his reform there was a 30% cut in the cereal intervention price, phased in over three years, together with smaller decreases in the institutional beef and butter prices. These reductions in support prices were compensated by a *per hectare payment* in the case of cereals, and increased premium payments for beef cows and cattle. The 1992 reform introduced a *set-aside* scheme in the arable sector which allowed the Commission to curtail the arable area and gain control of surpluses in that sector. In order to reduce production capacity and to improve the structure of farming, the reform also included three accompanying measures; these are *early retirement*, *agro-environment* and *afforestation*[56] *schemes*.

In 1999, the *Agenda 2000* was adopted. This was a package of CAP reforms to the cereals, beef and dairy sectors, which was designed in part to prepare the EU for enlargement. The reform included a reformulation of the aims of agricultural policy, to give greater emphasis to environmental policy objectives and the multifunctional role of the European model of farming. It further reduced support prices for cereals and beef and also, for the first time, intervention prices for dairy products although the latter move was postponed to the 2005/2006 marketing year because of the budgetary costs of compensation.

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[56] *Afforestation* is the process of converting open land into a forest by planting trees or their seeds.

According to the reform of Agenda 2000 the CAP rests on two pillars: the first pillar which comprises market policies and price support; the second pillar which includes Rural Development policies. In this way, the rural development polices achieved independence from the structural policy and the agricultural market policy of the EU.

However, the EU heads of government tempered the force and effectiveness of Agenda 2000 reform package at the very last minute. Nevertheless, in this agreement, Franz Fischler, the then Commissioner for Agriculture, got commitment to a "*mid-term review*" which would take place in 2002-2003. This mid-term review turned out to be the *2003 Reform of CAP*. On June 26, 2003 the Commission agreed on the *2003 CAP reform* and adopted it on September 29 of the same year.

The key elements of the 2003 CAP reforms can be summarized as follows (EU Newsletter, 2003):

(1) CAP becomes more **market-oriented**, simpler and less trade-distorting via:

- the introduction of a single payment scheme for EU farmers, which is independent (i.e. "decoupled") from production, with limited coupled elements maintained where Member States consider this necessary to avoid abandonment of production;
- the linking of the single payment scheme to the environmental, food safety, animal and plant health and animal welfare standards, as well as to the requirement to keep all farmland in good agricultural and environmental condition (Cross-compliance).

(2) CAP will strengthen **rural development policy** via:

- the shift of more EU money and new measures to promote the environment, quality and animal welfare and to help farmers to meet new EU standards;
- a reduction in direct payments (modulation) for bigger farms to finance the new rural development policy.

(3) Revisions were made to the market support parts of the CAP via:

- significant reforms in the intervention mechanism of sectors of structural imbalance (butter, rye, rice);
- adjustments in support mechanisms in other sectors (durum wheat, drying aids, starch potatoes, dried fodder, nuts);
- a mechanism for financial discipline ensuring that the farm budget fixed until 2013 is not overshot.

VII.B.1.1. Detailed Review of 2003 CAP Reforms

The key elements of the 2003 reform package are reviewed in greater detail below (EU Newsletter, 2003).

a. The Single Payment Scheme

S*ingle payment scheme* is introduced to substitute most of the direct aid payments to farmers (*premia*). The new single payment scheme is not linked to what a farmer produces. The amount of the payment is calculated on the basis of the direct aids a farmer received in the reference period (2000–2002). The main objective of the single payment scheme is to allow farmers to become more market oriented and to release their entrepreneurial potential. In order to guarantee continued land management activities throughout the EU, beneficiaries of direct payments is obliged to maintain their land in good agricultural and environmental condition. Farmers who can not succeed to comply with the cross-compliance requirements would face reductions in direct payments. As a result of the move to the single payment scheme, the majority of EU direct aids to farmers become fully decoupled.

The single payment scheme came into operation on 1 January 2005. Member States have the right to delay the implementation up to 2007. But, by 2007 at the latest, all Member States should introduce the single payment scheme.

Full decoupling (single payment scheme) became the general principle with 2003 CAP reforms. However, Member States may decide to maintain a proportion of direct aids to farmers in their existing form (partial decoupling), notably when they believe there may be disturbance to specific commodity market or abandonment of production as a result of the move to the single payment scheme. Member States may implement a number of options, at national or regional level, but only under well-defined conditions and within clear limits stated in the reform package.

Moreover, member States may grant "*additional payments*" to support agricultural activities that are important for the protection or enhancement of the environment or for improving the quality and marketing of the agricultural production. These "*additional payments*" may use up to 10 % of the funds that are available for a certain sector included in the single payment scheme of a Member State concerned.

Dairy direct aids are introduced in stages and will be fully implemented by 2007. Generally, dairy payments will form part of the single payment scheme from 2006/07 onwards, unless Member States decide on an earlier introduction of decoupling.

b. Compulsory cross-compliance

The reformed CAP puts greater emphasis on cross-compliance. Until 2003 CAP reforms, cross-compliance was voluntary for Member States and applied to environmental standards only. Cross-compliance became compulsory with 2003 CAP reform. All farmers receiving direct payments are subject to cross-compliance. A *priority list* of 18 statutory European standards in the fields of environment, food safety, and animal health and welfare were established and farmers would be sanctioned for non-respect of these standards, in addition to the sanctions generally applied, through cuts in direct payments. Beneficiaries of direct payments are also obliged to maintain all agricultural land in good agricultural and environmental condition, in order to avoid land abandonment and subsequent environmental problems. Where a farmer fails to comply with such requirements, reductions in his payments are applied as a sanction.

c. Modulation and financial discipline

The need to reinforce rural development has been an important element under discussion about the CAP over recent years. In this respect and in order to finance the additional agreed rural development measures, direct payments for bigger farms were reduced (the mechanism known as "modulation") by 3 % in 2005. The percentages defined are 4 % for 2006 and 5 % from 2007 onwards (Table 28). Direct payments up to an amount of EUR 5 000 per farm remained free of reductions.

Reductions in direct payments will not apply in the accession countries until direct payments reach EU levels. Outermost regions of the EU and the Aegean Islands are exempt from modulation.

Table 28 Modulation in 2003 CAP Reform

Budget Year	2005	2006	2007	2008-2013
Farms with up to EUR 5 000 direct payments a year.	0 %	0 %	0 %	0 %
Above EUR 5 000	3 %	4 %	5 %	5 %

Source: EU Newsletter (2003)

d. Strengthened rural development policy

The additional funds generated by modulation are decided to be added to rural development funds. The reform also included a significant extension of the scope of currently available instruments for rural development to promote food quality, meet higher standards and foster animal welfare. Together, these two changes are to strengthen EU rural development policy. The changes are all targeted primarily to help farmers to respond to new challenges. The new measures are comprised of the following items: (1) Food quality measures, (2) Meeting standards, (3) Farm advisory service, and (4) Animal welfare.

e. Specifications of the single payment scheme

There will be detailed rules for the application of the new payment. The main points already established are the following.

Payment entitlements

Entitlement to the new payment goes to farmers who are actively farming the land. In general, this covers farmers who are active at the moment the new scheme enters into force and who can prove historical claims during the reference period. Farmers are allotted payment entitlements based on historic reference amounts (amounts of aid received in the period 2000–02). Each entitlement is calculated by dividing the reference amount by the number of hectares which gave rise to this amount (including forage area) in the reference years. Payment entitlements may be transferred, with or without land, among farmers within the same Member State.

Regional application options

The single payment scheme may be "*regionalized*" with a high degree of discretion given to Member States in its application. Member States may (1) allocate uniform payment entitlements within a region rather than calculating a single payment individually for each farmer, (2) vary payment levels between arable land and grassland, without prejudice to the actual use of that land, (3) make different sectors contribute at different degrees to the redistributed regional envelope while allocating some payments or parts of them on the basis of individual reference amounts, (4) redistribute funds between regions when the regional financial envelopes are defined, and (5) advance the integration of the milk premiums into the single payment scheme.

National reserve

Member States are to create a national reserve via a linear percentage reduction of the reference amounts. This reduction may be up to 3 %. The national reserve is to be used to provide reference amounts for hardship cases. A host of individual farm circumstances will have to be taken into account especially during the transition phase. In addition, the national reserve will be used to allocate entitlements to solve problems of transition.

Set-aside

Within the single payment scheme, farmers receive set-aside entitlements calculated on the basis of historic references. Set-aside entitlements are activated only if they relate to an eligible hectare put into set-aside (excluding permanent pasture). Set-aside land may be subject to rotation and may be used for energy crop production. Organic producers are exempt from the set-aside obligation. Set-aside areas must cover at least 0.1 hectare in size and be at least 10 meters wide. For justified environmental reasons a width of 5 meters may be accepted.

f. The main support price/direct aid decisions

Cereals: Intervention price and direct payment of EUR 63/tonne is retained, but monthly increments are reduced by 50 %. Rye is excluded from the intervention system.

Durum wheat: The supplement for durum wheat in traditional production zones was decided to be paid independently from production. Member States may decide to keep 40 % linked to production. It is fixed at EUR 313/hectare in 2004, EUR 291 in 2005 and EUR 285 from 2006 and included in the single payment scheme.

Protein crops: The supplement for protein crops (EUR 9.5/tonne) is converted into a crop-specific area payment of EUR 55.57/hectare. It is paid within the limits of a new maximum guaranteed area of 1.4 million hectares.

Grain legumes: The regime is integrated in the single payment regime.

Drying aids: Supplementary payment is increased from EUR 19/ha to EUR 24/ha.

Starch potatoes: Forty percent of the existing payment of EUR 110.54/tonne of starch is included into the single payment scheme, on the basis of historical deliveries to the starch industry. The remainder is maintained as a crop specific payment for starch potatoes. The minimum price and production refund applications for starch are maintained.

Dried fodder: Support in the dried fodder sector is redistributed between growers and the processing industry. Direct support to growers is integrated into the single payment scheme, based on their historical deliveries to the industry. In 2004/05, the processing aid is fixed at EUR 33/tonne.

Support for energy crops: An aid of EUR 45 per hectare is offered to farmers who produce energy crops. Farmers qualify to receive the aid if their production of energy crops is covered by a contract between the farmer and the processing industry concerned. Where the processing occurs on the farm concerned no contract is necessary.

Rice: The intervention price was cut by 50 % to EUR 150/tonne. Intervention is limited to 75 000 tons per year. To stabilize producers' revenues, the direct aid was increased from EUR 52/tonne to EUR 177/tonne.

Nuts: The system before 2003 CAP reform is replaced by an annual flat-rate payment of EUR 120.75/hectare for 800 000 hectares divided into fixed national guaranteed areas for almonds, hazelnuts, walnuts, pistachios and locust beans. Member States are allowed to use their guaranteed quantities in a flexible way. This aid can be topped up by an annual maximum amount of EUR 120.75 per hectare by Member States.

Dairy: The Council decided on asymmetric price cuts in the milk sector. The intervention price for butter is reduced by 25 % (– 7 % in 2004, 2005, 2006 and – 4 % in 2007). For skimmed milk powder, prices are cut by 15 % (three steps from 2004 to 2006), as agreed in Agenda 2000. Intervention purchases of butter were suspended above a limit of 70 000 tones in 2004 and then planned to fall in annual steps of 10 000 tons to arrive at 30 000 tons from 2007 onward. The target price for milk was abolished. Compensation (i.e. becoming part of the single payment scheme) is fixed as follows: EUR 11.81/tonne in 2004, EUR 23.65 in 2005 and EUR 35.5 from 2006 onwards.

Table 29 summarizes the direct payments and aids of reformed CAP for selected products. The Agenda 2000 period figures are also provided in the table for comparison.

In future, the vast majority of subsidies for farmers will be paid independently from the volume of production ('decoupled’). This means that direct aids can be classified as ‘green box’ under the WTO agreements, i.e. nontrade-distorting. Therefore, they will not be subject to tariff reduction in the eventual trade agreement. Overall CAP expenditure will stay within the agreed ceilings, despite an increase of 50 % in the number of farmers following the EU’s enlargement.

Table 29 Direct Payments and Aids of CAP for Selected Products

	AGENDA 2000		2003 CAP REFORM	
	2002/03	**2003/04**	**2004/05**	**2005/06**
Cereals				
Intervention price (€/t)	101.31	101.31	101.31	101.31
Direct payments (€/ref. yield t/ha)	63.00	63.00	63.00	63.00
Durum Wheat				
Additional payment per ha (€/t)	344.50	344.50	313.00	291.00
Paddy Rice				
Target Price (€/t)	298.35	298.35	150.00	150.00
Oil Seeds				
Direct payments (€/ref. yield t/ha)	63.00	63.00	63.00	63.00
Protein Crops				
Direct payments (€/ref. yield t/ha)	72.50	72.50	63.00	63.00
Silage grass				
Direct payments (€/ref. yield t/ha)	63.00	63.00	63.00	63.00
Set-aside				
Direct payments (€/ref. yield t/ha)	63.00	63.00	63.00	63.00
Beef and Veal				
Intervention price (€/t carcasses)	-	-	-	-
Basic Price (Private storage)	2224.00	2224.00	2224.00	2224.00
Special male premium, bulls (€/head/one in life)	210.00	210.00	210.00	210.00
Special male premium, steers (€/head/twice in life)	150.00	150.00	150.00	150.00
Suckler cow premium (€/head/year)	200.00	200.00	200.00	200.00
Slaughter premium (€/head)	80.00	80.00	80.00	80.00
Calf slaughter premium (€/head)	50.00	50.00	50.00	50.00
Extensification payment (€/head)	100.00	100.00	100.00	100.00
Milk and Mik Products				
Direct payments (€/t of milk quota)	17.24	17.24	8.15	16.31
Butter intervention price (€/t)	3282.00	3282.00	3052.30	2824.40
Skim milk powder intervention price (€/t)	2055.20	2055.20	1952.40	1849.70
Milk Target price (€/t)	309.80	309.80	-	-

Source: European Commission, various regulations.

VII.B.2. EU Simulations and Results

In the first scenario (*EU-CU*), the customs union agreement between EU and Turkey is extended so as to cover the agricultural products. This means that, all trade measures are removed from the EU-Turkey trade in agricultural products. Restrictions on the area and/or production of tea, tobacco, hazelnut and sugar-beet production are operational. In this scenario, there are no input subsidies and deficiency payments for Turkey. Trade measures of Turkey for the third countries are similar to those of the EU. Finally, the yield growth rates until 2015 are assumed to be the same as in the baseline simulation.

In the second scenario (*EU-IN1*), Turkey is assumed to be a member of EU. Therefore, the compensatory direct payments for cereals, oilseeds and protein crops and compulsory set-aside regulations of EU apply fully to Turkey. Turkey is also eligible for other subsidies implemented in the EU, i.e. payments for durum wheat, tobacco, olive oil, cotton, milk, beef and sheep meat. All trade measures are removed for the EU-Turkey trade in agricultural products. EU intervention purchases and restrictions on tea, tobacco, hazelnut and sugar-beet productions are operational. As in the first scenario, there are no input subsidies and deficiency payments for Turkey. Trade measures of Turkey for the third countries are similar to the EU and yield growths are the same as in the baseline scenario (EU-OUT).

The policy framework for the second membership scenario, EU-IN2, is the same as in EU-IN1. The only difference stems from the fact that the econometrically estimated values of the annual yield growth rates are used in this simulation, so EU-IN2 scenario can be regarded as the optimistic version of the EU-IN1 scenario.

VII.B.2.1. General Results

The general results of EU simulations and the corresponding percentage changes over the base period are presented in Table 30 and Table 31, respectively. As before, producers' and consumers' surplus measures are the aggregate measures used to evaluate the impacts of the various scenarios. Unless otherwise stated, *all the comparisons will be done between the base period results and the results of the respective scenario*. When it is stated *membership*, the first membership scenario, EU-IN1, should be understood.

Table 30 General Results for EU Scenarios (USD million)

	2002-04	2015			
	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2
Total Surplus (Index)	**100.0**	**104.4**	**104.7**	**104.6**	**105.2**
With Full CAP Support	-	-	-	*106.4*	*107.1*
Producers' Surplus	100.0	101.7	100.5	100.5	100.8
With Full CAP Support	-	-	-	*102.3*	*102.8*
Consumers' Surplus	100.0	134.2	149.9	149.9	153.1
Total Production					
Volume [a]	33,997	40,406	38,295	37,871	40,461
Value	33,997	44,341	37,108	36,788	37,739
Direct Payments	-	-	-	8,026	8,801
Comp. Area Payments	-	-	-	*2,942*	*3,192*
Other Crop Payments	-	-	-	*3,022*	*3,427*
Livestock Prod. Payments	-	-	-	*2,062*	*2,182*
Crop Production					
Volume [a]	23,191	28,054	26,604	26,180	27,616
Value	23,191	29,275	26,448	26,128	26,172
Livestock Production					
Volume [a]	10,806	12,352	11,691	11,691	12,845
Value	10,806	15,066	10,660	10,660	11,568
Total Consumption					
Volume [a]	29,441	35,827	39,774	39,773	40,276
Value	29,441	39,055	36,811	36,813	36,079
Crop Consumption					
Volume [a]	18,368	23,082	23,431	23,431	23,790
Value	18,368	23,528	22,450	22,451	21,730
Livestock Consumption					
Volume [a]	11,073	12,745	16,342	16,342	16,486
Value	11,073	15,527	14,362	14,362	14,349
Net Exports	**2,264**	**2,860**	**-1,476**	**-1,757**	**-306**
Crop Products	2,537	3,336	2,228	1,947	2,512
Livestock Products	-273	-476	-3,704	-3,705	-2,818
Price Index (Laspeyres)	**100.0**	**109.9**	**94.6**	**94.6**	**91.3**
Crop Products	100.0	102.5	96.6	96.7	92.0
Livestock Products	100.0	122.2	91.3	91.3	90.1

Notes: See text for the scenarios.
[a] Model results at the base period prices.
Source: Author's calculations.

According to Table 30, the total surplus is expected to increase by 4.4 percent in 2015 in the case of non membership. Compared to the baseline simulation EU-OUT, the impact of extending the customs union agreement to agricultural products on total surplus is negligible (EU-CU). On the other hand, being a member of EU with full CAP support (EU-IN1) seems to bring an additional

2.0 percentage point increase in total surplus. However, this basically stems from the full application of CAP supports to producers. Therefore, if CAP is not applied this additional increase drops to 0.2 percentage points.

Table 31 Percentage Changes in General Results for EU Scenarios (2015)

	CHANGE OVER BASE (%)			
	EU-OUT	EU-CU	EU-IN1	EU-IN2
Total Surplus (Index)	**4.4**	**4.7**	**4.6**	**5.2**
Producers' Surplus	1.7	0.5	0.5	0.8
Consumers' Surplus	34.2	49.9	49.9	53.1
Total Production				
Volume [a]	18.9	12.6	11.4	19.0
Value	30.4	9.1	8.2	11.0
Crop Production				
Volume [a]	21.0	14.7	12.9	19.1
Value	26.2	14.0	12.7	12.9
Livestock Production				
Volume [a]	14.3	8.2	8.2	18.9
Value	39.4	-1.4	-1.4	7.0
Total Consumption				
Volume [a]	21.7	35.1	35.1	36.8
Value	32.7	25.0	25.0	22.5
Crop Consumption				
Volume [a]	25.7	27.6	27.6	29.5
Value	28.1	22.2	22.2	18.3
Livestock Consumption				
Volume [a]	15.1	47.6	47.6	48.9
Value	40.2	29.7	29.7	29.6
Net Exports	**26.3**	**-165.2**	**-177.6**	**-113.5**
Crop Products	31.5	-12.2	-23.2	-1.0
Livestock Products	74.4	1256.6	1256.6	932.1
Price Index (Laspeyres)	**9.9**	**-5.4**	**-5.4**	**-8.7**
Crop Products	2.5	-3.4	-3.3	-8.0
Livestock Products	22.2	-8.7	-8.7	-9.9

Notes: See text for the scenarios.
[a] Model results at the base period prices.
Source: Author's calculations.

In the membership scenarios (EU-IN1 and EU-IN2), we observe 2.3 to 2.8 percent increases in producers' surplus and 49.9 to 53.1 percent growth in consumers' surplus. However, without the CAP supports the increase in producers' surplus drops to 0.5-0.8 percent over the base period. The percentage increases in consumers' surplus are higher in membership scenarios but the percentage increases in producers' surplus depend on the application of the CAP support. If full CAP support is obtained, the increase in producers' surplus is higher than the non membership scenario, otherwise it is lower. Hence, CAP payments are important for welfare of producers.

The reason for relatively higher increases in consumers' surplus in the customs union and membership scenarios is the changing price structure. In customs union and membership situations, there are sharp declines in the prices of livestock products around 8.7-9.9 percents accompanied by 3.3-8.0 percent drops in the overall price level of crop products (Table 30 and Table 31, Price Index). These results explain the rather high growth rate observed in the consumers' surplus in the EU scenarios. Hence, assuming that the prevailing EU and Turkish agricultural policies remain intact, the customs union and membership will be definitely beneficial to the consumers. However, the impact on producers depends on the CAP applications.

As before, the values of production and consumption presented in Table 30 are calculated in two different ways: First with the 2002-2004 prices, and second with the model's prices. Both values are in US dollars and the impact of inflation is limited with the depreciation of the US dollars. The volumes calculated with constant prices correspond to changes in the quantities. The values are found by multiplying the model's prices with the corresponding quantities, and reflect the changes in both quantities and prices.

From Table 30, it can be seen that, in all cases, both the *volume* and the *value* of agricultural production increases. In the case of non membership the values of production seem to reflect the increase in the prices of agricultural products. If we compare EU scenarios with the baseline scenario (EU-OUT), however, we see that the volume of total agricultural production declines by 5.2 percent in customs union and by 6.3 percent in case of membership. The reason for the higher decline in the production volume in the EU-IN1 results from the implementation of obligatory set aside regulations of CAP for cereals, oilseeds and protein crops with the EU membership.

The results of the simulations on crop and livestock sub-sectors are strikingly different. The overall crop production seems to stay competitive even in the case of membership. The volume of crop production increases by about 15 percent in customs union, about 13-19 percent in membership and about 21 percent in non membership scenarios. Under trade liberalization with the EU, 13 to 14 percent increases in the value of crop production are observed over the base period, whereas in the case of non membership, the value of crop production goes up by 26 percent. Hence, compared to the baseline scenario, the volume of crop production is expected to decrease by 5.2 percent in customs union and 6.7 percent in case of membership.

In the baseline scenario (EU-OUT), due to the expansion in demand coupled with high protection, both the volume and value of livestock products increase significantly by about 14 percent and 39 percent, respectively. However, the volume is increased by 8 percent and the value is reduced by 1 percent over the base period if Turkey becomes a member in 2015 (EU-IN1). In our optimistic but plausible technological improvement scenario (EU-IN2), production volume of livestock and poultry products increases further by 11 percentage point and the value by 8 percentage point. The main source of these increases in the EU-IN2 scenario is the expansion in the production of poultry sector. Table 32 reports that, with double yield growths until 2015, a 37 percent increase in the production of poultry sector in membership over base period can be observed whereas in EU-IN1 this figure is estimated as only 19 percent. The results of EU-IN2 imply that even under EU membership the production volume of the sector may increase substantially. Table A3.B.1 (In appendix) shows that, under membership with double yield growth until 2015, milk and meat productions can expand by about 20 and 10 percents, respectively.

The most striking difference between crop and livestock sectors in the EU simulations is their net export performances. Table 30 shows that in all EU simulations, Turkey keeps its net exporter position in the trade of crop products with some decreases. The net exports of crop products decline by 12 percent in the customs union scenario, 23 percent in the first membership scenario and only 1 percent in the second membership scenario. The overall crop production seems to stay competitive in the customs union or membership situations. But this is not the case for the livestock products. The net livestock and poultry product imports of Turkey expand by about 13 fold in the customs union and first membership scenarios and reach to USD 3,705 million from USD 273 million. Higher technical improvements decrease the expansion in net imports by about USD 900 million. In the second membership scenario, the net import of livestock and poultry products is estimated as USD 2,818 million, which corresponds to 9 fold of the base period's figure. So the overall picture shows that, the competitiveness of the livestock sector may be improved with higher growth rates in productivity. However, the poultry sub-sector exhibit a relatively different pattern. Net poultry products export worth of USD 150 million can be realized under the second membership simulation (Table 36).

Crop and livestock consumption expand in all cases, but more significantly in EU scenarios (Table 30). Non membership brings 22 percent increase in total consumption volume and EU membership causes a further increase of about 13 percentage points. However the impact on consumption expenditures (value of total consumption) is quite different. The 33 percent increase in total consumption expenditures in the non membership case decreases down to about 25 percent when Turkey becomes a member in 2015 (EU-IN1). Hence under membership, relatively high consumption levels are achieved at much lower costs. Impact of membership is quite different at the sub-sectoral level. The volume of crop consumption increases by 26 percent in the non membership scenario (EU-OUT), and about 28 percent in the membership scenario (EU-IN1). Increase in the value of crop consumption is 28 percent in baseline scenario (EU-OUT) but about 22 percent under customs union and membership. Same pattern is observed more significantly in livestock consumption. In case of non-membership, livestock consumption volume increases by 15 percent but about 48 percent in membership and customs union. The value of livestock consumption increases by 40 percent in non membership, however, the increase is 30 percent in membership. Hence, in terms of both crop and livestock consumption, relatively high consumption levels are achieved at much lower expenditures in membership and customs union situations.

As expected, net exports are affected intensively from the change in production and consumption conditions. Trade liberalization with EU combined with the expansion of demand brings about more favorable conditions for livestock product imports compared to exports. In EU scenarios, an important deterioration in the net exports of Turkey is observed (see Table 30 above), mainly due to the removal of trade barriers from the livestock imports. In the base period, Turkey's net import of livestock products is reported as USD 273 million, in EU scenarios this figure goes up to about USD 2,800-3,700 million. These results highlight the necessity of a structural improvement in the Turkish livestock sector. If the production capabilities of the sector are not improved until 2015, Turkey will become a significant net importer of livestock products under membership or customs union. Turkey's net export of crop products is expected to decrease by 1-23 percent depending on the improvements in yield growths compared to base period. Hence, it seems that net exports of crop products will not be able to compensate the foreseen boom in the net imports of livestock products. As a result, under membership or customs union, Turkey becomes a net importer in the aggregate which totals to about USD 300-1,750 million depending on the different simulations. Extensive focus on the technological improvement seems to be necessary in order to lessen the expected high net agricultural imports in case of membership. Our optimistic but plausible membership scenario (EU-IN2) shows that higher yield growths can lead to substantial decreases in Turkey's net imports of agricultural products. Total net imports under membership shrink considerably to USD 300 million from USD 1,750 million by assuming higher growth in yields until 2015, which implies a saving of about USD 1,500 million per year. This result stresses the effectiveness of technological growth. On the other hand, in non-membership, although the net import of livestock products increases to USD 476 million from USD 273 million, with the expansion in net export of crop products from USD 2,500 million to 3,300 million, Turkey remains to be a net exporter in agricultural products (about USD 2,850 million).

Table 30 reports Laspeyres price indices for all of the simulations. The overall price level is expected to increase by about 10 percent when Turkey is out of EU, whereas the crop and livestock products prices go up by 2.5 percent and 22.2 percents, respectively. In the membership scenarios, 3 to 8 percent decreases in crop prices coupled with significant decline in livestock prices (a 8.7 percent decrease in EU-IN1 and a 9.9 percent decrease in EU-IN2) lead to a significant decline (5.4 percent in EU-IN1, 8.7 percent in EU-IN2) in the overall price level compared to the base period.

The budgetary outlays for CAP calculated from the simulations of two membership scenarios implies that the total CAP direct payments (if fully implemented) will be in the interval of USD 8,000-8,800 million depending on the technological improvement that Turkey will experience until 2015. This corresponds to about EUR 5,350-5,870 million at 2004 prices[57]. In the first membership scenario, USD 2,942 million (EUR 1,963 million at 2004 prices) is paid for *compensatory area payments* of cereals, oilseeds and protein crops. *Other crop payments* stand at USD 3,022 million (EUR 2,017 million at 2004 prices). These payments are for durum wheat, tobacco, olive oil, hazelnuts and cotton productions. For *livestock products*, budgetary outlays stand at USD 2,062 million (EUR 1,376 million at 2004 prices). This amount includes the payments for milk, beef and sheep meat productions. The issue of CAP supports will be addressed in detail in a separate section below (section VII.B.3).

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[57] Assuming 1,5 % inflation per year in EURO area until 2015.

VII.B.2.2. Production Volumes and Values

The levels and changes of production volumes for product groups are presented in Table 32. All of the model results are evaluated at base period average prices.

The sector when faced with a different relative price structure under membership shows different responses depending on the type of product. Products in the product groups display individually different responses to EU membership.

Table 32 Production Volumes in EU Scenarios (USD million at 2002-2004 prices)

	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2	CHANGE OVER BASE (%)			
	2002-04	2015	2015	2015	2015	EU-OUT	EU-CU	EU-IN1	EU-IN2
CROP PRODUCTS	***23,191***	***28,054***	***26,604***	***26,180***	***27,616***	***21.0***	***14.7***	***12.9***	***19.1***
CEREALS	6,509	7,408	6,115	5,741	6,193	13.8	-6.1	-11.8	-4.9
PULSES	942	1,170	1,204	1,203	1,219	24.2	27.8	27.8	29.4
INDUSTRIAL CROPS	2,370	2,686	2,668	2,669	3,161	13.4	12.6	12.6	33.4
OILSEEDS	558	722	458	408	430	29.3	-18.0	-26.8	-23.0
TUBERS	1,511	1,921	1,924	1,924	1,959	27.2	27.4	27.4	29.7
VEGETABLES	4,854	6,287	6,316	6,317	6,352	29.5	30.1	30.1	30.9
FRUITS AND NUTS	6,448	7,859	7,918	7,918	8,301	21.9	22.8	22.8	28.7
LIVESTOCK & POUL.	***10,806***	***12,352***	***11,691***	***11,691***	***12,845***	***14.3***	***8.2***	***8.2***	***18.9***
MEAT	4,777	5,281	4,963	4,963	5,275	10.5	3.9	3.9	10.4
MILK	3,482	4,091	3,756	3,756	4,172	17.5	7.9	7.9	19.8
HIDE, WOOL & HAIR	249	256	247	247	248	2.9	-0.7	-0.7	-0.3
POULTRY	2,297	2,724	2,724	2,724	3,150	18.6	18.6	18.6	37.1
TOTAL	***33,997***	***40,406***	***38,295***	***37,871***	***40,461***	***18.9***	***12.6***	***11.4***	***19.0***

Notes: See text for the scenarios.
Source: Author's calculations.

Oil seeds appear as the crop *product group* that will be likely subject to the highest production decline in all EU scenarios (decrease by about 18-27 percent). The largest decline, among the oilseed products, is seen in sunflower with 25 percent in customs union, and 32 to 36 percents in membership simulations whereas under non-membership its production volume expands by 35 percent (Table A3.B.1). Soybean production is expected to decrease by 59 percent in membership and 49 percent in customs union and non-membership. Application of obligatory set aside regulations of CAP for oilseed products under membership leads to higher declines in the production of oilseeds.

Table 32 shows that, the second biggest decline in the production volume among the crop products is expected to happen in cereals due to the liberalization of trade with the EU. The cereal production decreases by about 5-12 percents in membership and customs union scenarios. From Table A3.B.1, it is seen that basically three products are responsible for this decline: *common wheat, corn* and *rye*. Under the customs union scenario, the production of common wheat decreases by 23 percent. In the membership scenario, with the applications of set aside regulations for cereals, the production volume drops by 33 percent over the base period. Higher growth in yields does not change the picture and brings improvements by only about 5 percentage point (EU-IN2). Table A3.B.1 illustrates that corn production in the membership is expected to decrease by 30 to 45 percents according to the growth performance in the yields. Looking at the simulation results for corn, three points are worth pointing out. First, technological improvement has a considerable effect on the volume of corn production since the 45 percent decline observed under membership drops to 30 percent with higher yield growth rates (EU-IN2). Second, the obligatory set aside regulations of EU have a remarkable effect on the corn production volume in case of membership since the 35 % decline recorded in the customs union scenario goes up to 45 % with membership. Third, Table A3.B.5 reports a huge increase in the net corn imports from EU which arises because of the removal of tariffs between EU and Turkey in membership or customs union. It is expected that Turkey's net corn imports from USA will not decline, hence the liberalization of trade with the EU will likely result into a *trade creation* instead of *a trade diversion* in terms of the *corn* imports of Turkey, which will sharply enlarge the total net corn imports of the country. In the customs union scenario, the corn trade records net imports of USD 245 million from EU (Table A3.B.5). This figure goes up to USD 295 million with membership. Even higher yield growths until 2015 do not clear this huge net corn imports, but it only reduces its size to USD 238 million (EU-IN2).

Pulses are the most possible candidates to remain competitive with the membership since, compared to the baseline scenario (EU-OUT), the largest increase under membership is expected in this sector by about 3-4 percent. The production volume of pulses expands by 28 to 29 percents in membership or customs union cases but 24 percent in the non-membership scenario. The net exports of pulses are likely to increase by 34 to 38 percents in the case of membership compared to the base period, expanding to USD 255 to 263 million from USD 190 million (Table 36).

Other products which may possibly remain competitive in the case of membership are fruits & nuts, vegetables and tuber crops. With respect to the baseline scenario, the fruits & nuts, vegetables and tuber crops productions are expected to expand under membership by 0.8 to 5.6 percents, 0.5 to 1.0 percents, and 0.2 to 2.0 percents, respectively. These figures, compared to the base period, are reported as 23 to 29 percents, 30 to 31 percents and 27 to 30 percents correspondingly. In the case of EU membership the highest percentage increases in production among the fruits & nuts group are likely to be seen in hazelnut, dry fig and apricot with 8.8, 4.6 and 5.9 percents, respectively (Table A3.B.1).

Compared to the baseline scenario, EU-OUT, a small decline (about 0.7 percent) in the production volume of industrial crops is observed under customs union or membership. This is brought about by a 2 % decline in the sugarbeet production. The decline in sugarbeet production results from the rising net sugarbeet imports from EU under membership or customs union situations (USD 94 million under customs union, and USD 148 million under the membership). However, the simulation results show that the trade creation (arising sugarbeet imports from EU) disappears if Turkey exhibits higher yield growths until 2015 (EU-IN2). Table A3.B.1 (In appendix) shows that with customs union or membership the tobacco production does not increases because of the restrictions in its production. The cotton production does not record a sharp increase in membership, compared to the baseline scenario, because of a likely *quota application* of EU on the cotton production of Turkey. Turkey's net cotton exports post only a 5 percent rise in EU scenarios. It does not seem very realistic to expect high expansions in Turkish net cotton exports with membership since in such a case, EU cotton prices would probably tend to decline (since EU cotton prices are significantly higher than that of Turkey). The EU may become one of the major producers of cotton in the world when Turkey becomes a member.

It is expected that meat and milk productions of Turkey will decrease by 6 and 8 percents, respectively, with membership when compared to the non-membership situation (Table 32). The major decline will arise in cow meat and milk with around 9 percents. Production volume of poultry products does not seem to be much affected from membership.

The results on the value of production for product groups are summarized in Table 33. The production value includes changes in both the prices and the quantities. Under membership or customs union, the percentage decline in the livestock product prices is higher than the percentage increases recorded in their production volume. Therefore, the revenue drops even below the base period (2002-2004 average) level in membership or customs union. The production values of livestock products decline by 1.4 percent in EU scenarios. However, if the livestock product payments of CAP are fully applied to Turkey, then this decline disappears and an expansion of 18 percent over base period occurs. Hence, CAP payments can be considerably effective in terms of the revenue of livestock sector under membership.

Table 33 Value of Crop Production in EU Scenarios (USD million)

	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2	CHANGE OVER BASE (%)			
	2002-04	2015	2015	2015	2015	EU-OUT	EU-CU	EU-IN1	EU-IN2
CROP PRODUCTS	***23,191***	***29,275***	***26,448***	***26,128***	***26,172***	***26.2***	***14.0***	***12.7***	***12.9***
+ Comp. Area Pay.	-	-	-	*29,070*	*29,364*			*25.3*	*26.6*
+ Other Crop Pay.	-	-	-	*32,092*	*32,790*			*38.4*	*41.4*
CEREALS	6,509	7,576	5,038	4,764	4,840	16.4	-22.6	-26.8	-25.6
PULSES	942	1,215	1,169	1,170	1,142	29.1	24.2	24.2	21.3
INDUSTRIAL CROPS	2,370	3,370	3,354	3,354	3,931	42.2	41.5	41.5	65.9
OILSEEDS	558	699	418	372	381	25.2	-25.1	-33.3	-31.8
TUBERS	1,511	1,743	1,716	1,716	1,567	15.4	13.6	13.6	3.7
VEGETABLES	4,854	6,237	6,187	6,187	6,074	28.5	27.5	27.5	25.1
FRUITS AND NUTS	6,448	8,436	8,566	8,566	8,237	30.8	32.8	32.8	27.7
LIVESTOCK & POUL.	***10,806***	***15,066***	***10,660***	***10,660***	***11,568***	***39.4***	***-1.4***	***-1.4***	***7.0***
+ Livestock Pay.	-	-	-	*12,722*	*13,750*			*17.7*	*27.2*
MEAT	4,777	6,650	3,376	3,376	3,562	39.2	-29.3	-29.3	-25.4
MILK	3,482	4,918	3,979	3,979	4,390	41.2	14.3	14.3	26.1
HIDE, WOOL & HAIR	249	300	289	289	291	20.5	16.2	16.2	16.7
POULTRY	2,297	3,198	3,015	3,015	3,326	39.2	31.2	31.2	44.8
TOTAL	***33,997***	***44,341***	***37,108***	***36,788***	***37,739***	***30.4***	***9.1***	***8.2***	***11.0***
+ All CAP Pay.	-	-	-	*44,814*	*46,541*			*31.8*	*36.9*

Notes: See text for the scenarios.
Source: Author's calculations.

Table 32 and Table 33 point out that although the volume of meat production increases, its production value is expected to go down with respect to base period. This situation results from high decline in the price level of meat under membership or customs union (Table A3.B.4 in appendix). The declining meat prices with increasing volumes in the meat sector can be explained with the help of Figure 13, given below. Two developments take place in meat sector. (1) Prices decline (movement from P_b to P_{EU}) because of the removal of tariffs, (2) Supply curve shifts right due to the growth in yields so that the new equilibrium quantity is higher than that of the base period with declining prices (movement from q_b to q^*). Note that, the more inelastic the supply curve, the lower is the technological improvement required for this outcome to happen. For instance, with a perfectly inelastic supply curve, all kinds of shifts in the supply curve will lead to this result.

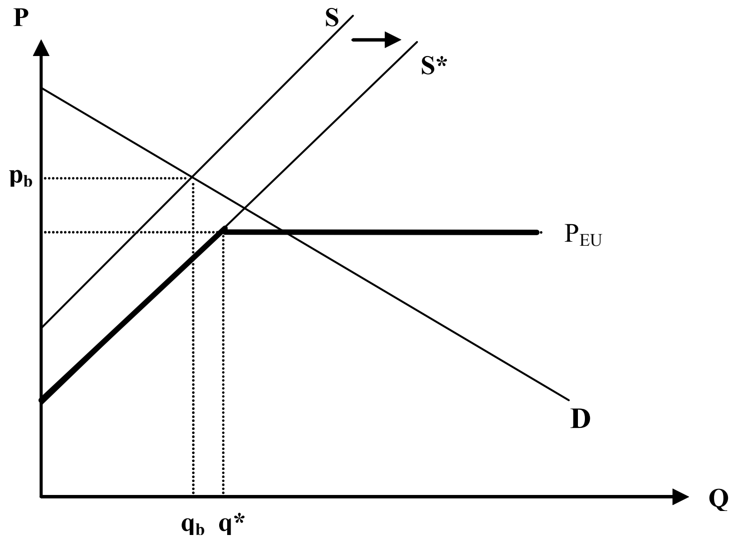

Figure 13 Production Expansion and Decreasing Prices in the Meat sector under EU Scenarios

The poultry products seem to realize the highest expansion in the production revenues under membership with about 31-45 percents, compared to the base period. The value of milk production will rise also in case of EU membership (by about 14-26 percent). However, compared to the baseline scenario, membership leads to about 6 and 19 percent drops in the values of poultry and milk productions, respectively. The hide, wool and hair sector is not affected too much from customs union or membership since the tariffs that Turkey applies for these products are already zero.

The value of crop production increases by 13 percent in the membership scenario (EU-IN1) when compared to the base period, whereas in non membership this expansion is reported as about 26 percent. Hence, in EU scenarios, the value of crop production diminishes substantially (by 11 percent). However, with the inclusion of compensatory area payments of CAP (if fully applied without any reductions), the decline in the revenue of crop production almost disappears. If *other crop payments* of CAP are applied as well, yet an increase by 10 percent in the revenue of crop production is expected to happen.

In all crop sub-sectors, except fruits and nuts, membership or customs union leads to declines in production revenues compared with non membership (EU-OUT). Among the crop products, the largest declines in the value of production are expected in oilseeds and cereals with 47 and 37 percents, respectively. The substantial decrease in the production values of these products results from the fact that their productions and prices drop below the base period levels under membership or customs union. On the other hand, fruits and nuts production value is expected to increase by 1.5 percent in EU scenarios, compared to the baseline simulation.

VII.B.2.3. Consumption

Table 34 shows the impacts of EU simulations on per capita consumptions. The details can be found in Table A4.B.3 in appendix. Some remarks are called for concerning the simulation results. Compared to the base period, total per capita consumption index expands by about 17-18 percent in EU-simulations but only 6 percent in non membership. Per capita consumption of livestock products increases by 28-29 percent under EU scenarios whereas it is expected to decline slightly in non-membership. The biggest rise in livestock products is expected to come up in meat consumption by about 49 percent, however in non membership it decreases by around 4 percent. In the EU simulations, the only product group whose per capita consumption tends to decline compared to non membership is Fruits and Nuts. This shows that the increases in their net exports under membership may lead to some decreases in domestic per capita consumption of these products. Per capita consumption index of total industrial products does not change. Table A3.B.3 illustrates that per capita tobacco consumption does not change with respect to baseline scenario. Per capita consumption of sugarbeet records a 4 percent expansion over baseline with the arising net imports. Per capita cotton consumption declines in EU scenarios compared to baseline simulation. It seems that increase in net exports accompanied with rising prices may pull down per capita domestic consumption.

Table 34 Per Capita Consumption Effects of EU Scenarios (Index)

BASE=100	EU-OUT	EU-CU	EU-IN1	EU-IN2
	2015	2015	2015	2015
CROP PRODUCTS	***109.1***	***110.8***	***110.8***	***112.5***
CEREALS	103.4	110.0	110.0	111.1
PULSES	111.0	113.0	113.0	114.0
INDUSTRIAL CROPS	100.0	99.9	100.0	100.3
OILSEEDS	117.2	118.2	118.1	118.3
TUBERS	110.4	110.7	110.7	112.6
VEGETABLES	113.2	113.5	113.5	114.1
FRUITS AND NUTS	110.4	109.7	109.7	114.0
LIVESTOCK & POUL.	***99.9***	***128.1***	***128.1***	***129.3***
MEAT	96.3	149.4	149.4	149.4
MILK	100.9	114.1	114.1	114.6
HIDE, WOOL & HAIR	111.9	111.9	111.9	111.9
POULTRY	103.2	109.3	109.3	113.9
TOTAL	***105.7***	***117.3***	***117.3***	***118.8***

Notes: See text for the scenarios.
Source: Author's calculations.

VII.B.2.4. Prices

The impact of EU simulations on the overall price level was discussed before. This section is more about the changes in the price levels of individual products. Base period prices are the averages of farm gate prices from 2002 to 2004. Within the model setup, mainly four factors affect the price levels in the simulations. (1) Changes in the border prices determined by world price forecasts, (2) Changes in the agricultural policies of Turkey and EU by 2015, (3) population and real per capita income growths, and (4) Removal of all trade barriers with EU membership.

The prices of fruits and nuts go up with membership (Table 35). The most important reason for this is the entry price mechanism of the EU. Entry price, acting like a variable levy, causes the EU prices to expand. Table A4.B.4

shows that the price of oil olive is expected to increase by 6 percent over the baseline in EU scenarios. The price of hazelnuts goes up by 2 percent in the EU simulations when compared to the non membership situation.

Table 35 Effects on Prices in EU Scenarios (USD/Ton)

BASE=100	EU-OUT	EU-CU	EU-IN1	EU-IN2
	2015	2015	2015	2015
CROP PRODUCTS	***102.5***	***96.6***	***96.7***	***92.0***
CEREALS	101.1	80.3	80.4	77.3
PULSES	104.0	97.2	97.3	94.0
INDUSTRIAL CROPS	121.2	117.6	117.6	116.5
OILSEEDS	93.2	90.3	90.3	89.7
TUBERS	90.7	89.2	89.1	80.0
VEGETABLES	99.2	97.9	97.9	95.6
FRUITS AND NUTS	107.5	108.5	108.5	99.1
LIVESTOCK & POUL.	***122.2***	***91.3***	***91.3***	***90.1***
MEAT	126.4	68.3	68.3	68.3
MILK	120.3	105.9	105.9	105.3
HIDE, WOOL & HAIR	117.4	117.4	117.4	117.4
POULTRY	117.4	110.7	110.7	105.7
TOTAL	***109.9***	***94.6***	***94.6***	***91.3***

Notes: See text for the scenarios.
Source: Author's calculations.

According to Çakmak and Kasnakoğlu (2002), an important factor to follow up closely, on the issue of fruits and nuts prices, is the bilateral trade agreements of EU with third countries, particularly with the North African countries. Price interventions of EU will diminish and the farmers will be compensated through direct payments. Hence, the level of domestic prices may turn out relatively less important for the revenue of the farmers (Çakmak and Kasnakoğlu, 2002, p.33). If Turkey enters into the EU without direct payments, with price declines occurring due to the bilateral trade concessions of EU to third parties, the fruit and vegetable producers may not be able to reap the benefits of membership.

Substantial declines are estimated in cereal prices due to membership (about 21 percent with respect to baseline scenario). Particularly, common wheat price is expected to decline by about 29 percent over baseline. The barley and corn prices decline by 16 and 18 percents, respectively (Table A3.B.4 in appendix).

The rightward shift in the domestic meat demand due to population and per capita income growth that will take place until 2015 does not seem to be compensated for an equal increase in the production volume of the meat sector in case of non membership. As a result of this, in 2015, the cow, sheep and goat meat prices soar to USD 6,269/ton; USD 7,191/ton; and USD 6,813/ton, respectively (Table A3.B.4. in Appendix). Their prices increase by 19, 35 and 37 percents, compared to base period. Hence, if the current status quo goes on without executing effective productivity enhancing measures for the meat sector, the low productivity of the sector combined with high import tariffs will likely produce this result in 2015. This situation gives clues about the possible developments in the future. Simulations point out that; due to notably high domestic prices, in case of membership, net meat import from EU seems to boom and reach to around USD 2,200 million in 2015 from almost nil import level in the base period. As a result of the huge rise in net meat import from EU, prices of cow, sheep and goat meat drop to USD 3,018/ton, USD 4,393/ton, and USD 3,828/ton, respectively The estimated high price increases under non-membership and huge net imports under membership show that, in both cases, the sector should be restructured, its productivity should be augmented, and hence the competitiveness of the sector should be ensured.

VII.B.2.5. Net Exports

Up to this section, we have discussed the impacts of the EU scenarios on the net trade position of several products. Here, we will briefly summarize the main points.

Table 36 reports the net exports of Turkey according to the results of different scenarios. Turkey's net exports of the products included in the model are about USD 2,250 million in the base period, with negligible trade in livestock products (USD 273 million).

The net exports of crop products are expected to increase by 26 percent if Turkey is out of the EU in 2015. The net imports of livestock products increase by 86 percent. Briefly, cereals, oilseeds and livestock products are imported but industrial crops, pulses, tubers, vegetables and fruits are exported in the non membership scenario.

Table 36 Net Exports in EU Scenarios (USD million)

	2002-04	EU-OUT (2015)				EU-CU (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***-611***	***1477***	***1363***	***2228***
CEREALS	-240	-233	-81	-8.0	-322	-233	-1199	42	-1390
PULSES	190	1.4	45	190	237	1.5	51	202	255
INDUSTRIAL CROPS	615	69	551	103	724	69	523	113	705
OILSEEDS	-747	-632	2.9	-293	-922	-632	-190	-293	-1115
TUBERS	55	0.0	4.1	79	83	0.0	4.1	76	80
VEGETABLES	598	59	354	451	864	58	407	430	895
FRUITS AND NUTS	2064	132	1734	807	2672	125	1882	791	2798
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***7.4***	***-3479***	***-233***	***-3704***
MEAT	11	0.0	0.0	1.8	2	0.0	-2168	11	-2157
MILK	-14	0.5	0.5	20	21	0.5	-899	23	-876
HIDE, WOOL & HAIR	-290	7.0	-250	-275	-517	6.9	-248	-287	-528
POULTRY	19	0.0	0.0	19	19	0.0	-164	20	-144
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***-604***	***-2002***	***1130***	***-1476***

	2002-04	EU-IN1 (2015)				EU-IN2 (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	***2537***	***-613***	***1198***	***1362***	***1947***	***-597***	***1659***	***1450***	***2512***
CEREALS	-240	-233	-1446	42	-1637	-231	-1284	51	-1464
PULSES	190	1.5	51	202	255	1.6	53	209	263
INDUSTRIAL CROPS	615	69	523	113	705	69	672	115	856
OILSEEDS	-747	-633	-223	-293	-1149	-633	-210	-293	-1136
TUBERS	55	0.0	4.1	76	80	0.0	4.3	80	85
VEGETABLES	598	58	407	430	895	58	413	431	902
FRUITS AND NUTS	2064	125	1882	791	2798	138	2013	856	3007
LIVESTOCK & POUL.	***-273***	***7.4***	***-3479***	***-233***	***-3705***	***7.4***	***-2596***	***-230***	***-2818***
MEAT	11	0.0	-2168	11	-2157	0.0	-1983	11	-1972
MILK	-14	0.5	-899	23	-876	0.5	-494	24	-470
HIDE, WOOL & HAIR	-290	6.9	-248	-287	-528	6.9	-248	-286	-527
POULTRY	19	0.0	-164	20	-144	0.0	129	21	150
TOTAL	***2264***	***-605***	***-2281***	***1129***	***-1757***	***-590***	***-936***	***1220***	***-306***

Notes: See text for the scenarios.
Source: Author's calculations.

Net imports of livestock products under membership reach to USD 2,027 million and almost all of the imports originate from the EU. The almost non-existing level of trade in livestock products in the base period does not allow us to identify any change in the direction of trade. However, the impact of trade liberalization on the livestock production points out that the shares of EU will be high in imports.

However, in the second membership scenario which assumes higher yield growths until 2015, the overall trade positions change drastically. The net importer position of Turkey drops to USD 547 million from USD 2,027 million. Turkey's net exporter position in crop products improves by about USD 600 million and net importer position in livestock products improves about USD 1,000 million. Technological improvement seems to change the view like a magic stick. This once more stresses the importance of technological improvement.

Table A3.B.5 (In appendix) illustrates that under EU scenarios, for following products, *trade creations* in favor of EU are estimated: rye (USD 29-36 million); sunflower (USD 194-226 million); cow meat (USD 973-1138 million), sheep meat (USD 868-887 million); goat meat (USD 142-143 million); cow milk (USD 461-864 million); goat milk (USD 34-36 million); poultry meat (USD 88 million); and Egg (USD 75 million). However, with higher yield growths until 2015 (EU-IN2), Turkey's rye imports from EU disappears; and net egg and poultry meat exports to EU rise, with USD 55 million and USD 74 million, respectively. Hence, with higher yield growths, the direction of trade creation in poultry meat and egg may be diverted in favor of Turkey.

VII.B.2.6. Regional Effects

The crop production is disaggregated into 4 regions in our model, whereas the livestock production is at the national level. The model may provide clues about the regional effects of membership, at least for the crop production.

Recall that, under Customs Union, with the removal of tariffs and other border protections on the agricultural products of EU, cereal production declined by 6 percent and oilseed production decreased by 18 percent in Turkey (See Table 32 above). Under membership, the obligatory set aside regulations of CAP for cereal and oilseed products led to further shrinkage in the production volumes of these products. The declines in the production volumes of cereals and oilseeds jumped to 12 and 27 percents, respectively. In this situation, it seems reasonable to expect the regions with large shares in the total output of these products to be heavily affected from membership. Clearly, the degree of impact would vary according to the quality and quantity of the resources in the regions. In this framework, it is seen from Table 37 that region that is affected most from the membership will be Central Anatolia. The volume of production in the region declines by about 14 percent with membership. This mainly results from the fact that Central Anatolia supplies 43 and 13 percents of total cereal and oilseed output of Turkey according to the base period (2002-2004 averages) figures. Moreover, region's quality of resources devoted to agricultural production is rather limited which leads to a sharp decline in the crop production volume of the region. If we look at the production values, we can see that the revenue of production in the region is expected to decline by about 22 percent. The decline that occurs in values is higher than that in volumes due to the high decrease that occurs in the price level of cereals and oilseeds under membership. Table 37 reports that even with the full application of direct crop supports of CAP, the production revenue in the region may stay below the level of non-membership (about 2 percent). Hence, it seems that Central Anatolia might be the most vulnerable region to the impacts of EU membership.

The impacts of the quantity and quality of the resources on the regional effects are significant. For example, the production volume of the Coastal region, which can be seen advantageous in this respect, decline by only 5.2 percent under membership although it produces 36 percent of cereal and 84 percent of oilseed products of Turkey according to the base period figures. The production volume of East Anatolia, on the other hand, decreases by 5.4 percent under membership, but it supplies only 7 percent of cereal and 1 percent of oilseed products of Turkey.

Table 37 Regional Effects in EU Scenarios (USD million)

	BP	EU-OUT	EU-CU	EU-IN1	EU-IN2	% CHANGE	
	2002-04	2015	2015	2015	2015	EU-IN1/BP	EU-IN1/OUT
Crop Production Volume	***23,191***	***28,054***	***26,604***	***26,180***	***27,615***	***12.9***	***-6.7***
Coastal Region	12,710	15,835	15,241	15,014	15,711	18.1	-5.2
East Anatolia	1,021	1,133	1,098	1,071	1,190	4.9	-5.4
Central Anatolia	6,599	7,731	6,784	6,665	7,003	1.0	-13.8
GAP Region	2,861	3,355	3,481	3,430	3,712	19.9	2.2
Crop Production Value	***23,191***	***29,275***	***26,448***	***26,128***	***26,172***	***12.7***	***-10.75***
+ Comp. Area Pay.				*29,070*	*29,364*	*25.3*	*-0.7*
+ Other Direct Pay.				*32,092*	*32,790*	*38.4*	*9.6*
Coastal Region	*12,710*	*16,547*	*15,524*	*15,335*	*15,238*	*20.6*	*-7.3*
+ Comp. Area Pay.				*16,337*	*16,343*	*28.5*	*-1.3*
+ Other Direct Pay.				*17,877*	*18,092*	*40.6*	*8.0*
East Anatolia	*1,021*	*1,162*	*1,002*	*996*	*1,025*	*-2.5*	*-14.3*
+ Comp. Area Pay.				*1,248*	*1,315*	*22.2*	*7.4*
+ Other Direct Pay.				*1,298*	*1,365*	*27.1*	*11.7*
Central Anatolia	6,599	7,858	6,221	*6,132*	6,070	*-7.1*	*-22.0*
+ Comp. Area Pay.				*7,412*	7,430	*12.3*	*-5.7*
+ Other Direct Pay.				*7,711*	7,736	*16.9*	*-1.9*
GAP Region	*2,861*	*3,708*	*3,701*	*3,665*	*3,838*	*28.1*	*-1.2*
+ Comp. Area Pay.				*4,073*	*4,277*	*42.4*	*9.9*
+ Other Direct Pay.				*5,206*	*5,597*	*82.0*	*40.4*

Notes: See text for the scenarios.
Source: Author's calculations.

These results reveal the significance of the quality and quantity of the basic factors of production. By the same token, the production volume of GAP region increases by 2.2 % under membership although its shares in the total cereal and oilseed production of Turkey are higher than that of East Anatolia with 14 and 2 percents, respectively. Indeed, in membership, the only expansion in the volume of production seems to happen in the GAP region. The impact of the Southeastern Anatolia Project is evidently notable on this outcome. Table 37 reports that the output volume is expected to enlarge slightly from USD 3,355 million to USD 3,430 million with membership. This mainly results from the increases in the production volumes of industrial crops and vegetables in the region under membership. In addition, the effects of obligatory set aside regulations of CAP is limited in GAP region since its shares in the total cereal and oilseed productions of Turkey are relatively small, especially compared to Central Anatolia and Coastal region. Thus, the expansion in the production volume of industrial crops and vegetables in GAP region outweighs the decline in the production volume of cereals and oilseeds. However, Table 37 also illustrates that, due to the decrease in the price level of crops under membership, the crop production revenue of GAP can stay a little below the level of non-membership.

VII.B.3. CAP Support Estimates for Turkish Agriculture

The budgetary outlays for CAP calculated[58] from our model simulations for two membership scenarios show that the total CAP direct payments (if fully implemented) will be in the interval of USD 8,000-8,800 million depending on the technological improvements that Turkey will experience until 2015. In the first membership scenario, about USD 2,942 million are paid for the *compensatory area payments* of cereals, oilseeds and protein crops. About USD 3,022 million is for *other crop payments*. That is for durum wheat, tobacco, olive oil, hazelnuts and cotton productions. For *livestock products*, a budgetary outlay about USD 2,062 million is calculated. This amount includes the payments for milk, beef and sheep meat productions. Taking into account the 1.5 % annual inflation assumption made for the Euro area, these amounts can be restated as EUR 1,963 million (at 2004 prices) for compensatory area payments; EUR 2,017 million (at 2004 prices) for other crop payments; EUR 1,376 million (at 2004 prices) for livestock products. The total of these payments amounts to EUR 5,350 million (at 2004 prices). Grethe (2005) estimates total CAP direct payments as EUR 5,274 million (at 2004 prices). Although our estimates for total budgetary outlays are very similar with that of

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[58] The following assumptions apply: direct payments for milk fully implemented, 5% modulation fully implemented, beef premiums/ton 50% above EU level as most payments are made per animal and Turkey has a higher number of animals/ton of meat produced, direct payments for sugar not yet included, direct payments fixed in nominal values, inflation in EU area between 2004 and 2015 assumed 1.5 % annually. These assumptions are similar to Grethe (2005).

Grethe (2005), the distribution of payments is different. The total payments reach to EUR 5,873 million (at 2004 prices) if Turkey experiences a higher yield growth until 2015[59]. This amount can be seen as an upper bound for total CAP direct payments.

However, as Grethe (2005, p.131) pointed out, the calculation of such numbers ignores the fact that Turkish producers are not very likely to ever paid direct income transfers of such size from the EU budget. Until the accession of Turkey, the high costs of such payments to the EU budget will probably result in further reforms in the direct payment system of the EU.

Table 38 reports the total CAP outlays in the form of direct payments to the regions under the EU-IN1 scenario.

Table 38 Total CAP Payments for EU-IN1 Scenario (USD million)

	EU-IN1 (2015)				
	Coastal	Central	Eastern	GAP	Turkey
Total Crop Payments	**2,542**	**1,579**	**302**	**1,542**	**5,964**
Compensatory Area Payments	*1,002*	*1,280*	*252*	*408*	*2,942*
Cereals	907	1,215	191	406	2,719
Oilseeds	75	12	0.6	1.5	89
Protein Crops	20	53	59	1.1	133
Other Direct Crop Payments	*1,539*	*299*	*51*	*1,133*	*3,022*
Durum Wheat	*47*	218	32	122	419
Hazelnut	*48*	0.2	0.1		48
Tobacco	*346*	33	18	51	447
Olive Oil	202	1.3		45	249
Cotton	*896*	46	0.5	916	1,858
Total Livestock Payments*	***975***	***615***	***236***	***236***	***2,062***
Beef Payments	*385*	*313*	*87*	*49*	*834*
Sheep Meat Payments	*366*	*159*	*46*	*159*	*730*
Milk Payments	*224*	*143*	*103*	*29*	*499*
TOTAL DIRECT PAYMENTS	***3,516***	***2,193***	***538***	***1,778***	***8,026***

Note: * Distributed according to livestock shares in base period.
Source: Author's calculations.

The largest portion of total direct payments (44 percent) will likely go to Coastal Region. Then Central Anatolia comes, receiving 27 percent of total

[59] This scenario estimates about EUR 2,130 million (at 2004 prices) for compensatory area payments; EUR 2,287 million (at 2004 prices) for other crop payments; and about EUR 1,456 million (at 2004 prices) for livestock products.

CAP outlays. The GAP region follows Central Anatolia with 22 percent. We expect the lowest share to go to East Anatolia with only 7 percent.

In terms of the compensatory area payments, Central Anatolia seems to get the biggest share (about 44 percent) with USD 1,280 million. Coastal region may obtain around USD 1,000 million which constitutes 34 percent of the total. The remaining 22 percent will be distributed to GAP (about 14 percent) and East Anatolia (about 8 percent).

Regarding the other direct crop payments, which represent the outlays for durum wheat, hazelnut, tobacco, olive oil and cotton, the largest payment (USD 1,239 million) goes to Coastal region accounting 51 percent of the total. GAP region is expected to get about 37 percent of these payments. Central Anatolia region will be paid by about USD 300 million which constitutes 9 percent of total. The highest payment for durum wheat, on the other hand, goes to Central Anatolia with USD 218 million. The least beneficiary region from of this group of payments is East Anatolia again, with less than 2 percent. The main part of livestock payments (47 percent) goes to Coastal Region with around USD 975 million. The other 30 percent of the total livestock payments is expected to be done to Central Anatolia with USD 615 million. East Anatolia is estimated to have about 11 percent of total livestock payments. This ratio is the same for GAP region, as well (11 percent). Table 39 illustrates the payments this time for the case of EU-IN2 which is our optimistic scenario.

As we stated at the outset of this section, it is not likely that Turkish producers will obtain the amounts that we have calculated above. However, in terms of negotiations the upper bounds of the payments are important. Most probably, the decreases in the payments will be done proportionately; hence, the percentages for regional payments of the above analysis may not change notably.

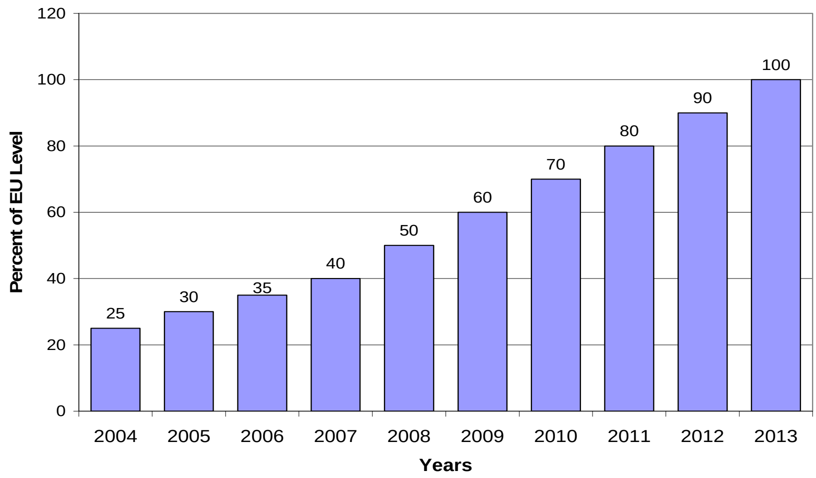
Table 39 Total CAP Payments for EU-IN2 Scenario (USD million)

	EU-IN2 (2015)				
	Coastal	Central	Eastern	GAP	Turkey
Total Crop Payments	**2,854**	**1,666**	**340**	**1,759**	**6,619**
Compensatory Area Payments	*1,104*	*1,360*	*289*	*439*	*3,192*
Cereals	1,005	1,295	206	436	2,942
Oilseeds	78	13	0.6	1.4	93
Protein Crops	20	53	83	1.1	157
Other Direct Crop Payments	*1,749*	*307*	*50*	*1,320*	*3,427*
Durum Wheat	*41*	217	32	122	411
Hazelnut	*49*	0.2	0.1		49
Tobacco	*346*	33	18	51	447
Olive Oil	238	1.3		48	287
Cotton	*1,077*	55	0.6	1,100	2,233
Total Livestock Payments*	***1,030***	***654***	***253***	***245***	***2,182***
Beef Payments	*416*	*338*	*94*	*52*	*900*
Sheep Meat Payments	*370*	*160*	*47*	*161*	*738*
Milk Payments	*244*	*156*	*112*	*31*	*544*
TOTAL DIRECT PAYMENTS	***3,884***	***2,321***	***593***	***2,004***	***8,801***

Note: * Distributed according to livestock shares in base period.
Source: Author's calculations.

Table 40 shows the budgetary outlays (2004 €) for direct payments under different reform and phasing assumptions for the case of the first membership scenario (EU-IN1). In the calculations, again we follow the assumptions made by Grethe (2005). The first column in Table 40 shows the possible budgetary outlays in case of full application of direct payments to Turkey in 2015 in their current form. These are the same figures that we presented above. However, this is not likely to happen as we stated in the previous paragraph. As Grethe (2005, p.131) pointed out the European Commission has already mentioned phasing in the direct payments for Turkey as for the new member 10 countries and as scheduled for Bulgaria and Romania (EU Commission, 2004a). The percentages of the EU-15 level that apply to the new Member States in each year are shown in Figure 14 below.

The second column in Table 40 reports the payments that Turkey can get in the first year of membership. Hence, such an approach decreases direct payments for Turkey in 2015 from EUR 5,350 million (at 2004 prices) to EUR 1,340 million (at 2004 prices). The second group of columns under the title "Reductions in Direct Payments" reports the corresponding values for the same figures assuming that the nominal level of direct payments in the EU will reduce by an annual rate of *3 percent* until 2015. The full implementation of the direct payments to Turkey results in a budgetary outlay of about EUR 3,800 million (at 2004 prices) in 2015.



Source: EU Commission (2004b, p.11)

Figure 14 Direct Payments for New EU Members (Phased in over 10 years)

Table 40 Budgetary Outlays for Direct Payments (EU-IN1) in 2004 €

	Current Policies			Reduction in Direct Payments		
	2015 Full	2015, 25%	2025	2015 Full	2015, 25%	2025
Total Crop Payments	**3,979**	**995**	**3,464**	**2,846**	**712**	**1,772**
Compensatory Area Pay.	*1,963*	*491*	*1,708*	*1,404*	*351*	*874*
Cereals	1,814	454	1,579	1,298	324	808
Oilseeds	60	15	52	43	11	27
Protein Crops	89	22	78	64	16	40
Other Direct Crop Pay.	*2,017*	*504*	*1,755*	*1,442*	*361*	*898*
Durum Wheat	280	70	244	200	50	125
Hazelnut	32	8	28	23	6	14
Tobacco	298	75	260	213	53	133
Olive Oil	166	42	145	119	30	74
Cotton	1,240	310	1,079	887	222	552
Total Livestock Payments*	**1,376**	**344**	**1,198**	**984**	**246**	**613**
Beef Payments	*557*	*139*	*484*	*398*	*100*	*248*
Sheep Meat Payments	*487*	*122*	*424*	*348*	*87*	*217*
Milk Payments	*333*	*83*	*290*	*238*	*60*	*148*
TOTAL	**5,355**	**1,339**	**4,661**	**3,831**	**958**	**2,385**

Note: * Distributed according to livestock shares in base period
Source: Author's calculations.

In the case of phasing in over 10 years, the total payment that Turkey might get in 2015 drops to about EUR 958 million (at 2004 prices). In 2025, when the phasing in period ends up, the total outlays for direct payments will be around EUR 2,400 million (at 2004 prices).

Table 41 reports the same figures for the EU-IN2 scenario. The figures in this table can be seen an upper bound for the total payments. Under the EU-IN2 scenario, the full implementation of the direct payments to Turkey results in a budgetary outlay of about EUR 4,200 million (at 2004 prices) in 2015.

Table 41 Budgetary Outlays for Direct Payments (EU-IN2) in 2004 €

	Current Policies			Reduction in Direct Payments		
	2015 Full	2015, 25%	2025	2015 Full	2015, 25%	2025
Total Crop Payments	**4,416**	**1,104**	**3,844**	**3,159**	**790**	**1,967**
Compensatory Area Pay.	*2,130*	*532*	*1,854*	*1,523*	*381*	*948*
Cereals	1,963	491	1,708	1,404	351	874
Oilseeds	62	16	54	44	11	28
Protein Crops	105	26	91	75	19	47
Other Direct Crop Pay.	*2,287*	*572*	*1,990*	*1,636*	*409*	*1,018*
Durum Wheat	274	69	239	196	49	122
Hazelnut	33	8	28	23	6	15
Tobacco	298	75	260	213	53	133
Olive Oil	191	48	166	137	34	85
Cotton	1,490	372	1,297	1,066	266	664
Total Livestock Payments*	**1,456**	**364**	**1,267**	**1,042**	**260**	**649**
Beef Payments	*601*	*150*	*523*	*430*	*107*	*268*
Sheep Meat Payments	*492*	*123*	*429*	*352*	*88*	*219*
Milk Payments	*363*	*91*	*316*	*260*	*65*	*162*
TOTAL	**5,873**	**1,468**	**5,111**	**4,201**	**1,050**	**2,615**

Note: * Distributed according to livestock shares in base period
Source: Author's calculations.

In the case of phasing in over 10 years, the total payment that Turkey would get in 2015 is estimated as about EUR 1,050 million (at 2004 prices). In 2025, when the phasing in period is finished, the total outlays for direct payments would be around EUR 2,600 million (at 2004 prices).

CHAPTER VIII

CONCLUSION

Science may be described as the art of systematic over-simplification.

Karl Popper (1982)
The Observer

Turkey has proceeded on a path towards integration with the EU since the Association Agreement (known as the Ankara Agreement) in 1963. The Ankara Agreement, which entered into force on 1 December 1964, aimed at securing Turkey's full membership in the European Economic Community[60] (EEC) through the establishment of a customs union which would serve as an instrument to bring about integration between the EEC and Turkey. The Ankara Agreement was supplemented by an *additional protocol* signed in November 1970, which set out a timetable for the abolition of tariffs and quotas on goods circulating between Turkey and the EEC. In 1995, customs union between Turkey and EU was formed. The Customs Union has entered

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[60] The predecessor of the EU.

into force as of January 1, 1996 and eliminated all custom duties and charges having equivalent effect on imports of industrial products from the EU. It has covered only manufacturing components of the processed agricultural products containing cereals, sugar and milk along with industrial products. At the Helsinki European Council of December 1999, Turkey was officially recognized as a candidate state on an equal footing with other candidate states. On 17 December 2004, the European Council defined the perspective for the opening of accession negotiations with Turkey. In October 2005, the screening process concerning the analytical examination of the *acquis* has started. Turkey closed the first chapter of its negotiations with the EU in June 2006[61]. The accession, *if any*, seems unlikely to happen before 2015 since the European Commission stated that the EU will need to define *its financial perspective for the period from 2014 before negotiations can be concluded.*[62]

Membership of Turkey will lead to full liberalization of agricultural trade with the EU since the agricultural components of agro-food products are excluded in the current customs union agreement between EU and Turkey. EU is a major trading partner of Turkey in agricultural products. Further expansion of economic integration with the EU would imply changes in the structure of production in Turkey and trade flows with the EU and the rest of the world. The possible results of the abolition of trade barriers between the EU and Turkey in agriculture have the outmost importance for the policy makers both in the EU and Turkey. The impacts of the shift in policy structure coupled with trade implications will be crucial both in the determination of the exceptions and derogations in agriculture during the membership negotiation process, and eventually in the estimation of net burden of Turkey's membership to the EU

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[61] The Science and Research chapter of Turkey's accession negotiations was discussed by the Council of Ministers on 12 June 2006, the first of the 35 chapters for the negotiations, assessing the compatibility of Turkish and EU law. The Council concluded that given Turkey's good general state of preparedness in the area of science and research, benchmarks were not required and the chapter required no further negotiations (EU, Ref: IP/06/1151, 05/09/2006).

[62] Commission document COM(2004) 656 final: Recommendation of the European Commission on Turkey's progress towards accession, p.10.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2004:0656:FIN:EN:DOC

budget. Çakmak and Kasnakoğlu (2002) point out that the benefits of trade liberalization between EU and Turkey are bound to depend on the path of agricultural policies both in Turkey and in the EU, and also on the process of accession negotiations. In this context, analyzing the potential effects of Turkey's EU membership on agricultural production and trade in Turkey takes on greater importance. However, as rightly pointed out in the EU Commission (2004c, p.33), any assessment of these effects must necessarily be based on a solid economic analysis of the impact on the existing *acquis*.

Agricultural protection continues to be the most controversial issue in global trade negotiations. Although limited, the industrial countries have started to reduce distortions in their agricultural trade policies. The pressures for liberalization of the agricultural trade will probably rise in the future. The Uruguay Round Agreement on Agriculture (1995) included a commitment to further progressive liberalization of the sector. A new round of negotiations was launched in Doha in November 2001. On 31 July 2004, the WTO's 147 Member Governments approved a Framework Agreement. The Framework Agreement affirms that substantial overall tariff reductions will be achieved as a final result from negotiations (FAO, 2005a, p.29). In December 2005, negotiations at the Hong Kong Ministerial ended with an agreement to ensure the parallel removal of all forms of export subsidies and disciplines on all export measures with equivalent effect by the end of 2013. However, the July 2006 negotiations in Geneva failed to reach an agreement about reducing farming subsidies and lowering import taxes. Hence, an application of an agreement before 2015 seems unlikely. Assessing the potential effects of a new WTO agreement is crucial both to determine the attitude of Turkey during the negotiations and to design necessary agricultural policies for the impacts. However, as we stated above, any assessment must necessarily be based on a solid economic analysis.

In the economic literature, several types of economic models are used in order to evaluate the possible impacts of a variety of policy alternatives and scenarios. The choice between these types depends on the aim of the analysis and the availability of data. Provided that adequate information is available, *econometric models* are usually preferred. However in dealing with agricultural development and policy issues the econometric analysis may be impractical since adequate data are extremely difficult to obtain. A sound alternative to econometrics is *mathematical programming* approach which requires a limited amount of information. For an accurate policy impact assessment, an essential point is that the models used for this purpose should be *positive* in their nature rather than *normative* since the latter answers the question, "what should happen?" while the former answers the question, "what will happen?" Positive models represent the economic environment *as it is* hence allows us to analyze the impacts of a change on this environment. Such a positive model can be solved under different assumptions about policy parameters, and the corresponding solutions provide information about the possible consequences of policy changes (Hazel and Norton, 1986, p.5).

To select the appropriate modeling type, we reviewed economic modeling practices under the heading of four broad categories: Global Trade Models, Computable General Equilibrium Models (CGE), Agricultural Sector Models and Farm Level Models. The review is not only intended to justify our choice of our modeling methodology but also to represent the main tendencies in the area of economic modeling for the agricultural policy impact analysis together with their pros and cons. As a result of our review, taking into account the data availability, regional differences, scope of our study, preferred disaggregation at product level, the complex interactions within the agricultural sector, and the tradition of Turkish Agricultural Sector modeling, TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002), we have decided to use agricultural sector modeling. The review of the experiences of TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002), TURKSIM (Grethe, 2003) and CAPRI Project of the EU provided valuable knowledge and insights which helped us to define the perspectives of the new model. Our model (TAGRIS) represents the *third* generation of the policy impact analysis using sector models, following TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002) and further develops and improves their methodologies. The use of Howitt's Positive Mathematical Programming (PMP) method for the calibration of domestic supply constitutes the core of TASM (Kasnakoğlu and Bauer, 1988) and TASM-EU (Çakmak and Kasnakoğlu, 2002) models and ensures the *necessary* adoption of the *positive* approach for policy analysis in their model structures. PMP method calibrates the model to the observed values of the base year by means of incorporating the behavior of the farmers to the model. It reconstructs the cost function of the agricultural sector recovering the hidden (opportunity) cost information, which cannot be directly observed by the modeler due to the lack of data, from sector's base year output decisions. As Çakmak and Kasnakoğlu (2002) rightly pointed out this approach is consistent with the main goal of the sector models: to simulate the response of the producers to changes in market environments, resource endowments, and production techniques. Hence, although the models are optimization models mathematically, they become simulation models by incorporating the behavior of the agents (maximization of economic surpluses) into the models' structure. In 1998, the PMP method was developed further with the integration of *Generalized Maximum Entropy* formalism of Golan *et al* (1996) by Paris and Howitt (1998). This contribution ensured the possibility of estimation of *all* parameters of the cost functions, including cross terms. Later on, this approach was extended to more than one *cross sectional* framework by Heckelei and Britz (1999 and 2000), and used in the construction of *Common Agricultural Policy Regional Impact* (CAPRI) model of the EU. This new version permits to take into account some further cross sectional information such as regional differences of *profitability* and *production scales* in the estimation of full cost matrix. In light of these developments in the literature, we decided to follow Heckelei and Britz (1999 and 2000) for the supply calibration of our model. The Maximum Entropy Econometrics of Golan *et al* (1996) is not easy to perceive and follows a completely different logic from the traditional *frequentist* econometrics. Therefore, a detailed review of this new area of econometrics is needed before the illustration of Maximum Entropy based Positive Mathematical Programming. Two separate chapters are devoted to both of these methods.

The new Turkish Agricultural Sector model is presented in Chapter VI. The model is a partial equilibrium comparative static agricultural sector model based on non-linear programming. It maximizes the *Marshallian surplus* (consumer plus producer surplus) so the output prices are endogenous following Samuelson (1952) and Takayama and Judge (1964). The calibration of demand follows the elasticity based approach. The calibration of supply follows Heckelei and Britz (1999 and 2000) as stated above. Foreign trade is allowed in raw and in raw equivalent form for processed products and trade is differentiated for EU, USA and the rest of the world (ROW). The base period of the model is the average from 2002 to 2004.

The model uses the maximum entropy based PMP methodology of Heckelei and Britz (1999 and 2000) in a *single* simultaneous system of demand and supply, instead of splitting up the model structure into a *supply* and a *market* component as in the case of CAPRI. The proposed system *simultaneously* solves for equilibrium between supply and demand and finds the equilibrium prices and quantities, by maximizing the sum of producer and consumer surplus. In other words, the whole system is solved as a unique model.

Elasticity based PMP methodology is integrated to the model in order to calibrate the exports to the base year observations. This application assigns increasing marginal cost functions for exports and hence prevents the drastic changes in the exports occurring due to the changes in the border prices. The approach seems reasonable since drastic export changes should necessitate accompanied changes in their costs, usually related to the changes in marketing and transportation costs. Hazel and Norton (1986, p.263) remark that, marketing costs are roughly similar for exports and domestic products, and if the exports are at the producer-level commodity balances, those costs would not be taken into account. Hence incremental costs for export should be included in the objective function in this case. To our knowledge, this problem has not been addressed in this way before.

Furthermore, the yield growth estimates are obtained by using a hybrid two-step estimation procedure consisting of Generalized Maximum Entropy (GME) and Ordinary Least Square (OLS) estimators. This allows for the estimation of annual yield growth rates with the data of recent years but with taking into account the information in the large sample historical data.

In this thesis, *two sets of scenarios* are defined and analyzed for their impacts in the year 2015. The first group is *Non-EU Scenarios*. This set includes two simulations. First simulation describes the non membership situation in which no changes are assumed in the current agricultural and trade policies of Turkey until 2015. Second simulation assumes that there will be a 15 percent decrease in Turkey's binding WTO tariff commitments in 2015. The second group is *EU Scenarios*. This set includes three simulations. First simulation assumes that Turkey is not a member of EU but extends the current Customs Union agreement with the EU to agricultural products. Second simulation describes Turkey as a member of the EU in 2015. The last simulation represents a second membership scenario; the difference is that, in this simulation, higher improvements in the product yields than the first one is assumed.

The overall results for the EU scenarios may be summarized with some remarks. Total surplus is not expected to be heavily affected from membership or customs union. However, the impacts on consumer and producers are different. Assuming that the prevailing EU and Turkish agricultural policies remain intact, the customs union or membership will be definitely beneficial to the consumers due to mainly the decline in price levels. The impacts on producers depend heavily on the implementation of CAP payments. Without direct payments of CAP, the impact of membership seems to be worse than customs union due to the application of obligatory set aside regulations of CAP under membership. However, if full CAP support is obtained the producer surplus expands more than the non-membership situation. Hence, we can conclude that the implementation of CAP payments will be crucial in terms of the welfare of producers under membership.

Simulations show that in all cases, both the value and the volume of crop production will be larger than base period levels. However, under EU scenarios, the values of livestock products may fall below the base period levels. The producers of some products will not be able to remain competitive. EU scenarios seem to be beneficial only for the GAP region in terms of production. In all other regions volume of production declines and this decline is most sharply in Central Anatolia due to the high declines in cereal and oilseed production. Crop and livestock products consumption expands in all cases, over the base period, but more significantly under EU scenarios. In addition, due to the drops in prices, relatively high consumption levels are achieved at much lower costs under EU scenarios compared to non membership. This pattern is observed more significantly in the consumption of livestock products. The overall price level is estimated to fall below its base period level under EU scenarios whereas in non membership it goes up above its base period level. This holds true for both the crop and livestock products, however, price changes are expected to be larger in livestock products compared to crops.

Under membership or customs union, Turkey seems to become a net importer of agricultural products since Turkey's net exports of crop products will not be able to compensate the boom in the net imports of livestock products. Almost all imports of livestock products will be from the EU. However, with higher yield growth performances, volume of net imports may be significantly decreased. This shows the effectiveness of technological improvement. Compared with results of Çakmak and Kasnakoğlu (2002), one can say that there is an improvement in the competitiveness of livestock sector due to the increases experienced in their yields in the last years, but except poultry sector that is not enough. Apart from livestock products, net imports of cereal and oilseeds can record large expansions under membership or customs union. Particularly, corn and wheat net imports can expand sharply under membership or customs union, so well defined policies should be directed to improve the competitiveness of these alarming sectors.

The direct payments of CAP, if fully implemented (which is not a likely case), will be in the interval of USD 8.0-8.8 billion depending on the technological improvement of Turkey until 2015. Coastal region seems to benefit the most from these payments however East Anatolia will have the lowest share, only 7% of total payments. If EU phases the payments of CAP supports in over 10 years, in 2015 Turkey can have a total of EUR 1.0-1.5 billion[63] agricultural support depending on Turkey's technological improvement in yields and whether EU implements CAP reforms reducing the subsidies.

The EU-scenario results reveal that technological improvement is remarkably effective; it can change everything in the opposite direction in some cases. That stresses the importance of policies to improve the yield levels, or productivity in broader terms.

The overall results for the Non-EU scenarios may be summarized as follows. Our model, given that the prevailing policy environment remains intact, estimates high price increases for livestock products, particularly for meat and milk, in 2015. The main reason for this high increase is that the shift in demand arising due to the real per capita income and population growth can not be compensated by a corresponding shift in supply. Since the tariff rates of Turkey for these products are notably high, the increase in demand can not be satisfied by increasing imports as well, and consequently prices tend to move up significantly. Regarding trade, it is projected that the net exports of crop products may expand notably until 2015; however, common wheat, corn, sugar

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[63] At 2004 prices.

beet, sesame and soybean sectors give signals of high net imports. The net imports of livestock products expand, as well. Given this situation of the agricultural sector, our WTO simulation points out a 15 percent reduction in Turkey's WTO tariff rate commitments will be beneficial to consumers with a small negative impact on the welfare of producers. The total welfare does not seem to be affected at all. The impact of tariff reduction on the volume of both the production and consumption is small. The prices of agricultural products decline slightly, but the decline in meat prices seems to be larger. The reductions in border protections will probably lead to a decrease in net exports by around USD 250 million. Expansion in net meat imports will account for almost all of the decrease in net exports. The impact of tariff reductions on net exports of crop products and other livestock products are rather negligible.

The results of our simulations point out to the necessity of changing the attitude towards agriculture. The main important point is to enhance the competitive power of agricultural sector via improving its productivity. Since the late 1980s, policy makers in Turkey have preferred to support agriculture by distorting prices instead of investing to productivity increasing programs. These policies did not contribute to the productivity of Turkish agricultural sector. Consequently, although Turkey has rich natural and human resources, its agricultural sector never reached its potential because of these increasingly inefficient agricultural policies implemented during the last decade.

Following Rausser (1992) and Çakmak and Kasnakoğlu (2002), we can categorize agricultural policies into two broad groups. The first group can be called as *productive policies* since it aims at the improvement of efficiency in the use of resources both in production and consumption. Areas such as, research and development, reduction of transaction costs, infrastructural services, quality and standard control, crop insurance, and extension services, all geared towards increasing the economic growth, are included in this group. Second group which can be named as *distributional policies*, consists of policies such as price supports, deficiency payments, interventions at the border, input subsidies, subsidized credits, by which wealth and income are transferred from the rest of the economy to agricultural producers. Economic and political returns of the productive policies are paid back throughout time. During the initial periods, they usually require transforming the institutional structure and use of public resources for effective organization. On the other hand, political returns of the policies that only include transfers are recouped in the short run. Governments in Turkey tended generally to choose the second group in order to strengthen their political returns (Çakmak, 2004) and therefore we came to the current situation of Turkish agricultural sector.

Turkey has been reforming its agricultural policies since 2000. However, the weight of productive policies is still negligible. Turkey should place more and more emphasis on productive policies. The long-term objective of agricultural policies obviously needs to be the improvement of productivity in the sector. Otherwise, given the ongoing developments, the sector will face a challenging international competition. Major policies that can be used to accomplish the change are technological development, improvement of productive resources, and more market-friendly policy environment in agriculture. The absence of markets or the imperfections in some input and output markets will be the frustrating factors along the path of this transformation. Therefore, state should regulate the factor markets and correct the externalities. Clear definition of property rights in land is the major issue in rural areas. The lack of effective cadastral works prevents agricultural land markets from working and thereby increases the costs. The prevailing conditions of the markets hamper structural transformation and restrict the set of policy tools that could be used. They also decrease the success chances of the new policies. Hence, it is necessary to upgrade the capacity of agricultural policy environment to handle the policy reforms (Çakmak, Kasnakoğlu and Akder, 1999).

Research, extension and training services need to be heavily and urgently provided by the state. In addition the perspective of the policies should be directed to cover the overall supply chain. This chain involves, in order, input supply, mode of production, productivity, pre and post-harvest technologies, management and marketing, and consumption. The agricultural policy needs to cover the appropriate measures for trade, as well.

Finally, without the construction of a detailed database for agricultural sector, the policy recommendations in order to increase productivity will not be healthy. A data network system like FADN (Farm Accountancy Data Network) of the EU is very crucial in this respect. The production costs, revenues and all data about production activities are important. Detailed cost analysis for each product at province level (at least) by different farm typologies should be done. This analysis needs to cover all the nodes in the supply chain from producer to both domestic and foreign consumers.

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APPENDICES

A1. OECD CLASSIFICATION OF POLICY MEASURES

The following list gives the classification of policy measures included in the OECD indicators of support (OECD, 2004).

I. Producer Support Estimate (PSE) [Sum of A to H]

A. Market Price Support
1. Based on unlimited output
2. Based on limited output
3. Price levies
4. Excess feed cost

B. Payments based on output
1. Based on unlimited output
2. Based on limited output

C. Payments based on area planted/animal numbers
1. Based on unlimited area or animal numbers
2. Based on limited area or animal numbers

D. Payments based on historical entitlements
1. Based on historical plantings/animal numbers or production
2. Based on historical support programs

E. Payments based on input use
1. Based on use of variable inputs
2. Based on use of on-farm services
3. Based on use of fixed inputs

F. Payments based on input constraints
1. Based on constraints on variable inputs
2. Based on constraints on fixed inputs
3. Based on constraints on a set of inputs

G. Payments based on overall farming income
1. Based on farm income level
2. Based on established minimum income

H. Miscellaneous payments
1. National payments
2. Sub-national payments

II. General Services Support Estimate (GSSE) [Sum of I to O]

I. Research and development
J. Agricultural schools
K. Inspection services
L. Infrastructure
M. Marketing and promotion
N. Public stockholding
O. Miscellaneous

III. Consumer Support Estimate (CSE) [Sum of P to S]

P. Transfers to producers from consumers
Q. Other transfers from consumers
R. Transfers to consumers from taxpayers
S. Excess Feed Cost

IV. Total Support Estimate (TSE) [I + II + R]

T. Transfers from consumers
U. Transfers from taxpayers
V. Budget revenues

Producer Support Estimate (PSE) is an indicator of the annual monetary value of gross transfers from consumers to tax payers to support agricultural producers, measured at farm gate level, stemming from policy measures which support agriculture. Percentage PSE is defined as the share of transfer in every TRY100 of producers' receipts. *Market Price Support (MPS)* is the major item in PSE. This is an indicator of the annual monetary value of gross transfers from consumers to agricultural producers arising from policy measures creating a difference between domestic market prices and border prices (world price at the border) of a specific commodity, measured at the farm gate level.

The transfers provided to the sector but that are not received by producers individually are reflected in the General Services Support Estimate (GSSE). These transfers include research and development activities, infrastructure, inspection, and marketing and promotion.

Consumer Support Estimate (CSE) is a measurement of the value of monetary transfers to consumers arising from agricultural policies in a given year. Percent (CSE) is the share of transfer in every TRY100 paid by consumers. Positive values indicate (implicit) subsidy, negative values measures the (implicit) tax on consumers as a share of consumption expenditure at the farm gate. In other words, Percent CSE is an indicator showing the costs (benefits) that support policies impose on consumption by increasing (decreasing) the prices paid by consumers (measured at farm gate).

Total Support Estimate (TSE) is an indicator of the annual monetary value of all gross transfers from consumers and taxpayers originating from policy measures which support agriculture, net of associated budget receipts. The TSE/GDP measures the overall transfers from agricultural policy as a percentage of GDP.

A2. MODEL PRODUCTS AND ALGEBRAIC PRESENTATION

A2.A Regional Distribution of Crop Production Activities

	Coastal				Central Anatolia				East Anatolia				GAP			
	R	I	F	O	R	I	F	O	R	I	F	O	R	I	F	O
CEREALS																
Wheat (soft)	X	X	X		X	X	X		X	X	X		X	X	X	
Wheat (durum)	X	X	X		X	X	X						X	X	X	
Barley	X	X	X		X	X	X		X	X	X		X	X	X	
Corn	X	X			X	X			X	X			X	X		
Rice		X				X								X		
Oats,rye,spelt,millet	X		X		X		X		X		X		X		X	
PULSES																
Chick pea	X	X			X	X			X	X			X	X		
Lentil	X				X				X				X			
Dry bean		X				X				X				X		
INDUSTRIAL CR.																
Tobacco	X				X				X	X			X			
Sugar beet		X				X				X				X		
Cotton		X				X				X				X		
OILSEEDS																
Sunflower	X	X			X	X							X	X		
Sesame	X												X			
Soybean		X				X								X		
Groundnut		X												X		
TUBERS																
Onion	X	X			X	X			X	X			X	X		
Potato		X				X				X				X		
VEGETABLES																
Watermelon-Melon	X	X			X	X			X	X			X	X		
Cucumber		X				X				X				X		
Eggplant		X				X				X				X		
Tomato (fresh)		X				X				X				X		
Tomato (processing)		X				X								X		
Green pepper		X				X				X				X		
FRUITS-NUTS																
Apple				X				X				X				X
Apricot				X				X				X				X
Peach				X				X								X
Olive (table)				X				X								X
Olive (oil)				X												X
Citrus				X												
Pistachio																X
Hazelnut				X				X								
Fig (dry)				X												X
Grape (fresh)				X				X				X				X
Grape (dry)				X				X								X
Tea				X												
FORAGE																
Alfalfa		X				X				X				X		
Cow&wild vetch,sainfo	X				X				X				X			

Note: R: Rain fed, I: Irrigated, F: Fallow, O: Orchard.

A2.B Algebraic Presentation of the Model

INDICES[64]

s	=	Land type (rain fed, irrigated, orchard, meadows and pasture
l	=	Quarterly labor
m	=	Quarterly machinery
f	=	Chemical fertilizers (N, P)
i, i'	=	Crop production activities
j, j'	=	Livestock and poultry production activities
e	=	Cost items (labor, machinery, fertilizer, seed, seedlings, annualized set-up investment)
o	=	Output
oc	=	Crop output
ol	=	Livestock output
$g1$	=	Feed, straw and forage
$g2$	=	Feed, concentrate
$g3$	=	Feed, cereals
$g4$	=	Feed, oilseeds
$g5$	=	Feed, high quality forage and silage
tf	=	Total feed energy supply (tstraw,tconcen,tgrain,toil,tfodd,tpast)
ts	=	Energy needs of livestock (tgrconoil,tgroil,pastfeed)

PARAMETERS

p	=	Crops I/O coefficients
q	=	Livestock and poultry I/O coefficients
$enec$	=	Energy coefficients
$concent$	=	Concentrates coefficients
$conoil$	=	Oilseed concentrates coefficients
$mingr$	=	Cereals for feed
$pcost$	=	Crop production cost coefficients
$qcost$	=	Livestock production cost coefficients
α	=	Demand intercept
β	=	Demand slope
$euexp$	=	EU export prices (fob)
$euimp$	=	EU import prices (cif)
$usaexp$	=	USA export prices (fob)
$usaimp$	=	USA import prices (cif)
$rexp$	=	ROW export prices (fob)
$rimp$	=	ROW import prices (cif)

[64] The indices of regions and techniques of production are not indicated to simplify the presentation.

αc	=	Crop costs intercept
γc	=	Crop costs slope
αl	=	Livestock costs intercept
γl	=	Livestock costs slope
alpha_eu	=	Export costs intercept (EU)
alpha_rw	=	Export costs intercept (RW)
alpha_usa	=	Export costs intercept (USA)
gamma_eu	=	Export costs slope (EU)
gamma_rw	=	Export costs slope (RW)
gamma_usa	=	Export costs slope (USA)

VARIABLES

CROP	=	Crop production
PRODUCT	=	Livestock and poultry production
LABUSE	=	Use of labor
MACHUSE	=	Use of machinery
FEED	=	Use of feed (energy)
FGRAIN	=	Cereals in feed
FERT	=	Use of fertilizer
PRCOST	=	Production cost
TOTALPROD	=	Total production
EUEXPORT	=	Exports to EU
EUIMPORT	=	Imports from EU
USAEXPORT	=	Exports to USA
USAIMPORT	=	Imports from USA
REXPORT	=	Exports to ROW
RIMPORT	=	Imports from ROW
TOTALCONS	=	Total consumption

EQUATIONS

Area constraints

$$\sum_i p_{i,s} * CROP_i \le resav_s \qquad \forall s$$

Labor

$$\sum_i p_{i,l} * CROP_i + \sum_j q_{j,l} * PRODUCT_j = LABUSE_l \qquad \forall l$$

Machinery

$$\sum_i p_{i,m} * CROP_i = MACHUSE_m \qquad \forall m$$

Feed for livestock and poultry production

Feed, straw

$$\sum_i \sum_{g1} p_{i,g1} * CROP_i * enec_{g1} \geq FEED_{tstraw}$$

Feed, concentrate

$$\sum_i \sum_{g2} p_{i,g2} * CROP_i * concent_{g2} * enec_{g2} \geq FEED_{tconcen}$$

Feed, cereals

$$\sum_{g3} FGRAIN_{g3} * enec_{g3} \geq FEED_{tgrain}$$

Feed, pasture

$$p_{past} * CROP_{past} \geq FEED_{tpast}$$

Feed, oilseeds

$$\sum_i \sum_{g4} p_{i,g4} * CROP_i * conoil_{g4} * enec_{g4} \geq FEED_{toil}$$

Feed, fodder

$$\sum_i \sum_{g5} p_{i,g5} * CROP_i * enec_{g5} \geq FEED_{tfodd}$$

Total feed

$$\sum_{tf} FEED_{tf} \geq \sum_j q_{tene,j} * PRODUCT_j$$

minimum feed

$$FEED_{tf} \geq \sum_j q_{tf,j} * PRODUCT_j$$

minimum cereals, oilseeds, concentrates

$$FEED_{tgrain} + FEED_{tconcen} + FEED_{toil} \geq \sum_j q_{tgrcooil,j} * PRODUCT_j$$

minimum cereals, oilseeds

$$FEED_{tgrain} + FEED_{toil} \geq \sum_j q_{tgroil,j} * PRODUCT_j$$

minimum cereals

$$FGRAIN_{g3} * enec_{g3} \geq FEED_{tgrain} * mingr_{g3} \qquad \forall g3$$

Use of fertilizer

$$\sum_i p_{i,f} * CROP_{i,f} = FERT_f \qquad \forall\, f$$

Variable costs

$$\sum_i pcost_{e,i} * CROP_i + \sum_i qcost_{e,j} * PRODUCT_j = PRCOST_e \qquad \forall\, e$$

Domestic production

$$\sum_i p_{i,o} * CROP_i + q_{j,o} * PRODUCT_j = TOTALPROD_o$$

Commodity Balances

$$TOTALPROD_o * (1 - concent_o) * (1 - conoil)$$

$$+ EUIMPORT_o + \; RIMPORT_o + USAIMPORT =$$

$$TOTALCONS_o + FGRAIN_o$$

$$+ EUEXPORT_o + REXPORT_o + USAEXPORT_o \qquad \forall\, o$$

First step objective function[65]

$$\sum_o \left[\alpha_o * TOTALCONS_o - 0.5\beta_o TOTALCONS_o^2 \right]$$

$$+ \sum_o (euexp_o * EUEXPORT_o + rexp_o * REXPORT + usaexp_o * USAEXPORT)$$

$$- \sum_o (euimp_o * EUIMPORT_o + rimp_o * RIMPORT + usaimp_o * USAIMPORT)$$

$$- \sum_e \; PRCOST_e$$

---

[65] Standard forms of the objective functions. Market interventions, deficiency payments and similar policies in Turkey or in EU may add additional terms to these functions.

Second step objective function

$$\sum_o \left[\alpha_o * TOTALCONS_o - 0.5\beta_o TOTALCONS_o^2 \right]$$

$$+\sum_o (euexp_o * EUEXPORT_o)$$

$$+\sum_o (alpha\_eu_o * EUEXPORT_o + 0.5 * gamma\_eu_o * EUEXPORT_o^2)$$

$$+\sum_o (rexp_o * REXPORT_o)$$

$$+\sum_o (alpha\_rw_o * REXPORT_o + 0.5 * gamma\_rw_o * REXPORT_o^2)$$

$$+\sum_o (usaexp_o * USAEXPORT_o)$$

$$+\sum_o (alpha\_usa_o * USAEXPORT_o + 0.5 * gamma\_usa_o * USAEXPORT_o^2)$$

$$\sum_e PRCOST_e + \left[\sum_i CROP_i * (\alpha c_i + \sum_{i'} 0.5\gamma c_{ii'} * CROP_{i'}) \right]$$

$$+\left[\sum_j PRODUCT_j * (\alpha l_j + \sum_{j'} 0.5\gamma l_{jj'} * PRODUCT_{j'}) \right]$$

A3. SIMULATION RESULTS FOR ALL PRODUCTS

A3.A. Baseline Scenario

A3.A.1. Production Volumes (USD million at 2002-04 prices)

	BASE	EU-OUT	% CHANGE
	2002-04	2015	EU-OUT/BASE
CROP PRODUCTS	***23,191***	***28,054***	***21.0***
CEREALS	**6,509**	**7,408**	**13.8**
Common Wheat	3,077	3,503	13.8
Durum Wheat	1,271	1,530	20.4
Barley	1,400	1,552	10.8
Corn	560	565	0.7
Rice	110	149	35.9
Rye	90	109	21.3
PULSES	**942**	**1,170**	**24.2**
Chickpea	400	489	22.1
Drybean	254	318	25.1
Lentil	287	363	26.6
INDUSTRIAL CROPS	**2,370**	**2,686**	**13.4**
Tobacco	377	342	-9.3
Sugarbeet	800	884	10.4
Cotton	1,192	1,461	22.5
OILSEEDS	**558**	**722**	**29.3**
Sesame	25	21	-18.1
Sunflower	450	605	34.5
Groundnut	64	86	35.0
Soybean	19	9.7	-48.7
TUBERS	**1,511**	**1,921**	**27.2**
Onion (dry)	418	547	31.0
Potato	1,093	1,374	25.7
VEGETABLES	**4,854**	**6,287**	**29.5**
Melon & Waterm.	1,222	1,589	30.0
Cucumber	493	652	32.3
Eggplant	283	370	30.8
Fresh Tomato	1,870	2,402	28.5
Processing Tomato	324	402	23.8
Green Pepper	661	873	32.0
FRUITS AND NUTS	**6,448**	**7,859**	**21.9**
Apple	959	1,232	28.5
Apricot	242	278	14.8
Peach	246	327	33.2
Table Olive	383	438	14.5
Oil Olive	509	496	-2.6
Citrus	818	1,094	33.7
Pistachio	180	215	19.6
Hazelnut	625	628	0.5
Fig	89	98	10.9
Table Grape	1,743	2,284	31.0
Raisin Grape	421	504	19.7
Tea	233	264	13.2
LIVESTOCK & POUL.	***10,806***	***12,352***	***14.3***
MEAT	**4,777**	**5,281**	**10.5**
Cow Meat	2,626	3,069	16.9
Sheep Meat	1,863	1,918	2.9
Goat Meat	288	294	1.8
MILK	**3,482**	**4,091**	**17.5**
Cow Milk	3,063	3,639	18.8
Sheep Milk	313	342	9.4
Goat Milk	106	109	3.0
HIDE, WOOL & HAIR	**249**	**256**	**2.9**
Cow Hide	55	59	7.3
Sheep Hide	125	127	1.7
Goat Hide	7.9	7.9	1.1
Sheep Wool	59	60	1.7
Goat Hair & Mohair	2.5	2.5	1.1
POULTRY	**2,297**	**2,724**	**18.6**
Poultry Meat	1,220	1,417	16.1
Egg	1,077	1,307	21.3
TOTAL	***33,997***	***40,406***	***18.9***

A3.A.2. Value of Production (USD million)

	BASE	EU-OUT	% CHANGE
	2002-04	2015	EU-OUT/BASE
CROP PRODUCTS	***23,191***	***29,275***	***26.2***
CEREALS	**6,509**	**7,576**	**16.4**
Common Wheat	3,077	3,566	15.9
Durum Wheat	1,271	1,569	23.5
Barley	1,400	1,630	16.4
Corn	560	565	0.7
Rice	110	128	16.9
Rye	90	117	30.4
PULSES	**942**	**1,215**	**29.1**
Chickpea	400	536	34.0
Drybean	254	325	27.8
Lentil	287	354	23.3
INDUSTRIAL CROPS	**2,370**	**3,370**	**42.2**
Tobacco	377	471	24.9
Sugarbeet	800	922	15.2
Cotton	1,192	1,977	65.8
OILSEEDS	**558**	**699**	**25.2**
Sesame	25	21	-15.2
Sunflower	450	592	31.6
Groundnut	64	77	20.1
Soybean	19	8.5	-55.5
TUBERS	**1,511**	**1,743**	**15.4**
Onion (dry)	418	501	20.1
Potato	1,093	1,242	13.6
VEGETABLES	**4,854**	**6,237**	**28.5**
Melon & Waterm.	1,222	1,563	27.9
Cucumber	493	616	24.9
Eggplant	283	369	30.4
Fresh Tomato	1,870	2,451	31.1
Processing Tomato	324	411	26.8
Green Pepper	661	826	24.9
FRUITS AND NUTS	**6,448**	**8,436**	**30.8**
Apple	959	1,301	35.6
Apricot	242	299	23.5
Peach	246	324	31.9
Table Olive	383	523	36.5
Oil Olive	509	691	35.7
Citrus	818	982	20.0
Pistachio	180	248	37.6
Hazelnut	625	744	19.1
Fig	89	113	27.8
Table Grape	1,743	2,336	34.0
Raisin Grape	421	535	27.1
Tea	233	340	46.0
LIVESTOCK & POUL.	***10,806***	***15,066***	***39.4***
MEAT	**4,777**	**6,650**	**39.2**
Cow Meat	2,626	3,659	39.4
Sheep Meat	1,863	2,590	39.0
Goat Meat	288	401	39.1
MILK	**3,482**	**4,918**	**41.2**
Cow Milk	3,063	4,328	41.3
Sheep Milk	313	442	41.2
Goat Milk	106	148	39.8
HIDE, WOOL & HAIR	**249**	**300**	**20.5**
Cow Hide	55	70	28.1
Sheep Hide	125	150	20.0
Goat Hide	8	8	1.4
Sheep Wool	59	68	16.9
Goat Hair & Mohair	2	3	22.7
POULTRY	**2,297**	**3,198**	**39.2**
Poultry Meat	1,220	1,696	38.9
Egg	1,077	1,502	39.5
TOTAL	***33,997***	***44,341***	***30.4***

A3.A.3. Per Capita Consumption Effects

BASE=100	EU-OUT
	2015
CROP PRODUCTS	***109.1***
CEREALS	**103.4**
Common Wheat	101.7
Durum Wheat	104.7
Barley	108.1
Corn	102.3
Rice	109.5
Rye	109.0
PULSES	**111.0**
Chickpea	110.5
Drybean	108.8
Lentil	114.3
INDUSTRIAL CROPS	**100.0**
Tobacco	81.0
Sugarbeet	112.2
Cotton	92.3
OILSEEDS	**117.2**
Sesame	121.6
Sunflower	114.2
Groundnut	114.9
Soybean	119.8
TUBERS	**110.4**
Onion (dry)	114.3
Potato	109.0
VEGETABLES	**113.2**
Melon & Waterm.	112.9
Cucumber	115.2
Eggplant	113.6
Fresh Tomato	112.2
Processing Tomato	112.1
Green Pepper	115.2
FRUITS AND NUTS	**110.4**
Apple	115.2
Apricot	114.8
Peach	116.5
Table Olive	101.0
Oil Olive	86.2
Citrus	118.4
Pistachio	106.2
Hazelnut	104.9
Fig	108.7
Table Grape	114.2
Raisin Grape	110.0
Tea	98.4
LIVESTOCK & POUL.	***99.9***
MEAT	**96.3**
Cow Meat	101.5
Sheep Meat	90.1
Goat Meat	88.6
MILK	**100.9**
Cow Milk	101.8
Sheep Milk	95.5
Goat Milk	89.5
HIDE, WOOL & HAIR	**111.9**
Cow Hide	99.7
Sheep Hide	115.8
Goat Hide	115.2
Sheep Wool	103.2
Goat Hair & Mohair	116.1
POULTRY	**103.2**
Poultry Meat	101.2
Egg	105.5
TOTAL	***105.7***

A3.A.4. Product Prices in 2015 (USD/Ton)

BASE=100	BASE 2002-04	EU-OUT 2015	% CHANGE EU-OUT/BASE
CROP PRODUCTS	***100.0***	***102.5***	***2.5***
CEREALS	**100.0**	**101.1**	**1.1**
Common Wheat	214	218	1.8
Durum Wheat	229	235	2.5
Barley	162	170	5.0
Corn	211	211	0.0
Rice	446	384	-14.0
Rye	160	172	7.6
PULSES	**100.0**	**104.0**	**4.0**
Chickpea	642	705	9.8
Drybean	1,017	1,040	2.2
Lentil	527	514	-2.5
INDUSTRIAL CROPS	**100.0**	**121.2**	**21.2**
Tobacco	2,683	3,692	37.6
Sugarbeet	56	59	4.4
Cotton	492	666	35.3
OILSEEDS	**100.0**	**93.2**	**-6.8**
Sesame	1,129	1,170	3.6
Sunflower	530	518	-2.2
Groundnut	752	669	-11.0
Soybean	276	240	-13.2
TUBERS	**100.0**	**90.7**	**-9.3**
Onion (dry)	214	197	-8.3
Potato	214	194	-9.6
VEGETABLES	**100.0**	**99.2**	**-0.8**
Melon & Waterm.	205	201	-1.6
Cucumber	286	270	-5.6
Eggplant	304	304	-0.3
Fresh Tomato	251	256	2.0
Processing Tomato	153	157	2.4
Green Pepper	379	358	-5.3
FRUITS AND NUTS	**100.0**	**107.5**	**7.5**
Apple	417	440	5.6
Apricot	663	713	7.5
Peach	569	563	-1.0
Table Olive	957	1,141	19.2
Oil Olive	501	698	39.4
Citrus	319	287	-10.2
Pistachio	3,486	4,010	15.0
Hazelnut	1,311	1,553	18.5
Fig	1,432	1,650	15.3
Table Grape	558	571	2.3
Raisin Grape	1,309	1,389	6.1
Tea	253	326	28.9
LIVESTOCK & POUL.	***100.0***	***122.2***	***22.2***
MEAT	**100.0**	**126.4**	**26.4**
Cow Meat	5,258	6,269	19.2
Sheep Meat	5,325	7,191	35.0
Goat Meat	4,987	6,813	36.6
MILK	**100.0**	**120.3**	**20.3**
Cow Milk	344	409	18.9
Sheep Milk	427	551	29.1
Goat Milk	426	578	35.7
HIDE, WOOL & HAIR	**100.0**	**117.4**	**17.4**
Cow Hide	774	924	19.3
Sheep Hide	1,614	1,905	18.0
Goat Hide	803	805	0.2
Sheep Wool	1,343	1,543	14.9
Goat Hair & Mohair	823	998	21.3
POULTRY	**100.0**	**117.4**	**17.4**
Poultry Meat	1,501	1,796	19.6
Egg	1,466	1,684	14.9
TOTAL	***100.0***	***109.9***	***9.9***

A3.A.5. Net Exports (USD million)

	2002-04	EU-OUT (2015)				% CHANGE
	TOTAL	USA	EU	ROW	TOTAL	EU-OUT/BASE
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***31.5***
CEREALS	**-240**	**-233**	**-81**	**-8.0**	**-322**	**34.2**
Common Wheat	-54		-84		-84	56.0
Durum Wheat	29	1	3	31	35	22.1
Barley	39		0	47	48	22.4
Corn	-183	-210		-41	-250	36.9
Rice	-65	-25		-46	-70	8.5
Rye	-6	0			0	-100.0
PULSES	**190**	**1.4**	**45**	**190**	**237**	**24.4**
Chickpea	97	1	25	92	118	21.2
Drybean	7		7	2	9	29.9
Lentil	86	1	14	96	110	27.6
INDUSTRIAL CROPS	**615**	**69**	**551**	**103**	**724**	**17.6**
Tobacco	237	69	128	44	241	1.5
Sugarbeet	69	0	-94	59	-35	-150.2
Cotton	309		518		518	67.6
OILSEEDS	**-747**	**-632**	**2.9**	**-293**	**-922**	**23.4**
Sesame	-46	0	3	-89	-86	85.7
Sunflower	-183			-204	-204	11.4
Groundnut	-1	0	0		0	-137.2
Soybean	-517	-632			-632	22.3
TUBERS	**55**	**0.0**	**4.1**	**79**	**83**	**49.7**
Onion (dry)	30	0	4	38	42	41.5
Potato	26			41	41	59.1
VEGETABLES	**598**	**59**	**354**	**451**	**864**	**44.5**
Melon & Waterm.	8		7	4	12	45.3
Cucumber	43	2	51	12	64	51.3
Eggplant	5	0	6	1	7	47.3
Fresh Tomato	231	46	112	169	327	41.7
Processing Tomato	202	1	41	240	283	40.1
Green Pepper	110	10	137	25	172	55.7
FRUITS AND NUTS	**2064**	**132**	**1734**	**807**	**2672**	**29.4**
Apple	249	4	314	11	330	32.6
Apricot	227	63	138	112	312	37.9
Peach	18	0	4	22	26	44.6
Table Olive	38	3	15	25	43	14.5
Oil Olive	134	33	87	38	158	18.3
Citrus	292	1	103	333	437	49.7
Pistachio	15	2	8	4	14	-7.6
Hazelnut	635	18	588	109	716	12.8
Fig	89	7	82	25	114	27.5
Table Grape	84	0	53	68	122	44.8
Raisin Grape	283	0	341	58	399	40.8
Tea	1	0	1	0	1	-3.1
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***74.4***
MEAT	**11**	**0.0**	**0.0**	**1.8**	**2**	**-84.4**
Cow Meat	2			0	0	-87.0
Sheep Meat	9			1	1	-84.4
Goat Meat	0			0	0	-71.9
MILK	**-14**	**0.5**	**0.5**	**20**	**21**	**-252.8**
Cow Milk	-19	**0.0**		16	16	-184.6
Sheep Milk	6	**0.4**	0	4	4	-22.6
Goat Milk	0	**0.0**		0	0	-29.4
HIDE, WOOL & HAIR	**-290**	**7.0**	**-250**	**-275**	**-517**	**78.6**
Cow Hide	-20	**0.3**	13	-45	-32	62.0
Sheep Hide	-253		-275	-172	-447	76.5
Goat Hide	-4		-3	-5	-8	93.3
Sheep Wool	-13	**7.2**	16	-53	-30	131.2
Goat Hair & Mohair	1	**-0.5**	0	0	0	-92.9
POULTRY	**19**	**0.0**	**0.0**	**19**	**19**	**-0.4**
Poultry Meat	14			14	14	-3.5
Egg	5			5	5	8.8
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***26.3***

A3.B. EU Scenarios

A3.B.1. Production Volumes (USD million at 2002-04 prices)

	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2	CHANGE OVER BASE (%)			
	2002-04	2015	2015	2015	2015	EU-OUT	EU-CU	EU-IN1	EU-IN2
CROP PRODUCTS	***23,191***	***28,054***	***26,604***	***26,180***	***27,616***	***21.0***	***14.7***	***12.9***	***19.1***
CEREALS	**6,509**	**7,408**	**6,115**	**5,741**	**6,193**	**13.8**	**-6.1**	**-11.8**	**-4.9**
Common Wheat	3,077	3,503	2,373	2,066	2,230	13.8	-22.9	-32.9	-27.5
Durum Wheat	1,271	1,530	1,598	1,598	1,642	20.4	25.7	25.7	29.2
Barley	1,400	1,552	1,557	1,559	1,647	10.8	11.2	11.3	17.6
Corn	560	565	366	306	390	0.7	-34.7	-45.4	-30.4
Rice	110	149	151	151	169	35.9	37.7	37.7	53.6
Rye	90	109	70	61	115	21.3	-22.5	-32.2	27.5
PULSES	**942**	**1,170**	**1,204**	**1,203**	**1,219**	**24.2**	**27.8**	**27.8**	**29.4**
Chickpea	400	489	508	508	509	22.1	27.0	27.0	27.1
Drybean	254	318	323	323	327	25.1	27.2	27.2	28.5
Lentil	287	363	372	372	384	26.6	29.5	29.5	33.6
INDUSTRIAL CROPS	**2,370**	**2,686**	**2,668**	**2,669**	**3,161**	**13.4**	**12.6**	**12.6**	**33.4**
Tobacco	377	342	342	342	342	-9.3	-9.3	-9.3	-9.3
Sugarbeet	800	884	866	866	1,064	10.4	8.1	8.1	32.9
Cotton	1,192	1,461	1,461	1,461	1,755	22.5	22.5	22.5	47.2
OILSEEDS	**558**	**722**	**458**	**408**	**430**	**29.3**	**-18.0**	**-26.8**	**-23.0**
Sesame	25	21	24	24	25	-18.1	-3.0	-3.2	-2.1
Sunflower	450	605	336	289	307	34.5	-25.2	-35.8	-31.8
Groundnut	64	86	87	87	90	35.0	36.5	36.5	40.9
Soybean	19	9.7	9.7	7.8	7.8	-48.7	-48.8	-58.9	-58.9
TUBERS	**1,511**	**1,921**	**1,924**	**1,924**	**1,959**	**27.2**	**27.4**	**27.4**	**29.7**
Onion (dry)	418	547	546	546	555	31.0	30.7	30.7	33.0
Potato	1,093	1,374	1,378	1,378	1,404	25.7	26.1	26.1	28.4
VEGETABLES	**4,854**	**6,287**	**6,316**	**6,317**	**6,352**	**29.5**	**30.1**	**30.1**	**30.9**
Melon & Waterm.	1,222	1,589	1,594	1,594	1,602	30.0	30.4	30.4	31.1
Cucumber	493	652	658	658	669	32.3	33.5	33.5	35.7
Eggplant	283	370	371	371	373	30.8	31.2	31.2	31.6
Fresh Tomato	1,870	2,402	2,409	2,409	2,409	28.5	28.8	28.8	28.8
Processing Tomato	324	402	395	395	395	23.8	21.6	21.6	21.6
Green Pepper	661	873	890	890	905	32.0	34.6	34.6	36.9
FRUITS AND NUTS	**6,448**	**7,859**	**7,918**	**7,918**	**8,301**	**21.9**	**22.8**	**22.8**	**28.7**
Apple	959	1,232	1,244	1,244	1,259	28.5	29.7	29.7	31.3
Apricot	242	278	294	294	316	14.8	21.7	21.7	30.7
Peach	246	327	327	327	332	33.2	33.2	33.2	35.2
Table Olive	383	438	438	438	466	14.5	14.3	14.3	21.7
Oil Olive	509	496	456	456	533	-2.6	-10.4	-10.4	4.7
Citrus	818	1,094	1,101	1,101	1,141	33.7	34.5	34.5	39.4
Pistachio	180	215	216	216	222	19.6	19.9	19.9	23.2
Hazelnut	625	628	683	683	744	0.5	9.3	9.3	19.1
Fig	89	98	103	103	104	10.9	16.0	16.0	16.9
Table Grape	1,743	2,284	2,286	2,286	2,358	31.0	31.1	31.1	35.2
Raisin Grape	421	504	506	506	531	19.7	20.2	20.2	26.2
Tea	233	264	264	264	296	13.2	13.2	13.2	27.3
LIVESTOCK & POUL.	***10,806***	***12,352***	***11,691***	***11,691***	***12,845***	***14.3***	***8.2***	***8.2***	***18.9***
MEAT	**4,777**	**5,281**	**4,963**	**4,963**	**5,275**	**10.5**	**3.9**	**3.9**	**10.4**
Cow Meat	2,626	3,069	2,794	2,794	3,081	16.9	6.4	6.4	17.3
Sheep Meat	1,863	1,918	1,880	1,880	1,903	2.9	0.9	0.9	2.1
Goat Meat	288	294	289	289	291	1.8	0.3	0.3	1.0
MILK	**3,482**	**4,091**	**3,756**	**3,756**	**4,172**	**17.5**	**7.9**	**7.9**	**19.8**
Cow Milk	3,063	3,639	3,313	3,313	3,703	18.8	8.2	8.2	20.9
Sheep Milk	313	342	336	336	359	9.4	7.2	7.2	14.8
Goat Milk	106	109	108	108	110	3.0	1.5	1.5	3.4
HIDE, WOOL & HAIR	**249**	**256**	**247**	**247**	**248**	**2.9**	**-0.7**	**-0.7**	**-0.3**
Cow Hide	55	59	54	54	55	7.3	-2.3	-2.3	-0.4
Sheep Hide	125	127	125	125	125	1.7	-0.3	-0.3	-0.3
Goat Hide	7.9	7.9	7.8	7.8	7.8	1.1	-0.4	-0.4	-0.4
Sheep Wool	59	60	58	58	58	1.7	-0.3	-0.3	-0.3
Goat Hair & Mohair	2.5	2.5	2.5	2.5	2.5	1.1	-0.4	-0.4	-0.4
POULTRY	**2,297**	**2,724**	**2,724**	**2,724**	**3,150**	**18.6**	**18.6**	**18.6**	**37.1**
Poultry Meat	1,220	1,417	1,417	1,417	1,614	16.1	16.1	16.1	32.2
Egg	1,077	1,307	1,307	1,307	1,536	21.3	21.3	21.3	42.6
TOTAL	***33,997***	***40,406***	***38,295***	***37,871***	***40,461***	***18.9***	***12.6***	***11.4***	***19.0***

A3.B.2. Value of Production (USD million)

	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2	CHANGE OVER BASE (%)			
	2002-04	2015	2015	2015	2015	EU-OUT	EU-CU	EU-IN1	EU-IN2
CROP PRODUCTS	***23,191***	***29,275***	***26,448***	***26,128***	***26,172***	***26.2***	***14.0***	***12.7***	***12.9***
+ Comp. Area Pay.	-	-	-	*29,070*	*29,364*			*25.3*	*26.6*
+ Other Crop Pay.	-	-	-	*32,092*	*32,790*			*38.4*	*41.4*
CEREALS	**6,509**	**7,576**	**5,038**	**4,764**	**4,840**	**16.4**	**-22.6**	**-26.8**	**-25.6**
Common Wheat	3,077	3,566	1,726	1,502	1,622	15.9	-43.9	-51.2	-47.3
Durum Wheat	1,271	1,569	1,462	1,462	1,383	23.5	15.0	15.1	8.8
Barley	1,400	1,630	1,367	1,372	1,305	16.4	-2.4	-2.1	-6.8
Corn	560	565	302	252	321	0.7	-46.2	-55.0	-42.6
Rice	110	128	125	125	118	16.9	13.4	13.4	7.3
Rye	90	117	58	51	91	30.4	-35.1	-43.2	1.0
PULSES	**942**	**1,215**	**1,169**	**1,170**	**1,142**	**29.1**	**24.2**	**24.2**	**21.3**
Chickpea	400	536	516	516	515	34.0	28.8	28.9	28.8
Drybean	254	325	312	312	303	27.8	22.6	22.6	19.4
Lentil	287	354	342	342	323	23.3	19.0	19.1	12.6
INDUSTRIAL CROPS	**2,370**	**3,370**	**3,354**	**3,354**	**3,931**	**42.2**	**41.5**	**41.5**	**65.9**
Tobacco	377	471	471	471	471	24.9	24.9	24.9	24.9
Sugarbeet	800	922	769	769	920	15.2	-4.0	-4.0	14.9
Cotton	1,192	1,977	2,114	2,114	2,541	65.8	77.3	77.3	113.1
OILSEEDS	**558**	**699**	**418**	**372**	**381**	**25.2**	**-25.1**	**-33.3**	**-31.8**
Sesame	25	21	24	24	24	-15.2	-3.6	-3.7	-2.9
Sunflower	450	592	311	267	284	31.6	-30.9	-40.6	-36.9
Groundnut	64	77	74	74	66	20.1	16.0	16.0	2.6
Soybean	19	8.5	8.4	6.8	6.8	-55.5	-55.6	-64.4	-64.4
TUBERS	**1,511**	**1,743**	**1,716**	**1,716**	**1,567**	**15.4**	**13.6**	**13.6**	**3.7**
Onion (dry)	418	501	491	491	451	20.1	17.5	17.5	8.1
Potato	1,093	1,242	1,225	1,225	1,116	13.6	12.0	12.0	2.1
VEGETABLES	**4,854**	**6,237**	**6,187**	**6,187**	**6,074**	**28.5**	**27.5**	**27.5**	**25.1**
Melon & Waterm.	1,222	1,563	1,543	1,543	1,503	27.9	26.3	26.3	23.0
Cucumber	493	616	614	614	584	24.9	24.6	24.6	18.5
Eggplant	283	369	367	367	364	30.4	29.6	29.6	28.5
Fresh Tomato	1,870	2,451	2,431	2,431	2,431	31.1	30.0	30.0	30.0
Processing Tomato	324	411	398	398	398	26.8	22.8	22.8	22.8
Green Pepper	661	826	833	833	794	24.9	26.0	26.0	20.0
FRUITS AND NUTS	**6,448**	**8,436**	**8,566**	**8,566**	**8,237**	**30.8**	**32.8**	**32.8**	**27.7**
Apple	959	1,301	1,316	1,316	1,275	35.6	37.2	37.2	33.0
Apricot	242	299	318	318	311	23.5	31.4	31.4	28.4
Peach	246	324	325	325	305	31.9	32.1	32.1	24.3
Table Olive	383	523	525	525	504	36.5	37.1	37.1	31.6
Oil Olive	509	691	674	674	702	35.7	32.5	32.5	37.8
Citrus	818	982	990	990	872	20.0	21.0	21.0	6.5
Pistachio	180	248	250	250	242	37.6	38.7	38.7	34.6
Hazelnut	625	744	826	826	815	19.1	32.2	32.2	30.4
Fig	89	113	119	119	118	27.8	34.1	34.1	33.6
Table Grape	1,743	2,336	2,344	2,344	2,256	34.0	34.4	34.4	29.4
Raisin Grape	421	535	539	539	526	27.1	28.0	28.0	24.9
Tea	233	340	340	340	311	46.0	46.0	46.0	33.5
LIVESTOCK & POUL.	***10,806***	***15,066***	***10,660***	***10,660***	***11,568***	***39.4***	***-1.4***	***-1.4***	***7.0***
+ Livestock Pay.	-	-	-	*12,722*	*13,750*			*17.7*	*27.2*
MEAT	**4,777**	**6,650**	**3,376**	**3,376**	**3,562**	**39.2**	**-29.3**	**-29.3**	**-25.4**
Cow Meat	2,626	3,659	1,604	1,604	1,769	39.4	-38.9	-38.9	-32.6
Sheep Meat	1,863	2,590	1,551	1,551	1,569	39.0	-16.8	-16.8	-15.8
Goat Meat	288	401	222	222	223	39.1	-23.1	-23.1	-22.5
MILK	**3,482**	**4,918**	**3,979**	**3,979**	**4,390**	**41.2**	**14.3**	**14.3**	**26.1**
Cow Milk	3,063	4,328	3,424	3,424	3,827	41.3	11.8	11.8	24.9
Sheep Milk	313	442	440	440	445	41.2	40.6	40.6	42.3
Goat Milk	106	148	115	115	117	39.8	8.4	8.4	10.4
HIDE, WOOL & HAIR	**249**	**300**	**289**	**289**	**291**	**20.5**	**16.2**	**16.2**	**16.7**
Cow Hide	55	70	64	64	65	28.1	16.6	16.6	18.8
Sheep Hide	125	150	147	147	147	20.0	17.6	17.6	17.7
Goat Hide	8	8	8	8	8	1.4	-0.2	-0.2	-0.1
Sheep Wool	59	68	67	67	67	16.9	14.6	14.6	14.6
Goat Hair & Mohair	2	3	3	3	3	22.7	20.9	20.9	20.9
POULTRY	**2,297**	**3,198**	**3,015**	**3,015**	**3,326**	**39.2**	**31.2**	**31.2**	**44.8**
Poultry Meat	1,220	1,696	1,609	1,609	1,758	38.9	31.9	31.9	44.1
Egg	1,077	1,502	1,406	1,406	1,568	39.5	30.5	30.5	45.5
TOTAL	***33,997***	***44,341***	***37,108***	***36,788***	***37,739***	***30.4***	***9.1***	***8.2***	***11.0***
+ All CAP Pay.	-	-	-	*44,814*	*46,541*			*31.8*	*36.9*

A3.B.3. Per Capita Consumption Effects

BASE=100	EU-OUT	EU-CU	EU-IN1	EU-IN2
	2015	2015	2015	2015
CROP PRODUCTS	***109.1***	***110.8***	***110.8***	***112.5***
CEREALS	**103.4**	**110.0**	**110.0**	**111.1**
Common Wheat	101.7	110.6	110.6	110.6
Durum Wheat	104.7	109.2	109.2	112.2
Barley	108.1	113.8	113.7	116.6
Corn	102.3	107.7	107.7	107.7
Rice	109.5	110.2	110.2	112.8
Rye	109.0	114.3	114.3	115.2
PULSES	**111.0**	**113.0**	**113.0**	**114.0**
Chickpea	110.5	113.1	113.0	113.1
Drybean	108.8	110.6	110.6	111.7
Lentil	114.3	116.0	116.0	118.3
INDUSTRIAL CROPS	**100.0**	**99.9**	**100.0**	**100.3**
Tobacco	81.0	81.0	81.0	81.0
Sugarbeet	112.2	116.9	116.9	117.7
Cotton	92.3	86.6	86.6	86.6
OILSEEDS	**117.2**	**118.2**	**118.1**	**118.3**
Sesame	121.6	124.1	124.0	124.3
Sunflower	114.2	115.8	115.8	115.8
Groundnut	114.9	116.1	116.1	119.8
Soybean	119.8	119.8	119.8	119.8
TUBERS	**110.4**	**110.7**	**110.7**	**112.6**
Onion (dry)	114.3	114.6	114.6	116.4
Potato	109.0	109.3	109.3	111.2
VEGETABLES	**113.2**	**113.5**	**113.5**	**114.1**
Melon & Waterm.	112.9	113.2	113.2	113.8
Cucumber	115.2	115.6	115.6	117.4
Eggplant	113.6	113.9	113.9	114.2
Fresh Tomato	112.2	112.4	112.4	112.4
Processing Tomato	112.1	112.4	112.4	112.4
Green Pepper	115.2	115.5	115.5	117.3
FRUITS AND NUTS	**110.4**	**109.7**	**109.7**	**114.0**
Apple	115.2	115.1	115.1	116.0
Apricot	114.8	114.5	114.5	116.6
Peach	116.5	116.5	116.5	118.0
Table Olive	101.0	100.6	100.6	106.6
Oil Olive	86.2	79.4	79.4	92.5
Citrus	118.4	118.4	118.4	121.1
Pistachio	106.2	105.9	105.9	108.6
Hazelnut	104.9	104.0	104.0	108.6
Fig	108.7	108.2	108.2	108.7
Table Grape	114.2	114.1	114.1	117.6
Raisin Grape	110.0	109.8	109.8	113.5
Tea	98.4	98.4	98.4	110.6
LIVESTOCK & POUL.	***99.9***	***128.1***	***128.1***	***129.3***
MEAT	**96.3**	**149.4**	**149.4**	**149.4**
Cow Meat	101.5	158.0	158.0	158.0
Sheep Meat	90.1	138.0	138.0	138.0
Goat Meat	88.6	143.3	143.3	143.3
MILK	**100.9**	**114.1**	**114.1**	**114.6**
Cow Milk	101.8	116.0	116.0	116.0
Sheep Milk	95.5	93.6	93.6	100.2
Goat Milk	89.5	115.8	115.8	115.8
HIDE, WOOL & HAIR	**111.9**	**111.9**	**111.9**	**111.9**
Cow Hide	99.7	99.7	99.7	99.7
Sheep Hide	115.8	115.8	115.8	115.8
Goat Hide	115.2	115.2	115.2	115.2
Sheep Wool	103.2	103.2	103.2	103.2
Goat Hair & Mohair	116.1	116.1	116.1	116.1
POULTRY	**103.2**	**109.3**	**109.3**	**113.9**
Poultry Meat	101.2	106.7	106.7	110.9
Egg	105.5	112.2	112.2	117.2
TOTAL	***105.7***	***117.3***	***117.3***	***118.8***

A3.B.4. Product Prices in 2015 (USD/Ton)

BASE=100	BASE	EU-OUT	EU-CU	EU-IN1	EU-IN2
	2002-04	2015	2015	2015	2015
CROP PRODUCTS	***100.0***	***102.5***	***96.6***	***96.7***	***92.0***
CEREALS	**100.0**	**101.1**	**80.3**	**80.4**	**77.3**
Common Wheat	214	218	156	156	156
Durum Wheat	229	235	210	210	193
Barley	162	170	142	143	128
Corn	211	211	174	174	174
Rice	446	384	368	368	312
Rye	160	172	134	134	127
PULSES	**100.0**	**104.0**	**97.2**	**97.3**	**94.0**
Chickpea	642	705	652	652	651
Drybean	1,017	1,040	981	981	945
Lentil	527	514	484	485	444
INDUSTRIAL CROPS	**100.0**	**121.2**	**117.6**	**117.6**	**116.5**
Tobacco	2,683	3,692	3,692	3,692	3,692
Sugarbeet	56	59	50	50	49
Cotton	492	666	712	712	712
OILSEEDS	**100.0**	**93.2**	**90.3**	**90.3**	**89.7**
Sesame	1,129	1,170	1,123	1,124	1,120
Sunflower	530	518	490	490	490
Groundnut	752	669	639	638	547
Soybean	276	240	240	240	240
TUBERS	**100.0**	**90.7**	**89.2**	**89.1**	**80.0**
Onion (dry)	214	197	193	193	174
Potato	214	194	191	191	170
VEGETABLES	**100.0**	**99.2**	**97.9**	**97.9**	**95.6**
Melon & Waterm.	205	201	198	198	192
Cucumber	286	270	267	267	250
Eggplant	304	304	301	301	297
Fresh Tomato	251	256	253	253	253
Processing Tomato	153	157	155	155	154
Green Pepper	379	358	354	354	332
FRUITS AND NUTS	**100.0**	**107.5**	**108.5**	**108.5**	**99.1**
Apple	417	440	441	441	422
Apricot	663	713	716	716	651
Peach	569	563	564	564	523
Table Olive	957	1,141	1,149	1,149	1,036
Oil Olive	501	698	740	740	659
Citrus	319	287	287	287	244
Pistachio	3,486	4,010	4,034	4,034	3,809
Hazelnut	1,311	1,553	1,585	1,585	1,435
Fig	1,432	1,650	1,655	1,655	1,637
Table Grape	558	571	572	572	534
Raisin Grape	1,309	1,389	1,394	1,394	1,296
Tea	253	326	326	326	265
LIVESTOCK & POUL.	***100.0***	***122.2***	***91.3***	***91.3***	***90.1***
MEAT	**100.0**	**126.4**	**68.3**	**68.3**	**68.3**
Cow Meat	5,258	6,269	3,018	3,018	3,018
Sheep Meat	5,325	7,191	4,393	4,393	4,393
Goat Meat	4,987	6,813	3,824	3,824	3,824
MILK	**100.0**	**120.3**	**105.9**	**105.9**	**105.3**
Cow Milk	344	409	355	355	355
Sheep Milk	427	551	560	560	529
Goat Milk	426	578	455	455	455
HIDE, WOOL & HAIR	**100.0**	**117.4**	**117.4**	**117.4**	**117.4**
Cow Hide	774	924	924	924	924
Sheep Hide	1,614	1,905	1,905	1,905	1,905
Goat Hide	803	805	805	805	805
Sheep Wool	1,343	1,543	1,543	1,543	1,543
Goat Hair & Mohair	823	998	998	998	998
POULTRY	**100.0**	**117.4**	**110.7**	**110.7**	**105.7**
Poultry Meat	1,501	1,796	1,704	1,704	1,636
Egg	1,466	1,684	1,576	1,576	1,495
TOTAL	***100.0***	***109.9***	***94.6***	***94.6***	***91.3***

A3.B.5. Net Exports (USD million)

	2002-04	EU-OUT (2015)				EU-CU (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***-611***	***1477***	***1363***	***2228***
CEREALS	**-240**	**-233**	**-81**	**-8.0**	**-322**	**-233**	**-1199**	**42**	**-1390**
Common Wheat	-54		-84		-84		-928		-928
Durum Wheat	29	1	3	31	35	1	3	34	38
Barley	39		0	47	48		0	54	54
Corn	-183	-210		-41	-250	-210	-245		-455
Rice	-65	-25		-46	-70	-25		-46	-70
Rye	-6	0			0	0	-29		-29
PULSES	**190**	**1.4**	**45**	**190**	**237**	**1.5**	**51**	**202**	**255**
Chickpea	97	1	25	92	118	1	30	100	131
Drybean	7		7	2	9		7	2	9
Lentil	86	1	14	96	110	1	14	101	116
INDUSTRIAL CROPS	**615**	**69**	**551**	**103**	**724**	**69**	**523**	**113**	**705**
Tobacco	237	69	128	44	241	69	128	44	241
Sugarbeet	69	0	-94	59	-35	1	-148	69	-79
Cotton	309		518		518		544		544
OILSEEDS	**-747**	**-632**	**2.9**	**-293**	**-922**	**-632**	**-190**	**-293**	**-1115**
Sesame	-46	0	3	-89	-86	0	3	-89	-85
Sunflower	-183			-204	-204		-194	-204	-398
Groundnut	-1	0	0		0	0	0		0
Soybean	-517	-632			-632	-632			-632
TUBERS	**55**	**0.0**	**4.1**	**79**	**83**	**0.0**	**4.1**	**76**	**80**
Onion (dry)	30	0	4	38	42	0	4	34	38
Potato	26			41	41			42	42
VEGETABLES	**598**	**59**	**354**	**451**	**864**	**58**	**407**	**430**	**895**
Melon & Waterm.	8		7	4	12		8	4	12
Cucumber	43	2	51	12	64	2	59	12	73
Eggplant	5	0	6	1	7	0	7	1	8
Fresh Tomato	231	46	112	169	327	44	124	163	332
Processing Tomato	202	1	41	240	283	1	44	224	269
Green Pepper	110	10	137	25	172	10	165	25	200
FRUITS AND NUTS	**2064**	**132**	**1734**	**807**	**2672**	**125**	**1882**	**791**	**2798**
Apple	249	4	314	11	330	4	332	11	347
Apricot	227	63	138	112	312	61	163	108	332
Peach	18	0	4	22	26	0	4	22	26
Table Olive	38	3	15	25	43	3	17	24	44
Oil Olive	134	33	87	38	158	29	83	33	145
Citrus	292	1	103	333	437	1	115	333	448
Pistachio	15	2	8	4	14	2	9	4	15
Hazelnut	635	18	588	109	716	17	663	107	788
Fig	89	7	82	25	114	7	89	25	121
Table Grape	84	0	53	68	122	0	61	67	128
Raisin Grape	283	0	341	58	399	0	344	57	401
Tea	1	0	1	0	1	0	1	0	1
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***7.4***	***-3479***	***-233***	***-3704***
MEAT	**11**	**0.0**	**0.0**	**1.8**	**2**	**0.0**	**-2168**	**11**	**-2157**
Cow Meat	2			0	0		-1138	1	-1137
Sheep Meat	9			1	1		-887	9	-878
Goat Meat	0			0	0		-143	1	-143
MILK	**-14**	**0.5**	**0.5**	**20**	**21**	**0.5**	**-899**	**23**	**-876**
Cow Milk	-19	**0.0**		16	16	**0.1**	-864	20	-844
Sheep Milk	6	**0.4**	0	4	4	**0.4**	0	3	4
Goat Milk	0	**0.0**		0	0	**0.0**	-36	0	-36
HIDE, WOOL & HAIR	**-290**	**7.0**	**-250**	**-275**	**-517**	**6.9**	**-248**	**-287**	**-528**
Cow Hide	-20	**0.3**	13	-45	-32	**0.3**	13	-52	-38
Sheep Hide	-253		-275	-172	-447		-275	-175	-450
Goat Hide	-4		-3	-5	-8		-3	-5	-8
Sheep Wool	-13	**7.2**	16	-53	-30	**7.2**	17	-55	-31
Goat Hair & Mohair	1	**-0.5**	0	0	0	**-0.6**	0	0	0
POULTRY	**19**	**0.0**	**0.0**	**19**	**19**	**0.0**	**-164**	**20**	**-144**
Poultry Meat	14			14	14		-88	14	-74
Egg	5			5	5		-75	6	-70
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***-604***	***-2002***	***1130***	***-1476***

A3.B.5. Net Exports (USD million continued

	2002-04	EU-IN1 (2015)				EU-IN2 (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	*2537*	*-613*	*1198*	*1362*	*1947*	*-597*	*1659*	*1450*	*2512*
CEREALS	**-240**	**-233**	**-1446**	**42**	**-1637**	**-231**	**-1284**	**51**	**-1464**
Common Wheat	-54		-1119		-1119		-1050		-1050
Durum Wheat	29	1	3	34	38	1	3	36	41
Barley	39		0	54	54		0	57	57
Corn	-183	-210	-295		-505	-210	-238		-448
Rice	-65	-25		-46	-70	-23		-42	-65
Rye	-6	0	-36		-36	0			0
PULSES	**190**	**1.5**	**51**	**202**	**255**	**1.6**	**53**	**209**	**263**
Chickpea	97	1	30	100	131	1	30	100	131
Drybean	7		7	2	9		7	2	9
Lentil	86	1	14	100	115	1	15	107	123
INDUSTRIAL CROPS	**615**	**69**	**523**	**113**	**705**	**69**	**672**	**115**	**856**
Tobacco	237	69	128	44	241	69	128	44	241
Sugarbeet	69	1	-148	69	-79	1	1	70	72
Cotton	309		544		544		544		544
OILSEEDS	**-747**	**-633**	**-223**	**-293**	**-1149**	**-633**	**-210**	**-293**	**-1136**
Sesame	-46	0	3	-89	-85	0	3	-89	-85
Sunflower	-183		-226	-204	-430		-214	-204	-418
Groundnut	-1	0	0		0	0	0		0
Soybean	-517	-633			-633	-633			-633
TUBERS	**55**	**0.0**	**4.1**	**76**	**80**	**0.0**	**4.3**	**80**	**85**
Onion (dry)	30	0	4	34	38	0	4	36	40
Potato	26			42	42			44	44
VEGETABLES	**598**	**58**	**407**	**430**	**895**	**58**	**413**	**431**	**902**
Melon & Waterm.	8		8	4	12		8	5	13
Cucumber	43	2	59	12	73	2	60	12	74
Eggplant	5	0	7	1	8	0	7	1	8
Fresh Tomato	231	44	124	163	332	44	124	163	332
Processing Tomato	202	1	44	224	269	1	44	224	269
Green Pepper	110	10	165	25	200	11	169	26	206
FRUITS AND NUTS	**2064**	**125**	**1882**	**791**	**2798**	**138**	**2013**	**856**	**3007**
Apple	249	4	332	11	347	4	342	11	358
Apricot	227	61	163	108	332	67	174	118	359
Peach	18	0	4	22	26	0	4	23	27
Table Olive	38	3	17	24	44	4	19	27	49
Oil Olive	134	29	83	33	145	34	97	40	171
Citrus	292	1	115	333	448	1	123	359	483
Pistachio	15	2	9	4	15	2	10	4	16
Hazelnut	635	17	663	107	788	19	724	118	862
Fig	89	7	89	25	121	7	90	26	122
Table Grape	84	0	61	67	128	0	64	70	134
Raisin Grape	283	0	344	57	401	0	365	60	425
Tea	1	0	1	0	1	0	1	0	1
LIVESTOCK & POUL.	*-273*	*7.4*	*-3479*	*-233*	*-3705*	*7.4*	*-2596*	*-230*	*-2818*
MEAT	**11**	**0.0**	**-2168**	**11**	**-2157**	**0.0**	**-1983**	**11**	**-1972**
Cow Meat	2		-1138	1	-1137		-973	1	-972
Sheep Meat	9		-887	9	-878		-868	9	-859
Goat Meat	0		-143	1	-143		-142	1	-141
MILK	**-14**	**0.5**	**-899**	**23**	**-876**	**0.5**	**-494**	**24**	**-470**
Cow Milk	-19	0.1	-864	20	-844	0.1	-461	20	-441
Sheep Milk	6	0.4	0	3	4	0.4	1	4	5
Goat Milk	0	0.0	-36	0	-36	0.0	-34	0	-34
HIDE, WOOL & HAIR	**-290**	**6.9**	**-248**	**-287**	**-528**	**6.9**	**-248**	**-286**	**-527**
Cow Hide	-20	0.3	13	-52	-38	0.3	13	-51	-37
Sheep Hide	-253		-275	-175	-450		-275	-175	-450
Goat Hide	-4		-3	-5	-8		-3	-5	-8
Sheep Wool	-13	7.2	17	-55	-31	7.2	17	-55	-31
Goat Hair & Mohair	1	-0.6	0	0	0	-0.6	0	0	0
POULTRY	**19**	**0.0**	**-164**	**20**	**-144**	**0.0**	**129**	**21**	**150**
Poultry Meat	14		-88	14	-74		55	15	70
Egg	5		-75	6	-70		74	6	80
TOTAL	*2264*	*-605*	*-2281*	*1129*	*-1757*	*-590*	*-936*	*1220*	*-306*

A3.C. WTO Scenario

A3.C.1. Production Volumes (USD million at 2002-04 prices)

	BASE 2002-04	EU-OUT 2015	WTO 2015	% CHANGE WTO/BASE
CROP PRODUCTS	***23,191***	***28,054***	***28,038***	***20.9***
CEREALS	**6,509**	**7,408**	**7,396**	**13.6**
Common Wheat	3,077	3,503	3,502	13.8
Durum Wheat	1,271	1,530	1,532	20.5
Barley	1,400	1,552	1,548	10.5
Corn	560	565	564	0.7
Rice	110	149	141	28.0
Rye	90	109	109	20.9
PULSES	**942**	**1,170**	**1,170**	**24.3**
Chickpea	400	489	489	22.1
Drybean	254	318	318	25.1
Lentil	287	363	363	26.6
INDUSTRIAL CROPS	**2,370**	**2,686**	**2,686**	**13.4**
Tobacco	377	342	342	-9.3
Sugarbeet	800	884	884	10.4
Cotton	1,192	1,461	1,461	22.5
OILSEEDS	**558**	**722**	**716**	**28.4**
Sesame	25	21	14	-42.9
Sunflower	450	605	606	34.7
Groundnut	64	86	86	35.1
Soybean	19	9.7	9.7	-48.7
TUBERS	**1,511**	**1,921**	**1,921**	**27.2**
Onion (dry)	418	547	547	31.0
Potato	1,093	1,374	1,374	25.7
VEGETABLES	**4,854**	**6,287**	**6,288**	**29.6**
Melon & Waterm.	1,222	1,589	1,589	30.0
Cucumber	493	652	652	32.3
Eggplant	283	370	370	30.8
Fresh Tomato	1,870	2,402	2,402	28.5
Processing Tomato	324	402	402	23.8
Green Pepper	661	873	873	32.0
FRUITS AND NUTS	**6,448**	**7,859**	**7,859**	**21.9**
Apple	959	1,232	1,232	28.5
Apricot	242	278	278	14.8
Peach	246	327	327	33.2
Table Olive	383	438	438	14.5
Oil Olive	509	496	496	-2.6
Citrus	818	1,094	1,094	33.7
Pistachio	180	215	215	19.6
Hazelnut	625	628	628	0.5
Fig	89	98	98	10.9
Table Grape	1,743	2,284	2,284	31.0
Raisin Grape	421	504	504	19.7
Tea	233	264	264	13.2
LIVESTOCK & POUL.	***10,806***	***12,352***	***12,268***	***13.5***
MEAT	**4,777**	**5,281**	**5,238**	**9.6**
Cow Meat	2,626	3,069	3,037	15.7
Sheep Meat	1,863	1,918	1,908	2.4
Goat Meat	288	294	293	1.6
MILK	**3,482**	**4,091**	**4,051**	**16.3**
Cow Milk	3,063	3,639	3,601	17.6
Sheep Milk	313	342	341	8.8
Goat Milk	106	109	109	2.8
HIDE, WOOL & HAIR	**249**	**256**	**255**	**2.3**
Cow Hide	55	59	58	6.2
Sheep Hide	125	127	127	1.2
Goat Hide	7.9	7.9	7.9	0.9
Sheep Wool	59	60	59	1.2
Goat Hair & Mohair	2.5	2.5	2.5	0.9
POULTRY	**2,297**	**2,724**	**2,724**	**18.6**
Poultry Meat	1,220	1,417	1,417	16.1
Egg	1,077	1,307	1,307	21.3
TOTAL	***33,997***	***40,406***	***40,305***	***18.6***

A3.C.2. Value of Production (USD million)

	BASE	EU-OUT	WTO	% CHANGE
	2002-04	2015	2015	WTO/BASE
CROP PRODUCTS	***23,191***	***29,275***	***29,207***	***25.9***
CEREALS	**6,509**	**7,576**	**7,542**	**15.9**
Common Wheat	3,077	3,566	3,556	15.5
Durum Wheat	1,271	1,569	1,567	23.3
Barley	1,400	1,630	1,620	15.7
Corn	560	565	563	0.4
Rice	110	128	121	10.0
Rye	90	117	116	29.4
PULSES	**942**	**1,215**	**1,214**	**28.9**
Chickpea	400	536	536	33.9
Drybean	254	325	325	27.6
Lentil	287	354	354	23.2
INDUSTRIAL CROPS	**2,370**	**3,370**	**3,347**	**41.2**
Tobacco	377	471	471	24.9
Sugarbeet	800	922	899	12.4
Cotton	1,192	1,977	1,977	65.8
OILSEEDS	**558**	**699**	**691**	**23.8**
Sesame	25	21	15	-41.7
Sunflower	450	592	591	31.3
Groundnut	64	77	77	20.0
Soybean	19	8.5	8.5	-55.5
TUBERS	**1,511**	**1,743**	**1,743**	**15.3**
Onion (dry)	418	501	501	20.1
Potato	1,093	1,242	1,241	13.5
VEGETABLES	**4,854**	**6,237**	**6,235**	**28.5**
Melon & Waterm.	1,222	1,563	1,563	27.9
Cucumber	493	616	616	24.9
Eggplant	283	369	369	30.4
Fresh Tomato	1,870	2,451	2,450	31.0
Processing Tomato	324	411	411	26.8
Green Pepper	661	826	826	24.9
FRUITS AND NUTS	**6,448**	**8,436**	**8,436**	**30.8**
Apple	959	1,301	1,301	35.6
Apricot	242	299	299	23.5
Peach	246	324	324	31.9
Table Olive	383	523	523	36.5
Oil Olive	509	691	691	35.7
Citrus	818	982	982	20.0
Pistachio	180	248	248	37.6
Hazelnut	625	744	744	19.1
Fig	89	113	113	27.8
Table Grape	1,743	2,336	2,336	34.0
Raisin Grape	421	535	535	27.1
Tea	233	340	340	46.0
LIVESTOCK & POUL.	***10,806***	***15,066***	***14,394***	***33.2***
MEAT	**4,777**	**6,650**	**5,984**	**25.3**
Cow Meat	2,626	3,659	3,299	25.6
Sheep Meat	1,863	2,590	2,319	24.5
Goat Meat	288	401	366	26.9
MILK	**3,482**	**4,918**	**4,914**	**41.1**
Cow Milk	3,063	4,328	4,325	41.2
Sheep Milk	313	442	442	41.0
Goat Milk	106	148	148	39.7
HIDE, WOOL & HAIR	**249**	**300**	**298**	**19.7**
Cow Hide	55	70	70	26.7
Sheep Hide	125	150	150	19.4
Goat Hide	8	8	8	1.1
Sheep Wool	59	68	68	16.3
Goat Hair & Mohair	2	3	3	22.4
POULTRY	**2,297**	**3,198**	**3,198**	**39.2**
Poultry Meat	1,220	1,696	1,696	38.9
Egg	1,077	1,502	1,502	39.5
TOTAL	***33,997***	***44,341***	***43,601***	***28.2***

A3.C.3. Per Capita Consumption Effects

BASE=100	EU-OUT 2015	WTO 2015	% CHANGE WTO/BASE
CROP PRODUCTS	***109.1***	***109.2***	***9.2***
CEREALS	**103.4**	**103.5**	**3.5**
Common Wheat	101.7	101.8	1.8
Durum Wheat	104.7	104.8	4.8
Barley	108.1	108.2	8.2
Corn	102.3	102.4	2.4
Rice	109.5	109.5	9.5
Rye	109.0	109.1	9.1
PULSES	**111.0**	**111.0**	**11.0**
Chickpea	110.5	110.6	10.6
Drybean	108.8	108.9	8.9
Lentil	114.3	114.3	14.3
INDUSTRIAL CROPS	**100.0**	**100.3**	**0.3**
Tobacco	81.0	81.0	-19.0
Sugarbeet	112.2	113.0	13.0
Cotton	92.3	92.3	-7.7
OILSEEDS	**117.2**	**117.3**	**17.3**
Sesame	121.6	122.6	22.6
Sunflower	114.2	114.3	14.3
Groundnut	114.9	115.0	15.0
Soybean	119.8	119.8	19.8
TUBERS	**110.4**	**110.4**	**10.4**
Onion (dry)	114.3	114.3	14.3
Potato	109.0	109.0	9.0
VEGETABLES	**113.2**	**113.2**	**13.2**
Melon & Waterm.	112.9	112.9	12.9
Cucumber	115.2	115.2	15.2
Eggplant	113.6	113.6	13.6
Fresh Tomato	112.2	112.2	12.2
Processing Tomato	112.1	112.1	12.1
Green Pepper	115.2	115.2	15.2
FRUITS AND NUTS	**110.4**	**110.4**	**10.4**
Apple	115.2	115.2	15.2
Apricot	114.8	114.8	14.8
Peach	116.5	116.5	16.5
Table Olive	101.0	101.0	1.0
Oil Olive	86.2	86.2	-13.8
Citrus	118.4	118.4	18.4
Pistachio	106.2	106.2	6.2
Hazelnut	104.9	104.9	4.9
Fig	108.7	108.7	8.7
Table Grape	114.2	114.2	14.2
Raisin Grape	110.0	110.0	10.0
Tea	98.4	98.4	-1.6
LIVESTOCK & POUL.	***99.9***	***104.2***	***4.2***
MEAT	**96.3**	**107.1**	**7.1**
Cow Meat	101.5	111.2	11.2
Sheep Meat	90.1	102.4	2.4
Goat Meat	88.6	99.3	-0.7
MILK	**100.9**	**99.9**	**-0.1**
Cow Milk	101.8	100.8	0.8
Sheep Milk	95.5	95.0	-5.0
Goat Milk	89.5	89.3	-10.7
HIDE, WOOL & HAIR	**111.9**	**111.9**	**11.9**
Cow Hide	99.7	99.7	-0.3
Sheep Hide	115.8	115.8	15.8
Goat Hide	115.2	115.2	15.2
Sheep Wool	103.2	103.2	3.2
Goat Hair & Mohair	116.1	116.1	16.1
POULTRY	**103.2**	**103.2**	**3.2**
Poultry Meat	101.2	101.2	1.2
Egg	105.5	105.5	5.5
TOTAL	***105.7***	***107.3***	***7.3***

A3.C.4. Product Prices in 2015 (USD/Ton)

BASE=100	BASE	EU-OUT	WTO	% CHANGE
	2002-04	2015	2015	WTO/BASE
CROP PRODUCTS	***100.0***	***102.5***	***102.3***	***2.3***
CEREALS	**100.0**	**101.1**	**100.8**	**0.8**
Common Wheat	214	218	217	1.5
Durum Wheat	229	235	234	2.3
Barley	162	170	170	4.7
Corn	211	211	210	-0.3
Rice	446	384	383	-14.1
Rye	160	172	171	7.0
PULSES	**100.0**	**104.0**	**103.8**	**3.8**
Chickpea	642	705	704	9.6
Drybean	1,017	1,040	1,038	2.0
Lentil	527	514	513	-2.7
INDUSTRIAL CROPS	**100.0**	**121.2**	**120.0**	**20.0**
Tobacco	2,683	3,692	3,692	37.6
Sugarbeet	56	59	57	1.8
Cotton	492	666	666	35.3
OILSEEDS	**100.0**	**93.2**	**93.0**	**-7.0**
Sesame	1,129	1,170	1,152	2.0
Sunflower	530	518	517	-2.5
Groundnut	752	669	668	-11.2
Soybean	276	240	240	-13.2
TUBERS	**100.0**	**90.7**	**90.7**	**-9.3**
Onion (dry)	214	197	197	-8.3
Potato	214	194	194	-9.7
VEGETABLES	**100.0**	**99.2**	**99.1**	**-0.9**
Melon & Waterm.	205	201	201	-1.7
Cucumber	286	270	270	-5.6
Eggplant	304	304	304	-0.3
Fresh Tomato	251	256	256	2.0
Processing Tomato	153	157	157	2.4
Green Pepper	379	358	358	-5.4
FRUITS AND NUTS	**100.0**	**107.5**	**107.5**	**7.5**
Apple	417	440	440	5.6
Apricot	663	713	713	7.5
Peach	569	563	563	-1.0
Table Olive	957	1,141	1,141	19.2
Oil Olive	501	698	698	39.4
Citrus	319	287	287	-10.2
Pistachio	3,486	4,010	4,010	15.0
Hazelnut	1,311	1,553	1,553	18.5
Fig	1,432	1,650	1,650	15.3
Table Grape	558	571	571	2.3
Raisin Grape	1,309	1,389	1,389	6.1
Tea	253	326	326	28.9
LIVESTOCK & POUL.	***100.0***	***122.2***	***117.5***	***17.5***
MEAT	**100.0**	**126.4**	**114.6**	**14.6**
Cow Meat	5,258	6,269	5,711	8.6
Sheep Meat	5,325	7,191	6,473	21.6
Goat Meat	4,987	6,813	6,231	24.9
MILK	**100.0**	**120.3**	**121.4**	**21.4**
Cow Milk	344	409	413	20.1
Sheep Milk	427	551	554	29.6
Goat Milk	426	578	579	35.9
HIDE, WOOL & HAIR	**100.0**	**117.4**	**117.4**	**17.4**
Cow Hide	774	924	924	19.3
Sheep Hide	1,614	1,905	1,905	18.0
Goat Hide	803	805	805	0.2
Sheep Wool	1,343	1,543	1,543	14.9
Goat Hair & Mohair	823	998	998	21.3
POULTRY	**100.0**	**117.4**	**117.4**	**17.4**
Poultry Meat	1,501	1,796	1,796	19.6
Egg	1,466	1,684	1,684	14.9
TOTAL	***100.0***	***109.9***	***108.0***	***8.0***

A3.C.5. Net Exports (USD million)

	2002-04	EU-OUT (2015)				WTO (2015)			
	TOTAL	USA	EU	ROW	TOTAL	USA	EU	ROW	TOTAL
CROP PRODUCTS	***2537***	***-604***	***2610***	***1330***	***3336***	***-605***	***2605***	***1322***	***3321***
CEREALS	**-240**	**-233**	**-81**	**-8.0**	**-322**	**-235**	**-81**	**-11**	**-326**
Common Wheat	-54		-84		-84		-84		-84
Durum Wheat	29	1	3	31	35	1	3	31	35
Barley	39		0	47	48		0	47	48
Corn	-183	-210		-41	-250	-210		-41	-250
Rice	-65	-25		-46	-70	-26		-48	-74
Rye	-6	0			0	0			0
PULSES	**190**	**1.4**	**45**	**190**	**237**	**1.4**	**45**	**190**	**237**
Chickpea	97	1	25	92	118	1	25	92	118
Drybean	7		7	2	9		7	2	9
Lentil	86	1	14	96	110	1	14	96	110
INDUSTRIAL CROPS	**615**	**69**	**551**	**103**	**724**	**69**	**546**	**103**	**719**
Tobacco	237	69	128	44	241	69	128	44	241
Sugarbeet	69	0	-94	59	-35	0	-99	59	-40
Cotton	309		518		518		518		518
OILSEEDS	**-747**	**-632**	**2.9**	**-293**	**-922**	**-632**	**2.9**	**-298**	**-927**
Sesame	-46	0	3	-89	-86	0	**2.6**	-94	-91
Sunflower	-183			-204	-204			-204	-204
Groundnut	-1	0	0		0	0	**0.3**		0
Soybean	-517	-632			-632	-632			-632
TUBERS	**55**	**0.0**	**4.1**	**79**	**83**	**0.0**	**4.1**	**79**	**83**
Onion (dry)	30	0	4	38	42	0	4	38	42
Potato	26			41	41			41	41
VEGETABLES	**598**	**59**	**354**	**451**	**864**	**59**	**354**	**451**	**864**
Melon & Waterm.	8		7	4	12		7	4	12
Cucumber	43	2	51	12	64	2	51	12	64
Eggplant	5	0	6	1	7	0	6	1	7
Fresh Tomato	231	46	112	169	327	46	112	169	327
Processing Tomato	202	1	41	240	283	1	41	240	283
Green Pepper	110	10	137	25	172	10	137	25	172
FRUITS AND NUTS	**2064**	**132**	**1734**	**807**	**2672**	**132**	**1734**	**807**	**2672**
Apple	249	4	314	11	330	4	314	11	330
Apricot	227	63	138	112	312	63	138	112	312
Peach	18	0	4	22	26	0	4	22	26
Table Olive	38	3	15	25	43	3	15	25	43
Oil Olive	134	33	87	38	158	33	87	38	158
Citrus	292	1	103	333	437	1	103	333	437
Pistachio	15	2	8	4	14	2	8	4	14
Hazelnut	635	18	588	109	716	18	588	109	716
Fig	89	7	82	25	114	7	82	25	114
Table Grape	84	0	53	68	122	0	53	68	122
Raisin Grape	283	0	341	58	399	0	341	58	399
Tea	1	0	1	0	1	0	1	0	1
LIVESTOCK & POUL.	***-273***	***7.4***	***-249***	***-235***	***-476***	***7.4***	***-249***	***-485***	***-727***
MEAT	**11**	**0.0**	**0.0**	**1.8**	**2**	**0.0**	**0.0**	**-246**	**-246**
Cow Meat	2			0	0			-120	-120
Sheep Meat	9			1	1			-111	-111
Goat Meat	0			0	0			-15	-15
MILK	**-14**	**0.5**	**0.5**	**20**	**21**	**0.5**	**0.5**	**20**	**20**
Cow Milk	-19	**0.0**		16	16	**0.0**		16	16
Sheep Milk	6	**0.4**	0	4	4	**0.4**	0	4	4
Goat Milk	0	**0.0**		0	0	**0.0**		0	0
HIDE, WOOL & HAIR	**-290**	**7.0**	**-250**	**-275**	**-517**	**7.0**	**-250**	**-277**	**-519**
Cow Hide	-20	**0.3**	13	-45	-32	**0.3**	13	-46	-33
Sheep Hide	-253		-275	-172	-447		-275	-173	-448
Goat Hide	-4		-3	-5	-8		-3	-5	-8
Sheep Wool	-13	**7.2**	16	-53	-30	**7.2**	16	-53	-30
Goat Hair & Mohair	1	**-0.5**	0	0	0	**-0.5**	0	0	0
POULTRY	**19**	**0.0**	**0.0**	**19**	**19**	**0.0**	**0**	**19**	**19**
Poultry Meat	14			14	14			14	14
Egg	5			5	5			5	5
TOTAL	***2264***	***-596***	***2361***	***1095***	***2860***	***-598***	***2356***	***837***	***2595***

A4. GAMS PROGRAM CODE

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$TITLE TAGRIS MODEL (July 22, 2006)
$ontext

**************************************************************************
*****|                TURKISH AGRICULTURAL SECTOR model             |*****
*****|                           (TAGRIS)                           |*****
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*************   ********     *********    *********     ****    *******
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     ***      ***      ***   *********    ***     ****  ****    *******

                                                            Version: 1.0


*------------------------------------------------------------------------*
*                BASE  PERIOD  :      2002-2004                          *
*------------------------------------------------------------------------*
*           # Regional: - Crop Production, 4 regions                     *
*                       - Fruits and Nuts Production, 4 regions          *
*                       - Animal Production, national                    *
*           # PMP - Domestic supply functions                            *
*           # ME - Maximum Entropy based algorithm                       *
*           # PMP Calibrated Export Supply Function                      *
*           # Trade disaggregated into: USA, EU and ROW                  *
*           # Trade policies explicit                                    *
*           # WITH DEFF PAYMENTS                                         *
*------------------------------------------------------------------------*
*                               Authors:                                 *
*                                    -PROF.DR.EROL H. ÇAKMAK             *
*                                    -H. OZAN ERUYGUR                    *
*------------------------------------------------------------------------*


         PRODUCT GROUPS OF THE MODEL:

                 CEREALS, PULSES, INDUSTRIAL CROPS,
                 OILSEEDS, VEGETABLES, TUBERS,
                 FRUITS AND NUTS, FODDER CROPS,
                 LIVESTOCK AND POULTRY PRODUCTS


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 "Policy makers, if they wish to forecast the response of citizens, must
  take the latter into their confidence."

                  Robert E. Lucas, Jr. 1976,
                         Econometric Policy Evaluation: a Critique.

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*------------------------------------------------------------------------*
*                       1. SET  DEFINITIONS                              *
*------------------------------------------------------------------------*

 SETS

   RE    REGIONAL DEFINITIONS   /CO, CE, EA, GA, TOTAL, DPROD, DPRICES/

   R(RE) AGRICULTURAL REGIONS OF TAGRIS

                           /CO    COASTAL TURKEY
                            CE    CENTRAL ANATOLIA
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                          EA    EASTERN ANATOLIA
                          GA    SOUTH EASTERN ANATOLIA (GAP) /


*---- output all crops and livestock

   OAL     ALL OUTPUTS (CROPS AND LIVESTOCK)

              /CWHT            SOFT WHEAT              (CEREAL)
               DWHT            DURUM WHEAT             (CEREAL)
               BRL             BARLEY                  (CEREAL)
               CRN             CORN                    (CEREAL)
               RIC             RICE                    (CEREAL)
               RYE             RYE,OATS,SPELT,MILLET   (CEREAL)
               CHC             CHICKPEA                (PULSE)
               DBN             DRY BEAN                (PULSE)
               LNT             LENTIL                  (PULSE)
               TOB             TOBACCO                 (INDUSTRIAL CROP)
               SBE             SUGARBEET               (INDUSTRIAL CROP)
               COT             COTTON                  (INDUSTRIAL CROP)
               SES             SESAME                  (OILSEED)
               SNF             SUNFLOWER               (OILSEED)
               GNT             GROUNDNUT               (OILSEED)
               SOY             SOYBEAN                 (OILSEED)
               ONI             ONION                   (TUBER)
               POT             POTATO                  (TUBER)
               MEL             MELON & WATERMELON      (VEGETABLE)
               CUC             CUCUMBER                (VEGETABLE)
               EGP             EGGPLANT                (VEGETABLE)
               FTOM            FRESH TOMATOE           (VEGETABLE)
               PTOM            PROCESSING TOMATOE      (VEGETABLE)
               GPE             PEPPER                  (VEGETABLE)
               APL             APPLE                   (FRUITS AND NUTS)
               APR             APPRICOT                (FRUITS AND NUTS)
               PEC             PEACH                   (FRUITS AND NUTS)
               TOLI            TABLE OLIVE             (FRUITS AND NUTS)
               OOLI            OIL OLIVE               (FRUITS AND NUTS)
               CIT             CITRUS                  (FRUITS AND NUTS)
               PIS             PISTACHIO               (FRUITS AND NUTS)
               HNT             HAZELNUT                (FRUITS AND NUTS)
               FIG             FIG                     (FRUITS AND NUTS)
               TGRP            TABLE GRAPE             (FRUITS AND NUTS)
               SGRP            RAISIN GRAPE            (FRUITS AND NUTS)
               TEA             TEA                     (FRUITS AND NUTS)
               ALF             ALFALFA                 (FODDER CROP)
               FOD             FODDER                  (FODDER CROP)
               PASTFEED        PASTURE FEED            (FODDER CROP)
               CMET            COW MEAT                (LIVESTOCK AND POULTRY)
               CMLK            COW MILK                (LIVESTOCK AND POULTRY)
               CHID            COW HIDE                (LIVESTOCK AND POULTRY)
               SMET            SHEEP MEAT              (LIVESTOCK AND POULTRY)
               SMLK            SHEEP MILK              (LIVESTOCK AND POULTRY)
               SHID            SHEEP HIDE              (LIVESTOCK AND POULTRY)
               SWOL            SHEEP WOOL              (LIVESTOCK AND POULTRY)
               GMET            GOAT MEAT               (LIVESTOCK AND POULTRY)
               GMLK            GOAT MILK               (LIVESTOCK AND POULTRY)
               GHID            GOAT HIDE               (LIVESTOCK AND POULTRY)
               GHAR            GOAT HAIR               (LIVESTOCK AND POULTRY)
               PMET            POULTRY MEAT (CHICKEN)  (LIVESTOCK AND POULTRY)
               EGG             EGG                     (LIVESTOCK AND POULTRY)
              /

*
*-------- OUTPUT CROPS & LIVESTOCK EXCLUDING ALF, VETCH, RANGE AND MEADOW
*

   O(OAL) CROPS & LIVESTOCK
                 /CWHT,DWHT,BRL,CRN,RIC,RYE, CHC,DBN,LNT,TOB,SBE,COT,SES,
                  SNF,GNT,SOY, ONI,POT, MEL,CUC,EGP,FTOM,PTOM,GPE,
                  APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,FIG,TGRP,SGRP,TEA,
                  CMET,CMLK,CHID,SMET,SMLK,SWOL,SHID,GMET,GMLK,GHAR,GHID,
                  PMET,EGG/

   OCR(OAL) ALL CROPS
                  /CWHT,DWHT,BRL,CRN,RIC,RYE, CHC,DBN,LNT,TOB,SBE,COT,SES,
                  SNF,GNT,SOY, ONI,POT, MEL,CUC,EGP,FTOM,PTOM,GPE,
                  APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,FIG,TGRP,SGRP,TEA,
                  ALF,FOD,PASTFEED/

   OC(OAL)  ALL CROPS EXCLUDING RANGE ETC
                 /CWHT,DWHT,BRL,CRN,RIC,RYE, CHC,DBN,LNT,TOB,SBE,COT,SES,
                  SNF,GNT,SOY, ONI,POT, MEL,CUC,EGP,FTOM,PTOM,GPE,
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               APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,FIG,TGRP,SGRP,TEA/

   OCAF(OAL) ALFALFA AND VETCH      /ALF,FOD/

   OCER(OAL)                        /CWHT,DWHT,BRL,CRN,RIC,RYE/

   OCI(OAL)  IMP CROPS              /CWHT,DWHT,BRL,CRN,CHC,LNT,SBE,COT,
                                    SNF,POT,MEL,FTOM,PTOM,TGRP,SGRP/

   OCF(OAL)  FOOD CROPS             /CWHT,DWHT,CRN,RIC,CHC,DBN,LNT,SBE,SNF,
                                    ONI,POT/

   OL(OAL)   OUTPUT LIVESTOCK       /SMET,SMLK,SHID,SWOL,GMET,GMLK,GHID,GHAR,
                                    CMET,CMLK,CHID,PMET,EGG/

   OCS(OAL)  STRAW CROPS            /CWHT,DWHT,BRL,CRN,RIC,RYE,CHC,
                                    DBN,LNT,ALF,FOD/

   TRI       TRADE INDICES          /EXP-Q,EXP-P,IMP-Q,IMP-P/

   TRI2      TRADE INDICES          /USAM-Q,USAX-Q,EUM-Q,EUX-Q,RWM-Q,RWX-Q,
                                   USAM-P,USAX-P,EUM-P,EUX-P,RWM-P,RWX-P /

   ENS        TRADE GROUPS       /USAM-Q,USAX-Q,EUM-Q,EUX-Q,RWM-Q,RWX-Q /
*
*-------- CROP AND LIVESTOCK ACTIVITIES
*

   AC     CROP ACTIVITIES
                                 /CWHT,DWHT,BRL,CRN,RIC,RYE,CHC,DBN,LNT,
                                  TOB,SBE,COT,SES,SNF,GNT,SOY,ONI,POT, MEL,
                                  CUC,EGP,FTOM,PTOM,GPE,ALF,FOD,PASTUS,
                                  APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,FIG,
                                  TGRP,SGRP,TEA/

   ACA(AC)         CROP ACTIVITIES EXC FOAL
                                 /CWHT,DWHT,BRL,CRN,RIC,RYE,CHC,DBN,LNT,
                                  TOB,SBE,COT,SES,SNF,GNT,SOY,ONI,POT, MEL,
                                  CUC,EGP,FTOM,PTOM,GPE,
                                  APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,FIG,
                                  TGRP,SGRP,TEA/

   ACB(AC)         ANNUAL CROP ACTIVITIES
                                  /CWHT,DWHT,BRL,CRN,RIC,RYE,CHC,DBN,LNT,
                                   TOB,SBE,COT,SES,SNF,GNT,SOY,ONI,POT, MEL,
                                   CUC,EGP,FTOM,PTOM,GPE/

   ACFOAL(AC)      AC-(ACB+ACFN)   /ALF,FOD,PASTUS/

   ACC(AC)         CEREAL ACTIVITIES      /CWHT,DWHT,BRL,CRN,RIC,RYE/


   ACF(AC)         FALLOW ACTIVITIES        /CWHT, DWHT,BRL,CRN,RYE/

   ACFN(AC)        FRUITS & NUTS   /APL,APR,PEC,TOLI,OOLI,CIT,PIS,HNT,
                                  FIG,TGRP,SGRP,TEA/

   ACAF(AC)        ALFA AND FODD   /ALF,FOD/

   AL              ALL ANIMAL ACTIVITIES   /SHP, GOT, CTT, PLT/

   TE TECHNOLOGIES        /D RAINFED
                           I IRRIGATED
                           F FALLOW
                           T TREE
                           E PASTURE/

   ALIAS (TE,TE1);

*
*---------- INPUTS OF PRODUCTION
*

 SETS

   CIO             CROP INPUT INDICES
                                 /DRY,IRR,TRE,PAST,LBQ1,LBQ2,LBQ3,LBQ4,
                                  TCQ1,TCQ2,TCQ3,TCQ4,NFRT,PFRT/

   LAT(CIO)                       /DRY,IRR,TRE,PAST/

   LBTC            LABORS & TRACTORS       /LBAL, TCAL/

   LB(CIO)         LABOR           /LBQ1,LBQ2,LBQ3,LBQ4/
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```
   TC(CIO)        TRACTOR         /TCQ1,TCQ2,TCQ3,TCQ4/

   FR(CIO)        FERTILIZER      /NFRT,PFRT/

   SD             SEEDS
                                 /S-WHT,S-BRL,S-CRN,S-RIC,S-RYE,S-CHC,
                                  S-DBN,S-LNT,S-TOB,S-SBE,S-COT, S-SES,S-SNF,
                                  S-GNT,S-SOY,S-ONI,S-POT,S-MEL,S-CUC,S-EGP,
                                  S-TOM,S-GPE,S-ALF,S-FOD/

*
*-------- FEED FOR LIVESTOCK
*

   G1      FEED: STRAW & HAY  /F-CWHT,F-DWHT,F-CRN,F-RYE,F-BRL,F-PLS,F-ALF,F-FOD/
   G2      FEED: CONCENTRATES /CWHT,DWHT,RYE,BRL,SBE/
   G3      FEED: GRAINS /CWHT,CRN,RYE,BRL/
   G4      FEED: OILCAKES /SNF,GNT,COT,SOY/
   G5      FEED: GREEN FODDER & HIGH QUALITY HAY /FOD,ALF/
   TF     TOTAL FEED SUPPLY IN ENERGY VALUES /TSTRAW,TCONCEN,TGRAIN,TFODD,TOIL,TPAST/
   TS      SUBGROUPS OF ENERGY REGQIREMENTS FROM LIVESTOCK SECTOR
/TGRCONOIL,TGROIL,PASTFEED/
   TEN    TOTAL ENERGY /TENE/


  SCALAR EPSL /.0001/;

  SETS

   AR      AREA
                /A-WHT,A-BRL,A-CRN,A-RIC,A-RYE, A-CHC,A-DBN,A-LNT,
                 A-TOB,A-SBE,A-COT, A-SES,A-SNF,A-GNT,A-SOY, A-ONI,A-POT,
                 A-MEL,A-CUC,A-EGP,A-TOM,A-GPE, A-APL,A-APR,A-PEC,A-OLI
                 A-CIT,A-PIS,A-HNT,A-FIG,A-GRP,A-TEA, A-ALF,A-FOD/

   ARC    CEREAL AREA     /A-CWHT,A-DWHT,A-BRL,A-CRN,A-RIC,A-RYE/
   ARF    FALLOW AREA     /FALLOW/
   A1     FODDER          /ALF,FOD/
   A2     FODDER          /A-ALF,A-FOD/

   E      PRODUCTION COST & STRUCTURE     /LABOR,TRACTOR,SEED,FERTILIZER,CAPITAL/

   CAR    ALL CROP AREAS ; CAR(AR)=YES; CAR(A2)=YES;

  SET LTC  LABOR AND TRACTOR;
                LTC(LB)=YES;
                LTC(TC)=YES;
  SET LTF  LABOR TRACTOR AND FERTILIZER;
                LTF(LTC)=YES;
                LTF(FR)=YES;
  SET FERC FEED REQUIREMENTS COEFFICIENTS;
                FERC(TF)=YES;
                FERC(TS)=YES;
  SET G    ALL FEED COMPONENTS INCLUDING TOTAL ENERGY AND SUBGROUPS;
                G(G1)=YES;  G(G2)=YES;
                G(G3)=YES;  G(G4)=YES;
                G(G5)=YES;  G(FERC)=YES;
                G(TEN)=YES;

*------------------------------- D A T A -------------------------------------

TABLE DOM_0204 NATIONAL AND REGIONAL PRODUCTION (2002-2004 AVERAGES)
*     REG AND DOM PRODUCTION (1000 TON) AND PRICES (USD/T)
* regional and domestic production, prices, 2002-2004 averages from SIS
* production 1000 tons, price received by farmers USD/t, ExRate CB selling
$INCLUDE 'DOM_0204.TXT';

TABLE AREA_0204 NATIONAL AND REGIONAL CROP AREA (2002-2004 AVERAGES)
*     REG AND DOM AREA (1000 HECTARS)
$INCLUDE 'AREA_0204.TXT';

TABLE TRADE FOREIGN TRADE DATA (2002-2004 AVERAGES) & 2015 EU POLICY FOR EU-IN
$INCLUDE 'TRADE.TXT';

TABLE PRI2015(O,*)    PRICE PROJECTIONS FOR 2015 (PERCENT)
$INCLUDE 'PRI2015.TXT';

TABLE TRPOL15 2015 TRADE AND EU POLICY FOR EU-IN
$INCLUDE 'TRPOL15.TXT';

*
*-------- 2015 YIELD GROWTH PROJECTIONS OF TURKEY BY GME
*
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TABLE YLD2015(*,*)
* PESI: PESIMIST (50% OF ESTIMATED YIELD GROWTH)
* OPTI: OPTIMIST (100% OF ESTIMATED YIELD GROWTH)
$INCLUDE 'YLD2015.TXT';

TABLE FRTP FOREIGN TRADE POLICIES (2002 AND 2004 AVERAGES)
*  IMPORT DUTY (AD VALOREM EQUIVALENTS) AND EXPORT SUBSIDIES
$INCLUDE 'FRTP.TXT';

TABLE PAR CONSUMPTION PARAMETERS (INCOME AND PRICE ELASTICITIES)
$INCLUDE 'PAR.TXT'

TABLE LANDAV(LAT,*)  LAND AVAILABILITY 2002-2004
* Areas consistent with the included crops, yields and production (1000ha)
* Including fallow land
$INCLUDE 'LANDAV.TXT'

TABLE INPRIC(*,*) INPUT PRICES
* Input prices TL per unit
* Prices in TL/unit, from GDRS and various sources
$INCLUDE 'INPRIC.TXT';

PARAMETER ANSTK(AL) ANIMAL STOCK 2002-2004 AVERAGES
* 1000 heads
$INCLUDE 'ANSTK.TXT';

PARAMETER EXR EXCHANGE RATE 2002-2004
* Central Bank selling rates TL/USD
$INCLUDE 'EXR.TXT';

TABLE DEFP DEFFICIENCY PAYMENT (US $ per Ton)
$INCLUDE 'DEFP.TXT';

PARAMETER DEFPA DEFFICIENCY PAYMENT (AVERAGE OF BASE PERIOD);

DEFPA("COT")=(DEFP("COT","Y02")+DEFP("COT","Y03")+DEFP("COT","Y04"))/3;
DEFPA("SOY")=(DEFP("SOY","Y02")+DEFP("SOY","Y03")+DEFP("SOY","Y04"))/3;
DEFPA("SNF")=(DEFP("SNF","Y02")+DEFP("SNF","Y03")+DEFP("SNF","Y04"))/3;
DEFPA("OOLI")=(DEFP("OOLI","Y02")+DEFP("OOLI","Y03")+DEFP("OOLI","Y04"))/3;

PARAMETER GRW INCOME (NET OF POPULATION) AND POPULATION GROWTH
$INCLUDE 'GRW.TXT';

PARAMETER POP POPULATION ESTIMATES FOR 2002-2005 AND 2015
$INCLUDE 'POP.TXT';

TABLE INCC(AC,TE,R,*) CROP INPUT COEFFICIENTS
* Input  coefficients
$INCLUDE 'INCC.TXT';

TABLE INSC(*,TE,R,*) SEED COEFFICIENTS
* Seed Input
$INCLUDE 'INSC.TXT';

PARAMETER  OTYC(AC,TE,R,*) CROP MAIN PRODUCT COEFFICIENTS
* Yields of main products
$INCLUDE 'OTYC.TXT';

TABLE IOCL(*,AL) LIVESTOCK INPUT OUTPUT COEFFICIENTS
$INCLUDE 'IOCL.TXT';

PARAMETERS

CONCENT   CONCENTRATIONS
$INCLUDE 'CONCENT.TXT'

CONOIL  OILSEED
$INCLUDE 'CONOIL.TXT'

ENEC    ENERGY EQUIVALENT
$INCLUDE 'ENEC.TXT'

FEEDREQ FEED REQUIREMENTS (ENERGY PER YIELD UNIT)
$INCLUDE 'FEEDREQ.TXT'

TABLE FEEDABS  ABSOLUTE FEED REQUIREMENTS
$INCLUDE 'FEEDABS.TXT'


TABLE FEEDGRAIN  DATA AND COEFFICIENT FOR FEEDING GRAIN
$INCLUDE 'FEEDGRAIN.TXT'

PARAMETER STRAW(OCR)     YIELD STRAW AND HAY
```

```
$INCLUDE 'STRAW.TXT'

*-----------------------------------------------------------

*  MODEL PARAMETERS

  PARAMETER  P   CROP PRODUCTION COEFFICIENTS;

   P(R,AC,LAT,TE) = INCC(AC,TE,R,LAT);
   P(R,AC,LB,TE) = INCC(AC,TE,R,LB);
   P(R,AC,TC,TE) = INCC(AC,TE,R,TC);
   P(R,AC,FR,TE) = INCC(AC,TE,R,FR);
   P(R,AC,"SEED",TE) = INSC(AC,TE,R,"SEED");
   P(R,AC,OCR,TE) = OTYC(AC,TE,R,OCR);
   P(R,AC,G,TE) = OTYC(AC,TE,R,G);

TABLE ACAREA_0204(AC,TE,*) ACTIVITY AREA
* Regional activity areas
* Area of activities consistent with prod and yields, 2002-2004 averages
* Calculated from GDRA and SIS
$INCLUDE 'ACAREA_0204.TXT';

*
* ---------- COST PARAMETERS CALCULATION
*

PARAMETERS PCOST  CROP PRODUCTION COSTS,
           QCOST  LIVESTOCK PRODUCTION COSTS
           FRPRI  USD PRICES OF FERTILIZERS
           LBPRI  USD PRICE OF LABOR
           TCPRI  USD RENTAL OF MACHINARY
           SDPRI  USD PRICE OF SEEDS
           TAIVC  USD ANNU INV COST FOR PERENNS ;

*
*---- input prices in US dollar terms (2002-2004 averages)
*

FRPRI(FR)=((INPRIC(FR,"INPRI02")/EXR("EXR02"))
          +(INPRIC(FR,"INPRI03")/EXR("EXR03"))
          +(INPRIC(FR,"INPRI04")/EXR("EXR04")))/3;
LBPRI(LB)=((INPRIC(LB,"INPRI02")/EXR("EXR02"))
          +(INPRIC(LB,"INPRI03")/EXR("EXR03"))
          +(INPRIC(LB,"INPRI04")/EXR("EXR04")))/3;
TCPRI(TC)=((INPRIC(TC,"INPRI02")/EXR("EXR02"))
          +(INPRIC(TC,"INPRI03")/EXR("EXR03"))
          +(INPRIC(TC,"INPRI04")/EXR("EXR04")))/3;
SDPRI(ACB)=((INPRIC(ACB,"INPRI02")/EXR("EXR02"))
          +(INPRIC(ACB,"INPRI03")/EXR("EXR03"))
          +(INPRIC(ACB,"INPRI04")/EXR("EXR04")))/3;
TAIVC(ACFN)=((INPRIC(ACFN,"INPRI02")/EXR("EXR02"))
          +(INPRIC(ACFN,"INPRI03")/EXR("EXR03"))
          +(INPRIC(ACFN,"INPRI04")/EXR("EXR04")))/3;

*
*------------- payments by inputs
*

PCOST(R,AC,"FERTILIZER",TE)=SUM(FR,P(R,AC,FR,TE)*FRPRI(FR));
PCOST(R,ACB,"SEED",TE)=P(R,ACB,"SEED",TE)*SDPRI(ACB);
PCOST(R,ACFN,"CAPITAL",TE)=P(R,ACFN,"TRE",TE)*TAIVC(ACFN);
PCOST(R,AC,"LABOR",TE)=SUM(LB,P(R,AC,LB,TE)*LBPRI(LB));
PCOST(R,AC,"TRACTOR",TE)=SUM(TC,P(R,AC,TC,TE)*TCPRI(TC));

QCOST("LABOR",AL)=SUM(LB,Q(LB,AL)*LBPRI(LB));
PCOST(R,AC,"TOT",TE)=SUM(E, PCOST(R,AC,E,TE));

*
************************ DEMAND CURVE CALCULATIONS *************************
*

PARAMETERS

                 TCON            CONSUMPTION OF RAW PRODUCTS,
                 DPRI            PRODUCT PRICES,
                 ALPHA           DEMAND CURVE INTERCEPTS,
                 BETA            DEMAND CURVE SLOPES,

                 IMPRICE_USA     USA IMPORT PRICE,
                 IMPRICE_EU      EU IMPORT PRICE,
                 IMPRICE_RW      ROW IMPORT PRICE,
                 EXPRICE_USA     USA EXPORT PRICE,
```

```
                 EXPRICE_EU      EU EXPORT PRICE,
                 EXPRICE_RW      ROW EXPORT PRICE,

                 EXPINDEX_USA    USA EXPORT INDEX,
                 EXPINDEX_EU     EU EXPORT INDEX,
                 EXPINDEX_RW     RW EXPORT INDEX,
                 IMPINDEX_USA    USA IMPORT INDEX,
                 IMPINDEX_EU     EU IMPORT INDEX,
                 IMPINDEX_RW     RW IMPORT INDEX;


******** DEFINING IMPORT AND EXPORT PRICES ACCORDING TO TRADE BLOCKS *****

       IMPRICE_USA(O)   =  TRADE(O,"USAM-P");
       IMPINDEX_USA(O) $TRADE(O,"USAM-Q") = 1;
       IMPRICE_EU(O)   =   TRADE(O,"EUM-P");
       IMPINDEX_EU(O) $TRADE(O,"EUM-Q") = 1;
       IMPRICE_RW(O)   =  TRADE(O,"RWM-P");
       IMPINDEX_RW(O) $TRADE(O,"RWM-Q") = 1;

       EXPRICE_USA(O)   =   TRADE(O,"USAX-P");
       EXPINDEX_USA(O) $ TRADE(O,"USAX-Q") = 1;
       EXPRICE_EU(O)   =   TRADE(O,"EUX-P");
       EXPINDEX_EU(O) $ TRADE(O,"EUX-Q") = 1;
       EXPRICE_RW(O)   =   TRADE(O,"RWX-P");
       EXPINDEX_RW(O) $ TRADE(O,"RWX-Q") = 1;

*
********** TOTAL CONSUMPTION (IN RAW EQUIVALENT FORM)
*

       TCON(O)  =  DOM_0204(O,"DPROD")*(1-CONCENT(O))*(1-CONOIL(O))
                    +TRADE(O,"USAM-Q")+TRADE(O,"EUM-Q")+TRADE(O,"RWM-Q")
                    -TRADE(O,"USAX-Q")-TRADE(O,"EUX-Q")-TRADE(O,"RWX-Q")
                    -FEEDGRAIN(O,"USEGR");
*
*********** Slope of Demand Function
*

       DPRI(O)  =  DOM_0204(O,"DPRICES");
       BETA(O)  =  DPRI(O)/(PAR(O,"ELAST-P")*TCON(O));

*
*********** Intercept of Demand Function
*
         ALPHA(O) = DPRI(O) - BETA(O)*TCON(O);

**********  Include tariffs and subsidies to Prices

       IMPRICE_USA(O)$((FRTP(O,"IMAV") NE 0 OR FRTP(O,"IMSP") NE 0) )
                       = (TRADE(O,"USAM-P")*(1+FRTP(O,"IMAV")))+FRTP(O,"IMSP");

       IMPRICE_EU(O)$((FRTP(O,"IMAV") NE 0 OR FRTP(O,"IMSP") NE 0) )
                       = (TRADE(O,"EUM-P")*(1+FRTP(O,"IMAV")))+FRTP(O,"IMSP");

       IMPRICE_RW(O)$((FRTP(O,"IMAV") NE 0 OR FRTP(O,"IMSP") NE 0) )
                       = (TRADE(O,"RWM-P")*(1+FRTP(O,"IMAV")))+FRTP(O,"IMSP");


       EXPRICE_USA(O)$((FRTP(O,"EXAV") NE 0 OR FRTP(O,"EXSP") NE 0) )
                       = (TRADE(O,"USAX-P")*(1+FRTP(O,"EXAV")))+FRTP(O,"EXSP");

       EXPRICE_EU(O)$((FRTP(O,"EXAV") NE 0 OR FRTP(O,"EXSP") NE 0) )
                       = (TRADE(O,"EUX-P")*(1+FRTP(O,"EXAV")))+FRTP(O,"EXSP");

       EXPRICE_RW(O)$((FRTP(O,"EXAV") NE 0 OR FRTP(O,"EXSP") NE 0) )
                       = (TRADE(O,"RWX-P")*(1+FRTP(O,"EXAV")))+FRTP(O,"EXSP");

*==================** EXPORT SUPPLY FUNCTION CALIBRATION **==================*

 PARAMETERS

          GAMMAX_USA(O)     Slope of PMP export supply function for USA
          ALPHAX_USA(O)     Intercept of PMP export supply function for USA
          GAMMAX_EU(O)      Slope of PMP export supply function for EU
          ALPHAX_EU(O)      Intercept of PMP export supply function for EU
          GAMMAX_RW(O)      Slope of PMP export supply function for ROW
          ALPHAX_RW(O)      Intercept of PMP export supply function for ROW

;
*---- in the calibration run they are all zero

          GAMMAX_USA(O)=0;
          ALPHAX_USA(O)=0;
```

```
          GAMMAX_EU(O)=0;
          ALPHAX_EU(O)=0;
          GAMMAX_RW(O)=0;
          ALPHAX_RW(O)=0;

*========================= EXPORT SUPPLY ELASTICITIES =======================*

  PARAMETERS
                 SELASX(O)      ELASTICITY OF EXPORT SUPPLY ;

*
**** EXPORT SUPPLY ELASTICITY (UNITY)
*

   SELASX(O)=1;

*==========================  EQUATION PART  ===========================*


         VARIABLES       PROFIT  OBJECTIVE FUNCTION ;


         POSITIVE VARIABLES

                 CROPS           AREA OF CROPS
                 PRODUCT         PRODUCTION OF LIVESTOCK
                 PUFERT          PURCHASE OF FERTILIZER
                 PRCOST          PRODUCTION COSTS
                 LATRUSE         LABOR AND TRACTOR USE
                 FEED            FEED USE IN ANIMAL PRODUCTION IN ENERGY UNITS
                 FGRAIN          COMPOSITION OF FEEDGRAIN IN PRODUCT WEIGHT
                 TOTALCONS       TOTAL CONSUMPTION IN PROCESSED FORM
                 IMPORT_USA      IMPORTS FROM USA
                 IMPORT_EU       IMPORTS FROM EU
                 IMPORT_RW       IMPORTS FROM REST OF THE WORLD
                 EXPORT_USA      EXPORTS FROM USA
                 EXPORT_EU       EXPORTS FROM EU
                 EXPORT_RW       EXPORTS FROM REST OF THE WORLD
                 EXPORTS         TOTAL EXPORTS
                 IMPORTS         TOTAL IMPORTS

         EQUATIONS

                 LAND        LAND CONSTRAINTS
                 LABTRAC     LABOR AND TRACTOR CONSTRAINTS
                 PURCFERT    PURCHASE FERTILIZER
                 PRODCOST    PRODUCTION COSTS
                 FEEDSTRAW   FEED SUPPLY STRAW
                 FEEDCON     FEED SUPPLY CONCENTRATES
                 FEEDCERI    GRAIN USED FOR ANIMAL FEEDING
                 FEEDPAST    FEED SUPPLY FROM PASTURE
                 FEEDOIL     FEED SUPPLY OIL CAKE
                 FEEDFODD    FEED SUPPLY ALFALFA AND FODDER
                 TOTALFEED   TOTAL FEED BALANCE
                 MINFEED     MINIMUM FEED REQUIREMENTS BY COMPONENTS
                 MINGRCOIL   MINIMUM GRAIN CONCENTRATES AND OILCAKE
                 MINGROIL    MINIMUM GRAIN AND OILCAKE
                 MINGRAIN    MINIMUM SHARE OF INDIVIDUAL GRAINS
                 IMPORTQ     TOTAL IMPORTS EQUATION
                 EXPORTQ     TOTAL EXPORTS EQUATION

                 IMPORT_USA_ IMPORTS FROM USA EQUATION
                 IMPORT_EU_  IMPORTS FROM EU EQUATION
                 IMPORT_RW_  IMPORTS FROM ROW EQUATION
                 COMBAL      COMMODITY BALANCES
                 SURPLUS     OBJECTIVE VALUE
;

*--------------------------- equations ------------------------------------*

  LAND(R,LAT).. SUM((AC,TE), P(R,AC,LAT,TE)*CROPS(R,AC,TE)) =L= LANDAV(LAT,R);

  LABTRAC(R,LTC)..  SUM((AC,TE), P(R,AC,LTC,TE)*CROPS(R,AC,TE))
                  +SUM(AL, Q(LTC,AL)*PRODUCT(AL)) =E= LATRUSE(LTC,R);

  FEEDSTRAW..  SUM((AC,G1,R,TE), P(R,AC,G1,TE)*CROPS(R,AC,TE)*ENEC(G1))
                                                          =G= FEED("TSTRAW");

  FEEDCON..    SUM((AC,G2,R,TE), P(R,AC,G2,TE)*CROPS(R,AC,TE)*CONCENT(G2)*ENEC(G2))
                                                         =G= FEED("TCONCEN");

  FEEDCERI..   SUM((G3,R) ,FGRAIN(G3,R)*FEEDGRAIN(G3,"ENEGR"))
                                                            =G= FEED("TGRAIN");
```

```
  FEEDPAST..   SUM(R,CROPS(R,"PASTUS","E")*P(R,"PASTUS","PASTFEED","E"))
                                                    =G= FEED("TPAST");

  FEEDOIL..    SUM((AC,G4,R,TE), P(R,AC,G4,TE)*CROPS(R,AC,TE)*CONOIL(G4)*ENEC(G4))
                                                    =G= FEED("TOIL");

  FEEDFODD..   SUM((AC,G5,R,TE), CROPS(R,AC,TE)*P(R,AC,G5,TE)*ENEC(G5))
                                                    =G= FEED("TFODD");

  TOTALFEED..  SUM(TF,FEED(TF))=G= SUM(AL,Q("TENE",AL)*PRODUCT(AL));

  MINFEED(TF)..SUM(AL,Q(TF,AL)*PRODUCT(AL)) =L= FEED(TF) ;

  MINGRCOIL..  FEED("TGRAIN")+FEED("TCONCEN")+FEED("TOIL")
                                   =G= SUM(AL,Q("TGRCONOIL",AL)*PRODUCT(AL));

  MINGROIL..   FEED("TGRAIN")+FEED("TOIL")
                                   =G= SUM(AL,Q("TGROIL",AL)*PRODUCT(AL));

  MINGRAIN(G3)..  SUM(R, FGRAIN(G3,R))*FEEDGRAIN(G3,"ENEGR")
                                   =G= FEED("TGRAIN")*FEEDGRAIN(G3,"MINGR");

  PURCFERT(R,FR)..  SUM((AC,TE), P(R,AC,FR,TE)*CROPS(R,AC,TE)) =E= PUFERT(R,FR);

  PRODCOST(E).. SUM((AC,R,TE), PCOST(R,AC,E,TE)*CROPS(R,AC,TE))
                +SUM(AL, QCOST(E,AL)*PRODUCT(AL))
                =E= PRCOST(E);

  IMPORTQ(O)..IMPORT_USA(O)+IMPORT_EU(O)+IMPORT_RW(O)=E=IMPORTS(O);

  EXPORTQ(O)..EXPORT_USA(O)+EXPORT_EU(O)+EXPORT_RW(O)=E=EXPORTS(O);


  IMPORT_USA_(O)..IMPORT_USA(O)=E=TRADE(O,"USAM-Q");
  IMPORT_EU_(O)..IMPORT_EU(O)=E=TRADE(O,"EUM-Q");
  IMPORT_RW_(O)..IMPORT_RW(O)=E=TRADE(O,"RWM-Q");

  COMBAL(O)..   SUM((AC,R,TE), P(R,AC,O,TE)*CROPS(R,AC,TE)
                *(1-CONCENT(O))*(1-CONOIL(O)))
                +SUM(AL, Q(O,AL)*PRODUCT(AL))
                +IMPORT_USA(O)+IMPORT_EU(O)+IMPORT_RW(O)
                =E= TOTALCONS(O)+QQ(O)*SUM(R, FGRAIN(O,R))
                +EXPORT_USA(O)+EXPORT_EU(O)+EXPORT_RW(O);
                       ;

  SURPLUS..   SUM(O, ALPHA(O)*TOTALCONS(O)+0.5*BETA(O)*TOTALCONS(O)**2)

               +SUM(O,EXPRICE_USA(O)*EXPORT_USA(O))
               +SUM(O,(ALPHAX_USA(O)+0.5*GAMMAX_USA(O)*EXPORT_USA(O))*EXPORT_USA(O))
               +SUM(O,EXPRICE_EU(O)*EXPORT_EU(O))
               +SUM(O,(ALPHAX_EU(O)+0.5*GAMMAX_EU(O)*EXPORT_EU(O))*EXPORT_EU(O))
               +SUM(O,EXPRICE_RW(O)*EXPORT_RW(O))
               +SUM(O,(ALPHAX_RW(O)+0.5*GAMMAX_RW(O)*EXPORT_RW(O))*EXPORT_RW(O))

               -SUM(O,IMPRICE_USA(O)*IMPORT_USA(O))
               -SUM(O,IMPRICE_EU(O)*IMPORT_EU(O))
               -SUM(O,IMPRICE_RW(O)*IMPORT_RW(O))

               -SUM(E,PRCOST(E))

    =E= PROFIT;

*--------------------------- end of model equations --------------------*

         OPTION RESLIM =  20000;
         OPTION ITERLIM = 100000;
         OPTION LIMROW=0;
         OPTION LIMCOL=0;

*
***** DEFINE THE MODEL
*

   MODEL  TAGRIS /ALL/;


********** calibration constraints for PMP (TO GET RIDE OF DEGENERACY) ******


*
*--------- SUPPLY PART
*
         CROPS.LO(R,AC,TE)= ACAREA_0204(AC,TE,R)*0.99999;
         CROPS.UP(R,AC,TE)= ACAREA_0204(AC,TE,R)*1.00001;
```

```
         PRODUCT.LO(AL)= ANSTK(AL)*0.99999;
         PRODUCT.UP(AL)= ANSTK(AL)*1.00001;

*
*-------- TRADE PART
*
         EXPORT_USA.LO(O)= TRADE(O,"USAX-Q")*0.9999;
         EXPORT_USA.UP(O)= TRADE(O,"USAX-Q")*1.0001;
         EXPORT_EU.LO(O)= TRADE(O,"EUX-Q")*0.9999;
         EXPORT_EU.UP(O)= TRADE(O,"EUX-Q")*1.0001;
         EXPORT_RW.LO(O)= TRADE(O,"RWX-Q")*0.9999;
         EXPORT_RW.UP(O)= TRADE(O,"RWX-Q")*1.0001;

*
*********** SOLVE THE TAGRIS MODEL (FIRST STEP FOR CALIBRATION)
*

         SOLVE TAGRIS MAXIMIZING PROFIT USING NLP;


*========= PMP COEFFICIENTS for Export Supply Functions ============*

  GAMMAX_USA(O)$ EXPINDEX_USA(O)= -1/SELASX(O)*(EXPRICE_USA(O)/TRADE(O,"USAX-Q"));
  ALPHAX_USA(O)=-EXPORT_USA.M(O)-GAMMAX_USA(O)*TRADE(O,"USAX-Q");
  GAMMAX_EU(O) $ EXPINDEX_EU(O)= -1/SELASX(O)*(EXPRICE_EU(O)/TRADE(O,"EUX-Q"));
  ALPHAX_EU(O) =-EXPORT_EU.M(O)-GAMMAX_EU(O)*TRADE(O,"EUX-Q");
  GAMMAX_RW(O) $ EXPINDEX_RW(O)= -1/SELASX(O)*(EXPRICE_RW(O)/TRADE(O,"RWX-Q"));
  ALPHAX_RW(O) =-EXPORT_RW.M(O)-GAMMAX_RW(O)*TRADE(O,"RWX-Q") ;

DISPLAY ALPHAX_EU,EXPRICE_EU, EXPORT_EU.M, GAMMAX_EU;
*$EXIT


*==============================================================================*
*==============================================================================*
*                                                                              *
*                    MAXIMUM ENTROPY BASED PMP MODEL                           *
*       (PMP with Multiple Data Points: Cross sectional Estimation)           *
*                                                                              *
*                                                                              *
*   Ref's: HECKELEI, T. and W. BRITZ (2000). Positive Mathematical             *
*          Programming with Multiple Data Points: A Cross-Sectional            *
*          Estimation Procedure. Cahiers d'economie et sociologie              *
*          rurales 57: 28-50.                                                  *
*                                                                              *
*          HECKELEI, T. and W. BRITZ (1999). Maximum Entropy Specification     *
*          of PMP in CAPRI, CAPRI Working Paper 99-08, Bonn University.        *
*                                                                              *
*          PARIS, Q., and R.E. HOWITT (1998). An Analysis of Ill-Posed         *
*          Production Problems Using Maximum Entropy. American Journal         *
*          of Agricultural Economics, 80(1): 124-138.                          *
*                                                                              *
*                                                                              *
*==============================================================================*
*==============================================================================*


  OPTION LIMROW=0;
  OPTION LIMCOL=0;
  OPTION NLP=CONOPT;

  SETS
         PR      PROBABILITY POINTS      /1*5/


********************************************************************************
*     (MODULE 1)     CROP PRODUCTION                                           *
********************************************************************************


         ALIAS(ACB,ACBL,ACBM,ACBK)
         ALIAS(TE,TEL,TEM,TEK)


 PARAMETER
                 COST_C  PER HA COST FOR CROP PRODUCTION
                 MC_C    MARGINAL COST (CROPS)
                 QT      TOTAL PRODUCTION PER CROPS;

  COST_C(R,ACB,TE)=SUM(E,PCOST(R,ACB,E,TE));

           DISPLAY COST_C;

  MC_C(R,ACBL,TEL)=CROPS.M(R,ACBL,TEL)+COST_C(R,ACBL,TEL);
```

```
         DISPLAY MC_C;

  QT(ACBL,TEL)=SUM(R,CROPS.L(R,ACBL,TEL));

         DISPLAY QT;

***************** RECOVERING Q MATRIX OF NONLINEAR COST FUNCTION****************

  SETS
       KK      NUMBER OF SUPPORT POINTS        /1*5/;


  PARAMETERS

       ZBMAT(*,*,*,*,KK)       SUPPORT VALUES FOR B MATRIX IN COST FUNCTION
       ZALPHA(*,*,*,KK)        SUPPORT VALUES FOR d MATRIX IN COST FUNCTION
       ZS(KK)                  SUPPORT VALUES FOR EXPONENT OF CPI
       AR_C(*)                 AVERAGE REVENUE PER HA IN REGION
       ARR_C(*)                AVERAGE RELATIVE REVENUE PER HA IN REGION;


  PARAMETER      ZS(KK)  SUPPORT POINTS FOR EXPONENT OF CPI
$INCLUDE 'ZS.TXT';

  PARAMETER      SCALPHA(KK)     SCALED SUPPORT VALUES FOR ALL ELEMENTS OF d
$INCLUDE 'SCALPHA.TXT';

  PARAMETER      WBD(KK) SCALED SUPPORT VALUES FOR DIAGONAL ELEMENTS OF B
$INCLUDE 'WBD.TXT';

  PARAMETER      WBOFFD(KK)      SCALED SUPPORT VALUES FOR OFF-DIAGONAL ELEMENTS OF B
$INCLUDE 'WBOFFD.TXT';

  PARAMETER      SCBMAT(*,*,*,*,KK)      SCALED SUPPORT VALUES FOR ALL ELEMENTS OF B;
   SCBMAT(ACBL,TEL,ACBM,TEM,KK) $ ( QT(ACBL,TEL) AND QT(ACBM,TEM) )
                 =WBD(KK) $ (SAMEAS(ACBL,ACBM) AND SAMEAS(TEL,TEM))
                                 +WBOFFD(KK) $ (NOT  (SAMEAS(ACBL,ACBM) AND
SAMEAS(TEL,TEM)) );

      DISPLAY SCBMAT;


*
*----------------formulate ME optimization
*

  VARIABLES

       ENTROPY                           OBJECTIVE VARIABLE: MAXIMUM ENTROPY

       ALPHA_C(R,ACBM,TEM)               POINT ESTIMATES FOR d
       BMAT(ACBM,TEM,ACBL,TEL)           POINT ESTIMATES FOR B
       ZETA(R,ACBM,TEM,ACBL,TEL)         POINT ESTIMATES FOR Q

       PALPHA(R,ACBM,TEM,KK)             PROBABILITIES OF SUPPORT POINTS FOR d
       PBMAT(ACBM,TEM,ACBL,TEL,KK)       PROBABILITIES OF SUPPORT POINTS FOR B
       PC(KK)                    PROBABILITIES OF SUPPORT POINTS FOR EXPONENT OF CPI
       CPI(R)                    CROP PROFITABILITY INDEX

       LTL(ACBM,TEM,ACBL,TEL)  CHOLESKY LOWER TRIANGULAR MATRIX;


  FREE VARIABLE ENTROPY;

  EQUATIONS

       ENTROPY_                          MAXIMIZED ENTROPY MEASUREMENT

       MC_C_(R,ACBM,TEM)                 MARGINAL COSTS EQUATION

       D_(ACBM,TEM)              CHOLESKY DECOMPOSITION FOR DIAGONAL ELEMENTS OF B
       L_(ACBL,TEL,ACBM,TEM)     CHOLESKY DECOM. FOR OFF-DIAGONAL ELEMENTS OF B

       PALPHA_(R,ACBM,TEM)       ADDING UP PROBABILITIES FOR ALPHA_C
       ALPHA_(R,ACBM,TEM)        DEFINITION OF ALPHA_C

       PBMAT_(ACBM,TEM,ACBL,TEL)         ADDING UP PROBABILITIES FOR B
       BMAT_(ACBM,TEM,ACBL,TEL)          DEFINITION OF B

       PCPI_   ADDING UP PROBABILITIES FOR EXPONENT OF CROP PROF. INDEX CPI
       CPI_    DEFINITION OF CPRI
```

```
        ZETA_(R,ACBM,TEM,ACBL,TEL)        DEFINITION OF REGIONAL MATRIX OF SLOPES Q;


*
*----------------summing up for probabilities (adding up to unity)
*

  PALPHA_(R,ACBM,TEM) $ ACAREA_0204(ACBM,TEM,R)..  SUM(KK, PALPHA(R,ACBM,TEM,KK))=E=1;

  PBMAT_(ACBL,TEL,ACBM,TEM) $ ( (QT(ACBL,TEL) AND QT(ACBM,TEM))
                AND ((10*ORD(ACBM)+ORD(TEM)) LE (10*ORD(ACBL)+ORD(TEL)))
                              )
                        .. SUM(KK, PBMAT(ACBL,TEL,ACBM,TEM,KK))=E=1;

  PCPI_ ..SUM(KK, PC(KK))=E=1;


*
*----------------definition of d and B matrices
*

  ALPHA_(R,ACBM,TEM) $ ACAREA_0204(ACBM,TEM,R)
                ..SUM(KK, PALPHA(R,ACBM,TEM,KK)*ZALPHA(R,ACBM,TEM,KK))
                        =E=ALPHA_C(R,ACBM,TEM);

  BMAT_(ACBL,TEL,ACBM,TEM)
        $ (   (QT(ACBL,TEL) AND QT(ACBM,TEM)) AND
              (10*ORD(ACBM)+ORD(TEM)) LE (10*ORD(ACBL)+ORD(TEL))
           )
         ..SUM(KK, PBMAT(ACBL,TEL,ACBM,TEM,KK)*ZBMAT(ACBL,TEL,ACBM,TEM,KK))
                =E=BMAT(ACBL,TEL,ACBM,TEM);

  CPI_(R).. ARR_C(R)**SUM(KK,PC(KK)*ZS(KK))=E=CPI(R);

  ZETA_(R,ACBL,TEL,ACBM,TEM) $ (ACAREA_0204(ACBL,TEL,R) AND ACAREA_0204(ACBM,TEM,R))
        ..ZETA(R,ACBL,TEL,ACBM,TEM)=E=
          CPI(R)*SQRT(1/(CROPS(R,ACBL,TEL)*CROPS(R,ACBM,TEM)))*
              (  BMAT(ACBL,TEL,ACBM,TEM)
                   $(   (10*ORD(ACBM)+ORD(TEL)) LE (10*ORD(ACBL)+ORD(TEL))   )
                  +BMAT(ACBM,TEM,ACBL,TEL)
                   $(   (10*ORD(ACBM)+ORD(TEL)) GT (10*ORD(ACBL)+ORD(TEL))   )
               );

*
*----------------Quadratic Cost-functions's marginal
*

  MC_C_(R,ACBL,TEL) $ ACAREA_0204(ACBL,TEL,R).. MC_C(R,ACBL,TEL)
             =E=ALPHA_C(R,ACBL,TEL)
                +SUM( (ACBM,TEM),CROPS(R,ACBM,TEM)*ZETA(R,ACBL,TEL,ACBM,TEM)  );

*
*---------------- Cholesky decomposition, B=LL'
*

  D_(ACBL,TEL) $ QT(ACBL,TEL) ..LTL(ACBL,TEL,ACBL,TEL)*LTL(ACBL,TEL,ACBL,TEL)
        =E=BMAT(ACBL,TEL,ACBL,TEL)
           -SUM(   (ACBK,TEK) $( (10*ORD(ACBM)+ORD(TEK)) LT (10*ORD(ACBL)+ORD(TEL)) ),
                 LTL(ACBL,TEL,ACBK,TEK)*LTL(ACBL,TEL,ACBK,TEK)   );

  L_(ACBM,TEM,ACBL,TEL)
        $ (     (QT(ACBM,TEM) AND QT(ACBL,TEL)) AND
                ((10*ORD(ACBM)+ORD(TEM)) GT (10*ORD(ACBL)+ORD(TEL)))
           )
             ..LTL(ACBM,TEM,ACBL,TEL)=E=(BMAT(ACBM,TEM,ACBL,TEL)
                -SUM( (ACBK,TEK)
                        $(    (10*ORD(ACBK)+ORD(TEK)) LT (10*ORD(ACBL)+ORD(TEL))    ),
                                LTL(ACBM,TEM,ACBL,TEK)*LTL(ACBL,TEL,ACBK,TEK) ))
                                        /LTL(ACBL,TEL,ACBL,TEL);
*
*---------------- Entropy definition
*
*       -Search "most uniform" distribution for Pb, PB and PC which is
*        consistent or which fits the constraints
*
*


  ENTROPY_..     ENTROPY=E=
        -SUM( (R,ACBL,TEL,KK) $ ACAREA_0204(ACBL,TEL,R),
                PALPHA(R,ACBL,TEL,KK)*LOG(PALPHA(R,ACBL,TEL,KK)+EPSILON2) )
        -SUM( (ACBL,TEL,ACBM,TEM,KK)$ (
                                        ( QT(ACBL,TEL) AND QT(ACBM,TEM) )
```

```
                  and ( (10*ORD(ACBL)+ORD(TEL)) GE (10*ORD(ACBM)+ORD(TEM)) )),
                 PBMAT(ACBL,TEL,ACBM,TEM,KK)*LOG(PBMAT(ACBL,TEL,ACBM,TEM,KK)+EPSILON2)  )
         -SUM( KK,
                 PC(KK)*LOG(PC(KK)+EPSILON2)  ) ;


  MODEL MAXENT

         /PALPHA_,PBMAT_, PCPI_, ALPHA_, BMAT_, CPI_, ZETA_, MC_C_, L_, D_, ENTROPY_/;

  MAXENT.SOLPRINT=1;
  MAXENT.OPTFILE=7;


*
*---------------- Prepare for ME estimation and set support points
*                  and start values for ME problem
*

*---sum of endogenous crop activities in cluster


  LANDAV(LAT,"TOTAL")=SUM(R,LANDAV(LAT,R));


*---average marginal costs in regions, weighted by activity levels

  MC_C("TOTAL",ACBL,TEL) $ QT(ACBL,TEL) =SUM(R,MC_C(R,ACBL,TEL)*CROPS.L(R,ACBL,TEL))
                 /QT(ACBL,TEL);

     DISPLAY MC_C;


*---average revenue per ha of activities

  AR_C(R)=SUM((ACBM,TEM), CROPS.L(R,ACBM,TEM)*
                 SUM(OC,
                     -COMBAL.M(OC)*P(R,ACBM,OC,TEM))
            )
         /SUM(LAT,LANDAV(LAT,R));

     DISPLAY AR_C;


*---average revenue per ha of activities


  AR_C("TOTAL")=SUM(R,AR_C(R)*SUM(LAT,LANDAV(LAT,R)))
                 /SUM(LAT,LANDAV(LAT,"TOTAL"));

     DISPLAY AR_C;


*---average revenue per ha of endogenous crop activities in region in relation
*   to total, a kind of crop profitability index
*

  ARR_C(R)$ AR_C("TOTAL")=AR_C(R)/AR_C("TOTAL");

     DISPLAY MC_C, AR_C, ARR_C;


*---supports for d matrix


  ZALPHA(R,ACBM,TEM,KK)=COST_C(R,ACBM,TEM)+AR_C("TOTAL")*SCALPHA(KK);
     DISPLAY ZALPHA;


*---supports for B matrix

  ZBMAT(ACBL,TEL,ACBM,TEM,KK)
         $ (    (10*ORD(ACBM)+ORD(TEM)) LE (10*ORD(ACBL)+ORD(TEL))    )=
  SCBMAT(ACBL,TEL,ACBM,TEM,KK)*0.5*(MC_C("TOTAL",ACAL,TEL)+MC_C("TOTAL",ACAM,TEM));

    DISPLAY ZBMAT;

*--------- scaling the model

  ENTROPY_.SCALE=1;
  ENTROPY.SCALE=ENTROPY_.SCALE;

  BMAT_.SCALE(ACBL,TEL,ACBM,TEM)=1/1000000;
  ZETA_.SCALE(R,ACBL,TEL,ACBM,TEM)=1/1000000;
```

```
*--- ensure Positive Definite Matrix of slopes

  LTL.LO(ACBM,TEM,ACBM,TEM) =1.E-5;


*--- fix activity levels in equations

  CROPS.FX(R,ACBM,TEM) $ ACAREA_0204(ACBM,TEM,R) =CROPS.L(R,ACBM,TEM);
  CROPS.FX(R,ACBM,TEM) $ (ACAREA_0204(ACBM,TEM,R) EQ 0) =0;

*--- substitute fixed variables on RHS

  MAXENT.HOLDFIXED=1;
  MAXENT.SCALEOPT=1;


*---solve the problem

  SOLVE MAXENT  USING NLP MAXIMIZING ENTROPY;


*---fix the point estimate of the parameters: d and Q


        ALPHA_C.FX(R,ACBM,TEM)=ALPHA_C.L(R,ACBM,TEM);
        ZETA.FX(R,ACBM,TEM,ACBL,TEL)=ZETA.L(R,ACBM,TEM,ACBL,TEL);


********************************************************************************
*       (MODULE 2)     LIVESTOCK PRODUCTION                                    *
********************************************************************************

        ALIAS(AL,AL_L,AL_M,AL_K)

 PARAMETERS
                COST_L   COST FOR LIVESTOCK PRODUCTION
                MC_L     MARGINAL COST (LIVESTOCK)
                QT_L     TOTAL PRODUCTION PER LIVESTOCK;

  COST_L(AL)=SUM(LB,Q(LB,AL)*LBPRI(LB));

          DISPLAY COST_L;


  MC_L(AL)=PRODUCT.M(AL)+COST_L(AL);

          DISPLAY MC_L;


  QT_L(AL)=PRODUCT.L(AL);

          DISPLAY QT_L;


***************** RECOVERING Q MATRIX OF NONLINEAR COST FUNCTION****************


  PARAMETERS

        ZBMAT_L(*,*,KK)           SUPPORT VALUES FOR B MATRIX IN COST FUNCTION
        ZALPHA_L(*,KK)            SUPPORT VALUES FOR d MATRIX IN COST FUNCTION
        AR_L(*)                   AVERAGE REVENUE PER HA IN REGION
        ARR_L(*)                  AVERAGE RELATIVE REVENUE PER HA IN REGION;


  PARAMETER      SCALPHA_L(KK)    SCALED SUPPORT VALUES FOR ALL ELEMENTS OF d
$INCLUDE 'SCALPHA_L.TXT';


  PARAMETER      WBD_L(KK)         SCALED SUPPORT VALUES FOR DIAGONAL ELEMENTS OF B
$INCLUDE 'WBD_L.TXT';

  PARAMETER      WBOFFD_L(KK)     SCALED SUPPORT VALUES FOR OFF-DIAGONAL ELEMENTS OF B
$INCLUDE 'WBOFFD_L.TXT';

  PARAMETER      SCBMAT_L(*,*,KK)  SCALED SUPPORT VALUES FOR ALL ELEMENTS OF B;

   SCBMAT_L(AL_L,AL_M,KK) $ ( QT_L(AL_L) AND QT_L(AL_M) )
             =WBD_L(KK) $ SAMEAS(AL_L,AL_M)
                          +WBOFFD_L(KK) $ (NOT  SAMEAS(AL_L,AL_M))  ;

          DISPLAY SCBMAT_L;
```

```
*
*----------------formulate ME optimization
*

  VARIABLES

         ENTROPY_L                          OBJECTIVE VARIABLE: MAXIMUM ENTROPY

         ALPHA_L(AL_M)                      POINT ESTIMATES FOR d
         BMAT_L(AL_M, AL_L)                 POINT ESTIMATES FOR B
         ZETA_L(AL_M,AL_L)                  POINT ESTIMATES FOR Q

         PALPHA_L(AL_M,KK)                  PROBABILITIES OF SUPPORT POINTS FOR d
         PBMAT_L(AL_M,AL_L,KK)              PROBABILITIES OF SUPPORT POINTS FOR B

         LTL_L(AL_M,AL_L)                   CHOLESKY LOWER TRIANGULAR MATRIX;


  FREE VARIABLE ENTROPY_L;

  EQUATIONS

         ENTROPY_L_               MAXIMIZED ENTROPY MEASUREMENT

         MC_L_(AL_M)              MARGINAL COSTS EQUATION

         D_L_(AL_M)               CHOLESKY DECOMPOSITION FOR DIAGONAL ELEMENTS OF B
         L_L_(AL_L,AL_M)          CHOLESKY DECOM. FOR OFF-DIAGONAL ELEMENTS OF B

         PALPHA_L_(AL_M)          ADDING UP PROBABILITIES FOR ALPHA_C
         ALPHA_L_(AL_M)           DEFINITION OF ALPHA_C

         PBMAT_L_(AL_M,AL_L)      ADDING UP PROBABILITIES FOR B
         BMAT_L_(AL_M,AL_L)       DEFINITION OF B

         ZETA_L_(AL_M,AL_L)       DEFINITION OF REGIONAL MATRIX OF SLOPES Q;


*
*----------------summing up for probabilities
*

  PALPHA_L_(AL_M) ..  SUM(KK, PALPHA_L(AL_M,KK))=E=1;

  PBMAT_L_(AL_L,AL_M) $ (ORD(AL_M) LE ORD(AL_L))
                           .. SUM(KK, PBMAT_L(AL_L,AL_M,KK))=E=1;

*
*----------------definition of d and B matrices
*

  ALPHA_L_(AL_M) ..SUM(KK, PALPHA_L(AL_M,KK)*ZALPHA_L(AL_M,KK))
                       =E=ALPHA_L(AL_M);

  BMAT_L_(AL_L,AL_M)
         $ (   ORD(AL_M) LE ORD(AL_L)    )
          ..SUM(KK, PBMAT_L(AL_L,AL_M,KK)*ZBMAT_L(AL_L,AL_M,KK))
                 =E=BMAT_L(AL_L,AL_M);

  ZETA_L_(AL_L,AL_M)  ..ZETA_L(AL_L,AL_M)=E=
              BMAT_L(AL_L,AL_M) $ (ORD(AL_M) LE ORD(AL_L))
             +BMAT_L(AL_M,AL_L) $ (ORD(AL_M) GT ORD(AL_L)) ;

*
*----------------Quadratic Cost-functions's marginal
*

  MC_L_(AL_L).. MC_L(AL_L)
              =E=ALPHA_L(AL_L) + SUM(  AL_M,PRODUCT(AL_M)*ZETA_L(AL_L,AL_M)  );

*
*---------------- Cholesky decomposition, B=LL'
*

  D_L_(AL_L)  .. LTL_L(AL_L,AL_L)*LTL_L(AL_L,AL_L)
         =E=BMAT_L(AL_L,AL_L)
            -SUM(   AL_K $(ORD(AL_L) LT ORD(AL_L)),
                  LTL_L(AL_L,AL_K)*LTL_L(AL_L,AL_K)   );

  L_L_(AL_M,AL_L)
         $ (   ORD(AL_M) GT ORD(AL_L)    )
              ..LTL_L(AL_M,AL_L)=E=(BMAT_L(AL_M,AL_L)
```

```
                -SUM( AL_K $(    ORD(AL_K) LT ORD(AL_L)   ),
                                LTL_L(AL_K,AL_K)*LTL_L(AL_L,AL_K) )  )
                                        /LTL_L(AL_L,AL_L);


*
*---------------- Entropy definition
*
*       -Search "most uniform" distribution of Pb, PB and PC which is
*        consistent or which fits the constraints
*
*

  ENTROPY_L_..      ENTROPY_L=E=
        -SUM( (AL_L,KK) ,
                PALPHA_L(AL_L,KK)*LOG(PALPHA_L(AL_L,KK)+EPSILON3) )
        -SUM( (AL_L,AL_M,KK)$ (ORD(AL_L) GE ORD(AL_M)),
                PBMAT_L(AL_L,AL_M,KK)*LOG(PBMAT_L(AL_L,AL_M,KK)+EPSILON3)  );

  MODEL MAXENT_L

        /PALPHA_L_,PBMAT_L_,ALPHA_L_,BMAT_L_,ZETA_L_,MC_L_,L_L_,D_L_,ENTROPY_L_/;

  MAXENT_L.SOLPRINT=1;
  MAXENT_L.OPTFILE=7;

*---supports for d matrix

  ZALPHA_L(AL_M,KK)=COST_L(AL_M)+1*SCALPHA_L(KK);

           DISPLAY ZALPHA_L;

*---supports for B matrix

  ZBMAT_L(AL_L,AL_M,KK)
        $ (    ORD(AL_M) LE ORD(AL_L)    )= SCBMAT_L(AL_L,AL_M,KK)

           DISPLAY ZBMAT_L;

*
* ---------- SCALING THE PROBLEM
*

        ENTROPY_L_.SCALE=1;
        ENTROPY_L.SCALE=ENTROPY_L_.SCALE;

        BMAT_L_.SCALE(AL_L,AL_M)=1/1000000;
        ZETA_L_.SCALE(AL_L,AL_M)=1/1000000;


*--- Ensuring positive definiteness of slope matrix


  LTL_L.LO(AL_L,AL_M) =1.E-5;


*--- fix activity levels in equations

  PRODUCT.FX(AL_M) =PRODUCT.L(AL_M);

*--- substitute fixed variables on RHS

  MAXENT_L.HOLDFIXED=1;
  MAXENT_L.SCALEOPT=1;

*--- solve the problem

  SOLVE MAXENT_L  USING NLP MAXIMIZING ENTROPY_L;


*---fix the point estimates of the parameters: d and Q matrices

        ALPHA_L.FX(AL_M)=ALPHA_L.L(AL_M);
        ZETA_L.FX(AL_M,AL_L)=ZETA_L.L(AL_M,AL_L);


*******************************************************************************
*     (MODULE 3)     FRUITS AND NUTS PRODUCTION                               *
*******************************************************************************

        ALIAS(ACFN,ACFNL,ACFNM,ACFNK)
        ALIAS(TE,TEL,TEM,TEK)

 PARAMETER
```

```
                 COST_CFN          PER HA COST FOR PRODUCTION
                 MC_CFN            MARGINAL COST
                 QTFN              TOTAL PRODUCTION PER PRODUCT;

  COST_CFN(R,ACFN,TE)=SUM(E,PCOST(R,ACFN,E,TE));

           DISPLAY COST_CFN;

  MC_CFN(R,ACFNL,TEL)=CROPS.M(R,ACFNL,TEL)+COST_CFN(R,ACFNL,TEL);

           DISPLAY MC_CFN;

  QTFN(ACFNL,TEL)=SUM(R,CROPS.L(R,ACFNL,TEL));

           DISPLAY QTFN;


****************** RECOVERING Q MATRIX OF NONLINEAR COST FUNCTION****************


  PARAMETERS

         ZBMAT_FN(*,*,*,*,KK)      SUPPORT VALUES FOR B MATRIX IN COST FUNCTION
         ZALPHA_FN(*,*,*,KK)       SUPPORT VALUES FOR d MATRIX IN COST FUNCTION
         ZS_FN(KK)                 SUPPORT VALUES FOR EXPONENT OF CPI
         AR_CFN(*)                 AVERAGE REVENUE PER HA IN REGION
         ARR_CFN(*)                AVERAGE RELATIVE REVENUE PER HA IN REGION;


  PARAMETER      ZS_FN(KK)         SUPPORT POINT FOR EXPONENT OF CPI
$INCLUDE 'ZS_FN.TXT';

  PARAMETER      SCALPHA_FN(KK)    SCALED SUPPORT VALUES FOR ALL ELEMENTS OF d
$INCLUDE 'SCALPHA_FN.TXT';


  PARAMETER      WBD_FN(KK)        SCALED SUPPORT VALUES FOR DIAGONAL ELEMENTS OF B
$INCLUDE 'WBD_FN.TXT';

  PARAMETER      WBOFFD_FN(KK)     SCALED SUPPORT VALUES FOR OFF-DIAGONAL ELEMENTS OF B
$INCLUDE 'WBOFFD_FN.TXT';

  PARAMETER      SCBMAT_FN(*,*,*,*,KK)      SCALED SUPPORT VALUES FOR ALL ELEMENTS OF B;
   SCBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK) $ ( QTFN(ACFNL,TEL) AND QTFN(ACFNM,TEM) )
                 =WBD_FN(KK) $ (SAMEAS(ACFNL,ACFNM) AND SAMEAS(TEL,TEM))
                                 +WBOFFD_FN(KK) $ (NOT  (SAMEAS(ACFNL,ACFNM) AND
SAMEAS(TEL,TEM)) );

           DISPLAY SCBMAT_FN;

*
*----------------formulate ME optimization
*

  VARIABLES

         ENTROPY_FN                        OBJECTIVE VARIABLE: MAXIMUM ENTROPY

         ALPHA_CFN(R,ACFNM,TEM)            POINT ESTIMATES FOR d
         BMAT_FN(ACFNM,TEM,ACFNL,TEL)      POINT ESTIMATES FOR B
         ZETA_FN(R,ACFNM,TEM,ACFNL,TEL)    POINT ESTIMATES FOR Q

         PALPHA_FN(R,ACFNM,TEM,KK)         PROBABILITIES OF SUPPORT POINTS FOR d
         PBMAT_FN(ACFNM,TEM,ACFNL,TEL,KK)  PROBABILITIES OF SUPPORT POINTS FOR B
         PC_FN(KK)                 PROBABILITIES OF SUPPORT POINTS FOR EXPONENT OF CPI
         CPI_FN(R)                 CROP PROFITABILITY INDEX

         LTL_FN(ACFNM,TEM,ACFNL,TEL)       CHOLESKY LOWER TRIANGULAR MATRIX;


  FREE VARIABLE ENTROPY_FN;

  EQUATIONS

         ENTROPY_FN_                       MAXIMIZED ENTROPY MEASUREMENT

         MC_CFN_(R,ACFNM,TEM)              MARGINAL COSTS EQUATION

         D_FN_(ACFNM,TEM)                  CHOLESKY DECOM. FOR DIAGONAL ELEMENTS OF B
         L_FN_(ACFNL,TEL,ACFNM,TEM)        CHOLESKY DECOM. FOR OFF-DIAGONAL ELEMENTS OF B

         PALPHA_FN_(R,ACFNM,TEM)           ADDING UP PROBABILITIES FOR ALPHA_C
         ALPHA_FN_(R,ACFNM,TEM)            DEFINITION OF ALPHA_C
```

```
        PBMAT_FN_(ACFNM,TEM,ACFNL,TEL)       ADDING UP PROBABILITIES FOR B
        BMAT_FN_(ACFNM,TEM,ACFNL,TEL)        DEFINITION OF B

        PCPI_FN_   ADDING UP PROBABILITIES FOR EXPONENT OF CROP PROF. INDEX CPI
        CPI_FN_    DEFINITION OF CPRI

        ZETA_FN_(R,ACFNM,TEM,ACFNL,TEL)      DEFINITION OF REGIONAL MATRIX OF SLOPES Q;


*
*----------------summing up for probabilities
*

  PALPHA_FN_(R,ACFNM,TEM) $ ACAREA_0204(ACFNM,TEM,R)..  SUM(KK,
PALPHA_FN(R,ACFNM,TEM,KK))=E=1;

  PBMAT_FN_(ACFNL,TEL,ACFNM,TEM) $ ( (QTFN(ACFNM,TEL) AND QTFN(ACFNM,TEM))
               AND ((10*ORD(ACFNM)+ORD(TEM)) LE (10*ORD(ACFNL)+ORD(TEL)))
                             )
                       .. SUM(KK, PBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK))=E=1;

  PCPI_FN_ ..SUM(KK, PC_FN(KK))=E=1;


*
*----------------definition of d and B matrices
*

  ALPHA_FN_(R,ACFNM,TEM) $ ACAREA_0204(ACFNM,TEM,R)
               ..SUM(KK, PALPHA_FN(R,ACFNM,TEM,KK)*ZALPHA_FN(R,ACFNM,TEM,KK))
                       =E=ALPHA_CFN(R,ACFNM,TEM);

  BMAT_FN_(ACFNL,TEL,ACFNM,TEM)
        $ (   (QTFN(ACFNL,TEL) AND QTFN(ACFNM,TEM)) AND
              (10*ORD(ACFNM)+ORD(TEM)) LE (10*ORD(ACFNL)+ORD(TEL))
           )
         ..SUM(KK, PBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK)*ZBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK))
               =E=BMAT_FN(ACFNL,TEL,ACFNM,TEM);

  CPI_FN_(R).. ARR_CFN(R)**SUM(KK,PC_FN(KK)*ZS_FN(KK))=E=CPI_FN(R);

  ZETA_FN_(R,ACFNL,TEL,ACFNM,TEM) $ (ACAREA_0204(ACFNL,TEL,R) AND ACAREA_0204(ACFNM,TEM,R))
        ..ZETA_FN(R,ACFNL,TEL,ACFNM,TEM)=E=
          CPI_FN(R)*SQRT(1/(CROPS(R,ACFNM,TEL)*CROPS(R,ACFNM,TEM)))*
              (  BMAT_FN(ACFNL,TEL,ACFNM,TEM)
                   $(   (10*ORD(ACFNM)+ORD(TEM)) LE (10*ORD(ACFNL)+ORD(TEL))   )
                  +BMAT_FN(ACFNM,TEM,ACFNL,TEL)
                   $(   (10*ORD(ACFNM)+ORD(TEM)) GT (10*ORD(ACFNL)+ORD(TEL))   )
               );

*
*----------------Quadratic Cost-functions's marginal
*

  MC_CFN_(R,ACFNM,TEL) $ ACAREA_0204(ACFNL,TEL,R).. MC_CFN(R,ACFNL,TEL)
            =E=ALPHA_CFN(R,ACFNL,TEL)
               +SUM( (ACFNM,TEM),CROPS(R,ACFNM,TEM)*ZETA_FN(R,ACFNL,TEL,ACFNM,TEM)  );

*
*---------------- Cholesky decomposition, B=LL'
*

  D_FN_(ACFNL,TEL) $ QTFN(ACFNL,TEL)
..LTL_FN(ACFNL,TEL,ACFNL,TEL)*LTL_FN(ACFNL,TEL,ACFNL,TEL)
        =E=BMAT_FN(ACFNL,TEL,ACFNL,TEL)
           -SUM(   (ACFNK,TEK) $( (10*ORD(ACFNK)+ORD(TEK)) LT (10*ORD(ACFNL)+ORD(TEL)) ),
                 LTL_FN(ACFNL,TEL,ACFNK,TEK)*LTL_FN(ACFNL,TEL,ACFNK,TEK)   );

  L_FN_(ACFNM,TEM,ACFNL,TEL)
        $ (     (QTFN(ACFNM,TEM) AND QTFN(ACFNL,TEL)) AND
                ((10*ORD(ACFNM)+ORD(TEM)) GT (10*ORD(ACFNL)+ORD(TEL)))
           )
             ..LTL_FN(ACFNM,TEM,ACFNM,TEL)=E=(BMAT_FN(ACFNM,TEM,ACFNL,TEL)
                -SUM( (ACFNK,TEK)
                        $(    (10*ORD(ACFNK)+ORD(TEK)) LT (10*ORD(ACFNL)+ORD(TEL))    ),
                                LTL_FN(ACFNL,TEM,ACFNK,TEK)*LTL_FN(ACFNL,TEL,ACFNK,TEK) ))
                                        /LTL_FN(ACFNM,TEL,ACFNL,TEL);

*
*---------------- Entropy definition
*
*        -Search "most uniform" distribution of Pb, PB and PC which is
*         consistent or which fits the constraints
*
```

```
*

  ENTROPY_FN_..     ENTROPY_FN=E=
        -SUM( (R,ACFNL,TEL,KK) $ ACAREA_0204(ACFNL,TEL,R),
                PALPHA_FN(R,ACFNL,TEL,KK)*LOG(PALPHA_FN(R,ACFNL,TEL,KK)+EPSILON2) )
        -SUM( (ACFNL,TEL,ACFNM,TEM,KK)$ (
                                        ( QTFN(ACFNL,TEL) AND QTFN(ACFNM,TEM) )
                 AND ( (10*ORD(ACFNL)+ORD(TEL)) GE (10*ORD(ACFNM)+ORD(TEM)) )),

PBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK)*LOG(PBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK)+EPSILON2)  )
        -SUM( KK,
                PC_FN(KK)*LOG(PC_FN(KK)+EPSILON2)  );


  MODEL MAXENT_FN

     /PALPHA_FN_,PBMAT_FN_,PCPI_FN_,ALPHA_FN_,BMAT_FN_,CPI_FN_,ZETA_FN_,MC_CFN_,L_FN_
        D_FN_,ENTROPY_FN_/;


  MAXENT_FN.SOLPRINT=1;
  MAXENT_FN.OPTFILE=7;


*
*---------------- Prepare for ME estimation ans set support points
*                 and start values for ME problem
*


*--- average marginal costs in regions, weighted by activity levels

  MC_CFN("TOTAL",ACFNL,TEL) $ QTFN(ACFNL,TEL)
=SUM(R,MC_CFN(R,ACFNL,TEL)*CROPS.L(R,ACFNL,TEL))
                /QTFN(ACFNL,TEL);

     DISPLAY MC_CFN;

*--- average revenue per ha of activities

  AR_CFN(R)=SUM((ACFNM,TEM), CROPS.L(R,ACFNM,TEM)*
                SUM(OC,
                    -COMBAL.M(OC)*P(R,ACFNM,OC,TEM))
            )
        /SUM(LAT,LANDAV(LAT,R));

     DISPLAY AR_CFN;

*--- average revenue per ha of activities


  AR_CFN("TOTAL")=SUM(R,AR_CFN(R)*SUM(LAT,LANDAV(LAT,R)))
                /SUM(LAT,LANDAV(LAT,"TOTAL"));

     DISPLAY AR_CFN;


*---average revenue per ha of endogenous crop activities in region in relation
*   to total, a kind of crop profitability index
*

  ARR_CFN(R)$ AR_CFN("TOTAL")=AR_CFN(R)/AR_CFN("TOTAL");

     DISPLAY MC_CFN, AR_CFN, ARR_CFN;

*---supports for d matrix

  ZALPHA_FN(R,ACFNM,TEM,KK)=COST_CFN(R,ACFNM,TEM)+AR_CFN("TOTAL")*SCALPHA_FN(KK);
     DISPLAY ZALPHA_FN;

*---supports for B matrix

  ZBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK)
        $ (    (10*ORD(ACFNM)+ORD(TEM)) LE (10*ORD(ACFNL)+ORD(TEL))    )=
                SCBMAT_FN(ACFNL,TEL,ACFNM,TEM,KK)
                        *0.5*(MC_CFN("TOTAL",ACFNL,TEL)+MC_CFN("TOTAL",ACFNM,TEM));

    DISPLAY ZBMAT_FN;

*
* ---------- SCALING THE PROBLEM
*

  ENTROPY_FN_.SCALE=1;
```

```
  ENTROPY_FN.SCALE=ENTROPY_FN_.SCALE;

  BMAT_FN_.SCALE(ACFNL,TEL,ACFNM,TEM)=1/1000000;
  ZETA_FN_.SCALE(R,ACFNL,TEL,ACFNM,TEM)=1/1000000;


*--- ensure positive definite matrix of slopes

  LTL_FN.LO(ACFNM,TEM,ACFNM,TEM) =1.E-5;


*---fix activity levels in equations

  CROPS.FX(R,ACFNM,TEM) $ ACAREA_0204(ACFNM,TEM,R) =CROPS.L(R,ACFNM,TEM);
  CROPS.FX(R,ACFNM,TEM) $ (ACAREA_0204(ACFNM,TEM,R) EQ 0) =0;


*---substitute fixed variables on RHS

  MAXENT_FN.HOLDFIXED=1;
  MAXENT_FN.SCALEOPT=1;

*---solve the problem

  SOLVE MAXENT_FN  USING NLP MAXIMIZING ENTROPY_FN;


*---fix the point estimate of the parameters: d and Q


         ALPHA_CFN.FX(R,ACFNM,TEM)=ALPHA_CFN.L(R,ACFNM,TEM);
         ZETA_FN.FX(R,ACFNM,TEM,ACFNL,TEL)=ZETA_FN.L(R,ACFNM,TEM,ACFNL,TEL);


*----------------------------------------------------------------------------*
*                                                                            *
*          DEFINING THE NONLINEAR MODEL FOR PMP WITH MAXIMUM ENTROPY         *
*                    AND CHECK FOR CALIBRATION BOUNDS                        *
*                                                                            *
*----------------------------------------------------------------------------*

  EQUATION

               MEPROFIT_       OBJECTIVE FUNCTION (CONSUMER+PRODUCER SURPLUS');

  MEPROFIT_..PROFIT=E=SUM(O, ALPHA(O)*TOTALCONS(O)+0.5*BETA(O)
             *TOTALCONS(O)**2)

             +SUM(O,EXPRICE_USA(O)*EXPORT_USA(O))
             +SUM(O,(ALPHAX_USA(O)+0.5*GAMMAX_USA(O)*EXPORT_USA(O))*EXPORT_USA(O))
             +SUM(O,EXPRICE_EU(O)*EXPORT_EU(O))
             +SUM(O,(ALPHAX_EU(O)+0.5*GAMMAX_EU(O)*EXPORT_EU(O))*EXPORT_EU(O))
             +SUM(O,EXPRICE_RW(O)*EXPORT_RW(O))
             +SUM(O,(ALPHAX_RW(O)+0.5*GAMMAX_RW(O)*EXPORT_RW(O))*EXPORT_RW(O))

             -SUM(O,IMPRICE_USA(O)*IMPORT_USA(O))
             -SUM(O,IMPRICE_EU(O)*IMPORT_EU(O))
             -SUM(O,IMPRICE_RW(O)*IMPORT_RW(O))

             -SUM(E,PRCOST(E))

* PMP-ME COST FUNCTIONS ESTIMATES (VEGETAL PRODUCTS)
      -SUM(R,SUM((ACBL,TEL),CROPS(R,ACBL,TEL)*(ALPHA_C(R,ACBL,TEL)
             +0.5*SUM((ACBM,TEM),CROPS(R,ACBM,TEM)*ZETA(R,ACBM,TEM,ACBL,TEL)))))

     -SUM(R,SUM((ACFNL,TEL),CROPS(R,ACFNL,TEL)*(ALPHA_CFN(R,ACFNL,TEL)
             +0.5*SUM((ACFNM,TEM),CROPS(R,ACFNM,TEM)*ZETA_FN(R,ACFNM,TEM,ACFNL,TEL)))))

* PMP-ME COST FUNCTIONS ESTIMATES (ANIMAL PRODUCTS)
      -SUM(AL_L,PRODUCT(AL_L)*(ALPHA_L(AL_L)
             +0.5*SUM(AL_M,PRODUCT(AL_M)*ZETA_L(AL_M,AL_l))))


  MODEL MEPMP

          / LAND
            LABTRAC
            PURCFERT
            FEEDSTRAW
            FEEDCON
            FEEDCERI
            FEEDPAST
            FEEDOIL
            FEEDFODD
```

```
            TOTALFEED
            MINFEED
            MINGRCOIL
            MINGROIL
            MINGRAIN
            COMBAL
            IMPORT_USA_
            IMPORT_EU_
            IMPORT_RW_
            MEPROFIT_ / ;

*-------- release bounds

        CROPS.LO(R,ACBM,TE)=0;
        CROPS.UP(R,ACBM,TE)= INF;
        CROPS.LO(R,ACFNM,TE)= 0;
        CROPS.UP(R,ACFNM,TE)= INF;

        PRODUCT.LO(AL)=0;
        PRODUCT.UP(AL)=INF;

        TOTALCONS.LO(O)=0;
        TOTALCONS.UP(O)=INF;

        EXPORT_USA.LO(O)=0;
        EXPORT_USA.UP(O)=INF;
        EXPORT_EU.LO(O)=0;
        EXPORT_EU.UP(O)=INF;
        EXPORT_RW.LO(O)=0;
        EXPORT_RW.UP(O)=INF;

*
*--------- reset variables
*

         PUFERT.L(R,FR)=0;
         PRCOST.L(E)=0;
         LATRUSE.L(LTC,R)=0;
         FEED.L(TF)=0;
         FGRAIN.L(O,R)=0;
         TOTALCONS.L(O)=0;
         IMPORT_USA.L(O)=0;
         EXPORT_USA.L(O)=0;
         IMPORT_EU.L(O)=0;
         EXPORT_EU.L(O)=0;
         IMPORT_RW.L(O)=0;
         EXPORT_RW.L(O)=0;
         IMPORTS.L(O)=0;
         EXPORTS.L(O)=0;


  MEPMP.OPTFILE=7;
  MEPMP.HOLDFIXED=1;


  SOLVE MEPMP USING NLP MAXIMIZING PROFIT;

*******************************************************************************
```

A5. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: ERUYGUR, H. Ozan
Nationality: Turkish (TC)
Date and Place of Birth: 11 February 1974, Kütahya
Marital Status: Single
Phone: +90 536 881 84 54
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EDUCATION

Degree	Institution	Year of Graduation
MS	IAMM, Natural Resource Economics, Montpellier, France.	2001
MS	METU Department of Economics	2000
BS	METU Department of Economics	1997
High School	Ankara Anadolu High School (French), Ankara.	1992

WORK EXPERIENCE

Year	Place	Enrollment
2005 (March)-Present	EU-MED AGPOL, EU-FP6 Policy Oriented Research Project, METU.	Researcher
2004 (August & September)	Food and Agriculture Organization of the United Nations, FAO.	Consultant
1998-2005	METU Department of Economics	Research Assistant

PUBLICATION(S)

Eruygur, H. O., and Çakmak, E. H., (2006), Causes and Impacts of Agricultural Structures, Chapter 14: Analysis of EU membership of Turkey on Turkish agriculture: A Sector Model Approach with Maximum Entropy, Edit. Stefan Mann, Nova Publishers (in Print), New York, USA.

A6. TURKISH SUMMARY

Türkiye, eski adıyla Avrupa Ekonomik Topluluğu (AET)'na, kuruluşundan hemen sonra, Temmuz 1959'da üyelik başvurusunda bulunmuştur. Türkiye'nin topluluğa tam üyeliğini bir nihai hedef olarak ortaya koyan Ortaklık Anlaşması (Ankara Anlaşması), 1963 yılında imzalanmış ve 1 Aralık 1964'de yürürlüğe girmiştir. Ankara Anlaşması, Kasım 1970'te imzalanan "Katma Protokol" ile desteklenmiştir. Katma Protokol Türkiye ile AB arasında Gümrük Birliği'nin kademeli olarak tesisini amaçlamaktadır. Mart 1995 tarihinde yapılan Ortaklık Konseyi toplantısında alınan karar uyarınca Türkiye ile AB arasındaki gümrük birliği 1 Ocak 1996 tarihinde yürürlüğe girmiştir. Türkiye-AB Gümrük Birliği, sanayi ürünleri ile buğday, şeker ve süt içeren işlenmiş tarım ürünlerini kapsamakta, geleneksel işlenmemiş tarım ürünleri ise kapsam dışı tutulmaktadır. Türkiye, Aralık 1999'da Helsinki'de yapılan AB Devlet ve Hükümet Başkanları Zirvesi'nde oybirliği ile diğer aday ülkelerle eşit konumda olarak Avrupa Birliği'ne aday ülke olarak kabul edilmiştir. AB Devlet ve Hükümet Başkanları Konseyinin Brüksel'de yapmış olduğu Zirve Toplantısında Türkiye'nin 3 Ekim 2005 tarihinde katılım müzakerelerine başlaması öngörüldü. Avrupa Birliğine Katılım Müzakerelerinin başlamasının hemen ardından belirli bir takvim içerisinde bir yılda tamamlanması planlanan Tarama Süreci, 20 Ekim 2005 tarihinde Brüksel'de yapılan Tanıtıcı Tarama Toplantısı ile başlamıştır. Türkiye, AB ile müzakerelerin ilk faslını Haziran 2006'da kapattı. Eğer gerşekleşecek ise, AB üyeliğinin 2015 yılından önce olması olası gözükmüyor, çünkü Avrupa Komisyonu müzakereler sonuçlanmadan önce AB'nin 2014 sonrası mali perspektiflerini belirlemesi gerektiğini belirtiyor.

Türkiye'nin AB üyeliği AB ile olan tarımsal ticaretin tam olarak liberalleşmesine neden olacaktır, çünkü yukarıda belirttiğimiz gibi yürürlükte olan gümrük birliği anlaşması sadece sanayi ürünlerini ve buğday, şeker ve süt içeren işlenmiş tarım ürünlerini (çikolata, şekerleme, çocuk mamaları, bisküvi, pasta, makarna, dondurma gibi) kapsamakta, diğer tarım ürünleri ise kapsam dışı bulunmaktadır. AB, tarımsal ürünlerde, Türkiye'nin önemli bir ticaret partneridir. Bu yüzden, AB ile Türkiye arasındaki ekonomik entegrasyonun genişlemesinin, Türkiye'deki üretim yapısında ve Türkiye'nin AB ve diğer dünya ülkeleri ile olan ticaret akımında önemli değişiklikler yaratması beklenmektedir. Türkiye ve AB tarımsal ticaretindeki korumaların kaldırılmasının olası etkilerinin kestirilmesi, hem ülkemiz hem de AB politika belirleyicileri açısından büyük önem taşımaktadır. Politika yapısındaki değişim tarımsal ticarette oluşacak etkilerle birleşerek, üyelik müzakerelerinde muafiyet ve derogasyonların belirlenmesinde ve nihai olarak Türkiye'nin üyeliğinin AB ve Türkiye bütçeleri üzerindeki net etkilerinin tahmin edilmesinde kritik bir rol oynayacaktır. Çakmak ve Kasnakoğlu (2002), AB ile Türkiye arasındaki ticari liberalleşmenin olası faydalarının hem Türkiye hem de AB'nin uygulayacağı tarımsal politikalara ve aynı zamanda katılım müzakereleri sürecine bağlı olduğunu dile getirmişlerdir. Bu bağlamda, Türkiye'nin AB üyeliğinin tarımsal üretim ve ticarette yaratacağı olası etkileri analiz etmek önem kazanmaktadır. Fakat bu tür bir etki değerlendirme çözümlemesi, AB Komisyonu (2004c, p.33)'nun da haklı olarak belirttiği gibi, sağlam bir ekonomik analize dayanmalıdır.

Diğer taraftan, tarımsal korumalar küresel ticaret müzakerelerinde en tartışmalı ve çekişmeli konu olmayı sürdürmektedir. Sınırlı da olsa, endüstrileşmiş ülkeler kendi tarım politikalarının, dünya tarımsal ticaretindeki rekabeti bozucu yönlerini azaltmaya başladılar ve buna zorlanmaktalar. Dünya tarımsal ticaretinin liberalleştirilmesi yönündeki baskılar gelecekte de artarak devam edecek gibi gözüküyor. Uruguay Turu Tarım Anlaşması (1995), uluslararası tarımsal ticaretin ileride daha da liberalleştirilmesi yönünde bir ön karar içeriyordu. Bu doğrultuda, yeni müzakereler Kasım 2001'de Doha'da başladı. 31 Temmuz 2004 tarihinde, Dünya Ticaret Örgütü (DTÖ)'nün 147 üye hükümeti bir Çerçeve Anlaşması'nı onayladılar. Bu Çerçeve Anlaşması müzakereler sonunda önemli gümrük ve koruma indirimlerine gidileceğini bildiriyordu (FAO, 2005a, p.29). Aralık 2005'te, Hong Kong Bakanlar müzakereleri 2013 yılı sonuna kadar ihracat sübvansiyonlarının bütün DTÖ üyesi ülkeler tarafından paralel olarak kaldırılması yönünde bir anlaşmaya varılarak sona erdi. Fakat, Temmuz 2006 Cenova müzakerelerinde ithalat vergilerinin ve çiftçi sübvansiyonlarının azaltılması konusunda anlaşmaya varılamadı. Bütün bu gelişmeler ışığında, 2015'ten önce yeni bir DTÖ anlaşmasının uygulanmaya başlanması olası gözükmüyor. Fakat, bu tarihten sonra dünya tarımsal ticaretinde daha çok liberalleşmeye yönelik bağlayıcı değişikliklerin bütün DTÖ üyesi ülkeler tarafından uygulanması gerekecek. Bu bağlamda, yeni bir DTÖ anlaşmasının olası etkilerinin analizi hem Türkiye'nin müzakereler boyunca sürdüreceği tavrı belirlemesinde ve bu etkileri dikkate alarak yeni tarımsal politikalar oluşturmasında büyük önem kazanmaktadır. Ancak, daha önce AB entegrasyonu ile ilgili olarak ta belirttiğimiz gibi, bu analizin sağlıklı bir şekilde yapılabilmesi için kullanılan değerlendirme çerçevesinin sağlam bir ekonomik temelinin olması gereklidir.

Ekonomi literatüründe, değişik politika alternatif ve senaryolarının olası etkilerini değerlendirmek için bir çok ekonomik model tipi kullanılmaktadır. Modelleme tarzının seçimi, analizin amaçına ve eldeki verinin düzeyine göre yapılmaktadır. Yeterli veri olmasi durumunda *ekonometrik modelleme* tercih edilebilir. Fakat, tarımsal kalkınma ve politika konularında sağlıklı analiz yapmayı sağlayacak düzeyde (hem nitelik hem de nicelik olarak) veri bulmak genelde çok zor olduğu için, bu konularda ekonometrik modelleme uygulamasına literatürde az rastlanmaktadır. Bu yüzden, ekonometrik modellere göre daha sınırlı veri ile çok daha fazla ekonomik etkileşimin modellenebilmesine olanak sağlayan *matematiksel programlama* yaklaşımını kullanmak çoğu kez en uygun metod olarak karşımıza çıkmaktadır. Matematiksel ekonomik modeller, kompleks bir matematiksel sisteme dayanan sağlam bir ekonomik yapı üzerine kurulmuş etki değerlendirme araçlarıdır. Sağlıklı bir politika etki değerlendirmesi yapabilmek için önemli olan nokta kullanılan matematiksel modelin *normatif* değil *pozitif* olmasıdır. Çünkü, normatif modeller “*ne olmalıdır?*” sorusuna cevap ararlarken pozitif modeller “*ne olacak?*” sorusuna cevap verirler. Pozitif modeller ekonomik yapıyı olduğu gibi yansıtmaya çalışırlar, bu yüzden bir değişikliğin betimledikleri bu yapı üzerindeki olası etkilerini analiz etmemize olanak sağlarlar. Bu tür pozitif bir model, politika parametrelerinin farklı varsayımları altında çalıştırılıp çözülür ve bu şekilde değişik politikaların olası etkileri hakkında bilgi sağlar (Hazel and Norton, 1986, p.5).

Bu çalışmada, ekonomik modelleme şekline karar vermek için, önce ekonomik modelleme uygulamalarını şu dört ana başlık altında inceledik: Küresel Ticaret Modelleri, Hesaplanabilir Genel Denge Modelleri (HGD), Tarımsal Sektör Modelleri ve Çiftlik Düzeyi Modelleri. Bu incelememizde, artıları ve eksileri ile tarım politikaları etki analizi alanındaki temel modelleme uygulamalarını ve yaklaşımlarını da tartıştık. İncelememizin sonunda; veri yeterliliği ve düzeyini, bölgesel farklılıkları, çalışmamızın ölçeğini, tercih ettiğimiz ürün toplulaştırma düzeyini, tarımsal sektördeki özel üretim etkileşimlerini ve Türkiye Tarım Sektör Modeli tecrübesi ve geleneğini de göz önüne alarak[66], çalışmamızda Tarımsal Sektör Modellemesi yaklaşımını kullanmaya karar verdik. Modelimiz, *TAGRIS*, Türkiye Tarım Sektör Modelleri geleneğinde *TASM* (Kasnakoğlu ve Bauer, 1988) ve *TASM-EU* (Çakmak and Kasnakoğlu, 2002)’dan sonra üçüncü nesli temsil etmektedir. Toplam arz’ın kalibre edilmesi için Howitt’in Pozitif Matematiksel Programlama (PMP) metodunun kullanılması, TASM (Kasnakoğlu ve Bauer, 1988) ve TASM-EU (Çakmak and Kasnakoğlu, 2002) modellerinin temelini oluşturmakta ve model yapılarında politika analizi yapmak için bulunması gerekli olan pozitif yaklaşımı sağlamaktadır. PMP metodu, çiftçinin üretim kararlarını belirleyen davranışlarını, matematiksel bir formülasyonla modele katarak, modeli temel dönemin gözlenen değerlerine kalibre etmektedir. Metod modelleyicinin, veri eksikliği yüzünden, doğrudan gözlemleyemediği üretim sürecinin saklı kalan (fırsat) maliyet bilgilerini temel dönemin gözlemlenen üretim düzeylerinden

[66] TASM (Kasnakoğlu ve Bauer, 1988) ve TASM-EU (Çakmak ve Kasnakoğlu, 2002),

kestirerek, tarım sektörünün söz konusu ürün için maliyet fonksiyonunu yeniden oluşturmaktadır. Çakmak ve Kasnakoğlu (2002)'nun çok yerinde bir şekilde belirttiği gibi, bu yaklaşım sektör modellerinin temel amacıyla tutarlıdır; bu amaç, üreticilerin piyasa koşullarındaki, kaynak dağılımındaki ve üretim tekniğindeki değişikliklere yanıtlarını, tepkilerini simüle etmektir. Diğer bir değişle, sektör modelleri üreticinin davranışlarını modelleyerek, matematiksel olarak optimizasyon modelleri olmalarına rağmen benzetim (simülasyon) modellerine dönüşebilmektedirler. 1998 yılında, Paris ve Howitt (1998), Golan *ve diğ.* (1996)'nin Genelleştirilmiş Maksimum Entropi (GME) tahmincisini PMP metoduna integre ederek metodu geliştirdiler. Bu katkı, maliyet fonksiyonlarının çapraz terimler dahil bütün terimlerinin tahmin edilebilmesini sağladı. Daha sonra, Maksimum Entropi'ye Dayanan PMP yaklaşımı, Heckelei ve Britz (1999 ve 2000) tarafından geliştirildi ve AB'nin Tarım Sektör Modeli CAPRI (Common Agricultural Policy Regional Impact Model)'de kullanıldı. Heckelei ve Britz (1999 ve 2000)'in yaklaşımları, PMP maliyet fonksiyonlarının kestirilmesinde *bölgesel karlılık* ve *üretim ölçeği* farklılıkları gibi birden fazla *yatay kesit* verinin kullanılmasına olanak vermektedir. Literatürdeki bu gelişmeler ışığında, yeni modelimiz TAGRIS'in arz kalibrasyonunda Heckelei ve Britz (1999 ve 2000)'in yaklaşımlarını kullanmayı uygun bulduk.

Golan *ve diğ.* (1996)'nin Maksimum Entropi Ekonometrisi, geleneksel ekonometri'den tamamen farklı bir temelden geldiği için kavranması kolay değildir. Maksimum Entropi'ye dayanan Pozitif Matematiksel Programlama'yı anlayabilmek için bu yeni ekonometri tarzının detaylı bir incelemesi gerekmiştir. Bu bağlamda, Maksimum Entropi Ekonometrisi ve Maksimum Entropi'ye dayanan Pozitif Matematiksel Programlama için çalışmamızda ayrı birer bölüm ayrılmıştır.

Yeni Türkiye Tarım Sektör Modeli (*TAGRIS*) Bölüm VI'da sunulmuştur. Model doğrusal olmayan programlamaya dayanan, statik, kısmi denge tarımsal sektör modelidir. Marshallcı artığı maksimize etmektedir, dolayısıyla çıktı fiyatları içseldir (Samuelson, 1952; Takayama ve Judge, 1964). Talep kalibrasyonu elastikiyetlere dayanmaktadır. Yukarıda belirttiğimiz gibi, arz kalibrasyonu için Heckelei ve Britz (1999 and 2000)'in, yatay kesit gözlemli, Maksimum Entropi'ye dayanan Pozitif Matematiksel Programlama yaklaşımı kullanılmıştır. Dış ticaret ham ve işlenmiş ürünler için ham eşdeğeri şeklinde modellenmiş ve AB, ABD ve diğer dünya ülkeleri olarak üç bloğa ayrılmıştır. Modelin temel periodu 2002, 2003 ve 2004 ortalamasıdır. Politika etki analizinde bölgeler arası mukayeseli üstünlükleri hesaba katabilmek için, modelin üretim kısmı 4 ayrı bölgeye ayrıştırılmıştır. Bunlar; Kıyı Bölgesi, İç Anadolu, Doğu Anadolu ve GAP bölgeleridir. Toplulaştırma hatasını en aza indirebilmek için bölge verileri iller düzeyindeki verilerden elde edilmiştir. Üretim aktiviteleri baz alınan dönemdeki üretimler dikkate alınarak bölgelere dağıtılmıştır. Bitkisel ve hayvansal alt sektörleri içsel olarak birbirlerine bağlanmışlardır, diğer bir değişle, hayvancılık alt sektörü, bitkisel üretim alt sektörünün çıktılarını kullanmaktadır.

Modelin kurulumunda kullanılan *varsayımlar* şunlardır: (1) Tarım sektörünün üretimi bölgelere dağıtılabilir. (2) Tüm üretim aktivitelerinde girdi ve çıktılar arasında sabit ilişki vardır. (3) Dört mal sınıfı tanımlanabilir, bunlar; (i) üretimde kullanılan kaynaklar, (ii) çiftlik seviyesindeki aktivitelerde üretilip başka bir üretim aktivitesine girdi olan içsel ara girdiler, (iii) çiftlik seviyesindeki aktivitelerde üretilip işleme aktivitesine girdi olan ara çıktılar, ve (iv) çiftlik seviyesindeki üretildiği haliyle tüketilen ürünlerdir. (4) Tüketim ulusal düzeyde olmaktadır. (5) Bölgelerin kaynak varlığı bilinmektedir ve sabittir. (6) Kimyevi gübre gibi girdilerde arz elastikiyeti sonsuzdur. (7) Ekonominin diğer sektörlerindeki gelir düzeyi veri alınmıştır. (8) İhracat arzı'nın artan marjinal maliyetleri vardır. (9) Ürünlerin talebi doğrusal ve fiyata bağımlı fonksiyonlarla belirlenmektedir. (10) Sisteme katılan tüm ajanlarda rekabetçi davranış vardır ve malların ticareti rekabetçi piyasalarda yapılmaktadır.

Modelde 52 adet ürün hemen hemen 200'den fazla aktivite aracılığıyla üretilmekte ve 250 civarında denklem ile 350'den fazla değişken yer almaktadır. Maksimum Entropi'ye dayanan yapısı ile model, 49 adet ürünün, farklı üretim teknikleri ve bölgelerden kaynaklanan, *5276 çapraz ve düz maliyet terimini tahmin ederek*, bu terimleri sektörün maliyet fonsiyonuna dahil etmektedir.

Her üretim aktivitesinde hektara verim veya hayvan başına verim tanımlanmaktadır. Bitkisel üretim aktiviteleri sabit oranlarda emek, makine gücü, kimyasal gübre, tohum veya fide kullanmaktadır. Hayvancılık ve kanatlı üretim aktiviteleri enerji cinsinden tanımlanmıştır. Girdiler ve çıktılar arasındaki ilişkiler bölgelerde olası biyolojik veya ekonomik optimum yerine, çiftliklerde gözlenen ilişkileri yansıtmaktadır. Modeldeki ürünler, 2003-2005 ortalamasına göre, Türkiye'nin toplam ekilen alanının % 93.3'ünü kapsamaktadır.

Modelimizin bir özelliği Heckelei ve Britz (1999 ve 2000)'in yaklaşımının, bildiğimiz kadarıyla, ilk defa tek parça bir eşanlı talep ve arz sisteminde uygulanmış olmasıdır. CAPRI modelinde, market ve talep için iki ayrı modülden meydana gelen birleşik bir yapıda vardır. Halbuki, çalışmamızda önerilen model, arz ve talep dengesini Marshallcı artığı maksimize ederek eşanlı olarak çözen ve bu şekilde denge fiyat ve miktarını belirleyen bir yapıya sahiptir. Diğer bir değişle, bütün sistem tek seferde bir bütün olarak çözülmektedir.

Yeni Türkiye Tarım Sektör Modeli'nin bir diğer özelliği, ihracat miktarlarını da temel periyodun gözlenen değerlerine kalibre etmek için PMP metodunu (elastikiyetlere dayanan) kullanmasıdır. Bu yaklaşım ihracat için artan majinal maliyetler öngörmektedir ve böylece, ihracat sınır fiyatlarındaki değişiklikler yüzünden ihracatta şiddetli değişimler olmasını engellemektedir. Bu yaklaşım bize gerçekçi gelmektedir çünkü, özellikle pazarlama ve ulaşım maliyetleri yüzünden, ihracattaki hızlı değişimlerin maliyetlerde önemli etkilerinin olması beklenir. Hazel ve Norton (1986, p.263), ihracat ve iç piyasa pazarlama maliyetlerinin birbirlerine çok benzer olduklarını belirtmekte ve ihracatın sadece ürün denge denklemlerinde yer alması durumunda bu maliyetlerin hesaba katılmayacağını belirtmektedirler. Bu durumda, artan ihracat maliyetlerinin amaç fonksiyonuna eklenmesi gerektiğini ifade etmektedirler. Bildiğimiz kadarıyla, bu konu literatürde daha önce, çalışmamızda olduğu şekilde, ihracat arzı elastikiyetlerine dayanan bir PMP uygulamasıyla ele alınmamıştır. Yaklaşım aynı zamanda ihracat miktarlarının temel periyod değerlerine kalibre olmasını da sağlamakta ve artan marjinal ihracat maliyetleri sayesinde modelin ani ve yüksek ihracat artışları simüle etmesine engel olmaktadır.

Çalışmamızın bir diğer özelliği, yıllık verim değişimleri tahminlerinin iki aşamalı melez bir tahmin süreciyle elde edilmesidir. Yaklaşımın melez olarak nitelendirilmesinin nedeni, hem En Küçük Kareler (EKK) tahmincisini hem de Genelleştirilmiş Maksimum Entropi (GME) tahmincisini kullanmasıdır. Birinci aşamada, yıllık verim artışları (veya düşüşleri) EKK ile uzun dönem verisi kullanılarak (1961-2005) tahmin edilmiştir. Bu tahminler uzun dönem tahminleri olarak düşünülmüştür. Verim değişimlerinde son yıllarda farklı trendlerin olabileceği ve bunların da tahmin sürecinde dikkate alınmasını sağlamak için, ikinci aşamada GME tahmincisi kullanılmıştır. On yıl sonrasını tahmin etmek için en önemli verinin son on yıl olduğu düşünülmüştür. Fakat, sadece son on yılın verilerini kullanmak, uzun dönem trendleri dikkate almamak olacak ve ayrıca gözlem sayısı da az olacaktır. GME tahmincisi, tahmin aşamasında *önsel* (a priori) bilgi kullanımına olanak vermekte ve küçük gözlem sayılarında da EKK tahmincisinden daha iyi sonuçlar vermektedir (Golan *et al,* 1996, pp.117-123; ve Eruygur, 2005). Bu yüzden, ikinci aşamada, birinci aşamada EKK yöntemi ile elde edilen uzun dönem tahminleri GME tahmincisi için *önsel* bilgi olarak kullanılmış ve sadece son on yılın gözlemleri ile tahmin yapılmıştır.

Bu tezde, 2015 yılı için, iki senaryo kümesi tanımlanmış ve bu senaryoların Türk tarımı üzerindeki etkileri analiz edilmiştir. Birinci grup *AB-Dışı Senaryolardır*. Bu küme iki simülasyon içermektedir. İlk simülasyon AB'ye üye olmama halidir (EU-OUT). Bu simülasyonda, Türkiye'nin günümüzdeki tarım ve ticaret politikalarında 2015 yılına kadar değişiklik olmayacağı varsayılmaktadır. Kümenin ikinci simülasyonunda, yeni bir DTÖ anlaşmasının uygulaması olarak, Türkiye'nin DTÖ bağlayıcı ithalat tarifeleri taahhütlerinde 2015 yılında yüzde 15 indirim yapacağı varsayılmıştır (WTO). İkinci senaryo kümesi ise *AB Senaryoları*'dır. Bu küme üç ayrı simülasyon içermektedir. Birinci simülasyonda Türkiye, 2015 yılında AB üyesi değildir fakat AB ile süregelen gümrük birliğini tarımsal malları da kapsayacak şekilde genişletmiştir (EU-CU). İkinci simülasyon, 2015 yılında Türkiye'nin AB üyesi olacağını varsaymaktadır (EU-IN1). Son simülasyonda ise ikinciden farklı olarak 2015 yılına kadar diğer simülasyonlarda öngörüldüğünden daha yüksek verim artışı olacağı varsayılmıştır (EU-IN2).

AB-Senaryolarının sonuçları genel olarak bazı bulgularla özetlenebilir. Toplam refah üyelik veya gümrük birliğinden çok etkilenmemektedir. Fakat, üretici ve tüketici refahı acısından sonuçlar değişmektedir. Varolan AB ve Türkiye tarım politkalarının değişmeyeceğini varsayarsak, gümrük birliği ve üyelik, tüketiciler için faydalı olacaktır. Bunun temel nedeni üyelik veya gümrük birliği durumunda düşen iç fiyatlardır. Üreticiler üzerindeki etkide ise Ortak Tarım Politikası (OTP)'nın destekleri belirleyicidir. OTP'nin doğrudan ödemeleri olmadan, üyelik durumu üreticileri gümrük birliğinden daha kötü etkilemektedir. Bunun nedeni üyelik durumunda Türkiye'nin tahıl ve yağlı tohumlarda uygulaması gereken OTP'nin zorunlu üretimden çekme (set-aside) politikasıdır. Diğer taraftan, OTP'nin doğrudan destekleri tam olarak Türkiye'ye uygulanırsa, üretici artığı üyelik durumunda üye olmama durumuna göre artmaktadır. Dolayısıyla, OTP'nin doğrudan destek ödemeleri ve düzeyi, üyelik durumunda üreticilerin refahı üzerindeki etkiyi belirleyici faktör olacaktır.

Simülasyonlar göstermektedir ki, bütün durumlarda (yani üye olmama ve üç AB simülasyonunda), temel dönem değerlerine göre, bitkisel üretimin hem değeri hem de miktarı artmaktadır. Fakat, hayvansal ürünlerde aynı durum görülmemektedir. AB senaryolarında hayvansal ürünlerin toplam üretim değeri, temel periyodun altına düşebilmektedir. Bazı üreticiler rekabetçi kalamayacaklardır. AB senaryolarında, üye olmama durumuna göre, bitkisel üretim sadece GAP bölgesinde artmaktadır. Üyelik veya gümrük birliği ile, diğer bütün bölgelerde bitkisel üretim miktarı düşmektedir. Bu durum en çok tahıl ve yağlı tohum üretimindeki önemli azalma yüzünden Orta Anadolu'da görülmektedir.

Gene simülasyonların sonuçları göstermektedir ki, bütün durumlarda (yani üye olmama ve üç AB simülasyonunda), temel dönem değerlerine göre, toplam bitkisel ve hayvansal ürün tüketimi artmaktadır, fakat bu artış en fazla AB senaryolarında gözlemlenmektedir. Buna ek olarak, AB üyeliği veya gümrük birliği durumunda, toplam fiyatlardaki düşme yüzünden, tüketici üye olmama durumuna göre daha yüksek tüketim miktarlarını daha az harcama yaparak elde edilebilmektedir. Bu durum hayvansal ürünlerde çok daha önemli bir şekilde görülmektedir.

AB senaryolarında fiyatlar temel dönemdekinin altına düşmektedir, fakat AB dışı durumda fiyatlar temel periyodun üstüne çıkmaktadır. Bu durum hem bitkisel hem de hayvansal ürünler için geçerlidir ama hayvansal ürünlerde fiyat düşmeleri (AB senaryolarında) ve artışları (AB dışı durum) çok daha yüksek olmaktadır.

Gümrük birliği veya AB üyeliği durumunda Türkiye toplam tarım malları ticaretinde net ithalatçı olacak gibi gözükmektedir. Bu durumun sebebi ise, bitkisel ürünlerdeki net ihracatın, hayvansal ürünlerin net ithalatındaki patlamayı karşılayamayacak olmasıdır. Hemen hemen bütün hayvansal ürün ithalatı AB'den olacaktır. Fakat, ikinci üyelik simülasyonu (EU-IN2) göstermektedir ki, eğer Türkiye 2015'e kadar daha yüksek verim artışları sağlayabilirse, net ithalatın hacmi önemli şekilde azalabilecektir. Bu sonuç, teknolojik gelişmenin etkinliğini gözler önüne sermektedir.

Çakmak ve Kasnakoğlu (2002)'nun sonuçlarıyla karşılaştırıldığında son yıllardaki verim artışlarının sonucu olarak hayvancılık sektörünün rekabetçi durumunda bir iyileşme görülmektedir, fakat bu artış yeterli gözükmemektedir. Hayvansal ürünler dışında, 2015'te gümrük birliği veya AB üyeliği durumlarında, tahıl ve yağlı tohumların net ithalatında da önemli artışların olabileceği görülmektedir. Bu yüzden alarm veren bu sektörlerin rekabet gücünü artırıcı iyi tanımlanmış politikalar hayata geçirilmelidir.

OTP'nin doğrudan ödemeleri kesintisiz olarak Türkiye'ye ödenirse (ki bu durum çok olası gözükmemektedir) desteğin miktarının, Türkiye'nin 2015 yılına kadar tarımsal ürün verimlerinde göstereceği teknolojik gelişme performansına bağlı olarak, 8,0-8,8 milyar dolar aralığında olacağı tahmin edilmiştir. Kıyı Bölgeleri bu ödemelerden en çok faydalanacak bölgeler olarak karşımıza çıkmaktadır. Fakat, Doğu Anadolu Bölgesi bu ödemelerin sadce % 7'sini alabilecektir. Eğer, AB yeni üye olan 10 ülkeye uyguladığı şekilde, OTP doğrudan destek ödemelerini sonraki 10 yıla yayarsa; Türkiye 2015 yılına kadar tarımsal ürün verimlerinde göstereceği teknolojik gelişme performansına ve OTP desteklerini azaltan AB reformlarına bağlı olarak, 2015 yılında OTP'den 1,0-1,5 milyar Avro arasında bir tarımsal destek alabilecektir.

AB senaryoları tarımsal üretimdeki teknolojik gelişmenin çok önemli etkileri olabileceğini göstermektedir: bu gelişmelerin düzeyi, etkileri önemli şekilde değiştirebilmektedir. Bu durum ise, verim veya daha geniş ifade ile üretkenlik artırıcı politikaların etkinliğini ve önemini göstermektedir.

AB-Dışı Senaryoların sonuçları da kısaca şu bulgularla özetlenebilir. Modelimiz, süregelen politikaların değişmemesi varsayımı altında, 2015 yılına kadar hayvansal ürünlerin fiyatlarında, özellikle de et ve süt fiyatlarında önemli yükselmeler olabileceğinin işaretlerini vermektedir. Bu ciddi yükselmenin en önemli nedeni kişi başına reel gelirdeki ve nüfüstaki artıştan kaynaklanan talep artışının, arzda benzer bir artış ile karşılanamayacak olmasıdır. Bu mallarda (özellikle et ve süt) Türkiye'nin ithalat vergileri de önemli şekilde yüksek olduğundan, talepteki bu artış ithalatın artması ile de karşılanamamakta ve bunun sonucunda ürün fiyatları önemli miktarda yükselmektedir.

Diğer taraftan, çalışmamızın sonuçları, AB dışı durumda 2015 yılına kadar net bitkisel ürün ihracatımızın önemli şekilde yükselebileceğini işaret etmektedir. Fakat, ekmeklik buğday, mısır, şeker pancarı, susam ve soya fasulyesi sektörlerinde yüksek net ithalat miktarlarının gerçekleşebileceğinin işaretleri görülmektedir. Buna ek olarak, hayvansal ürün net ithalatı da yükselmektedir. DTÖ üyesi devletlerin DTÖ bağlayıcı tarife taahhütlerinde % 15'lik bir indirim yapmalarını öngörecek yeni bir DTÖ anlaşmasının 2015 yılında uygulanması durumunda, bir miktar düşen fiyatlardan tüketiciler faydalanacak, üreticilerin refahı üzerinde ise sınırlı bir azalma olacaktır. Fakat, toplam refahta bir değişme görülmemektedir. Üretim miktarı ve hasılatındaki azalma çok değildir. Tarım malları genel fiyat düzeyi biraz düşecek, fakat özellikle et fiyatlarındaki düşüş daha fazla olacaktır. Bunun nedeni artan net et ithalatıdır. Net et ithalatı, gümrük tarifelerindeki düşüş ile, 250 milyon Dolar kadar artmaktadır. Hemen hemen bütün net ithalat artışı, net et ithalatındaki genişlemeden kaynaklanmaktadır. Bitkisel ürünlerin ve diğer hayvansal ürünlerin net ihracatı üzerindeki etki azdır.

Simülasyonların sonuçları, ülkemizde tarıma bakış tarzının değişmesinin gerekliliğini bir kere daha işaret etmektedir. Önemli olan nokta, tarım sektörünün rekabet gücünü, verimliliğini yükselterek, artırmaktır. Türkiye'de 1980'lerin sonlarında beri politika yapıcıları, tarımı verimlilik artırıcı programlara yatırım yaparak desteklemek yerine piyasa fiyatlarını bozarak desteklemeyi tercih etmişlerdir. Bu politikalar Türk tarım sektörünün verimliliğini artırmamış ve sektörün rekabet gücü yükselememiştir. Ülkemiz zengin doğal ve beşeri kaynaklara sahip olmasına rağmen, son dönemlerdeki etkin olmayan tarım politikaları yüzünden Türk tarım sektörü ne yazık ki potansiyelini hiç kullanamamıştır.

Bu noktada, Rausser (1992) ile Çakmak ve Kasnakoğlu (2002)'nun tarımsal politikalar ile ilgili sınıflamalarını aktarmak yerinde olacaktır. Birinci grup tarım politikaları, *verimlilik artırıcı politikalar* olarak adlandırılabilirler. Çünkü bu gruptaki politikaların amacı kaynakların kullanımında etkinliği artırmaktır. Bu tür politikalara örnek olarak özellikle şu uygulamalar verilebilir: araştırma - geliştirme ve yayım programları, piyasa işlem maliyetlerini azaltıcı ptogramlar, altyapı yatırımları, enformasyon ve pazarlama hizmetleri, kalite kontrol hizmetleri, ürün sigortası programları vb. Diğer taraftan, ikinci grup politikalar *dağılım politikaları* olarak adlandirilabilirler çünkü bu politikaların verimlilik artırma amacı ve doğrudan etkisi yoktur. Bu politikalara; fiyat destekleri, fark ödemeleri, sınır müdahaleleri, girdi sübvansiyonları ve sübvansiyonlu kredi gibi ekonominin diğer kesimlerinden tarımsal üreticilere varlık ve gelir transfer eden tüm politikalar dahildir. Verimlilik artırıcı politikaların ekonomik ve politik etkileri zamana yayılmakta ve özellikle bu politikaların ilk dönemlerde kurumsal yapının dönüştürülmesi ve etkin organizasyon için kamu kaynaklarının kullanımı gerekmektedir. Diğer taraftan, sadece dağılım politikalarından ibaret uygulamaların özellikle politik getirileri kısa dönemde hemen alınmakta ama üretkenlik artırıcı bir etkileri olmamakta ve tüketici ve bütçeye yeni yükler getirmektedirler. Türkiye'de hükümetler, politik kaygıları yüzünden olsa gerek (Çakmak, 2004), genellikle ikinci grup politikaları uygulamayı yeğlemişler ve bunun sonucunda Türk tarımının potansiyelinin altında çalışması durumuna neden olmuşlardır.

Türkiye 2000 yılından beri tarımsal politikalarında değişiklikler yapıyor. Fakat, hala verimlilik artırıcı politikaların payının çok düşük düzeylerde olduğu gözlemlenmekte. Türkiye gittikçe artan bir şekilde verimlilik artırıcı politikalara ağırlık vermelidir. Tarımsal politikaların uzun dönem hedefi açık olarak sektördeki üretkenliğin artırılması olmalıdır. Aksi halde, süregelen gelişmeler ışığında, sektörün çok ciddi bir uluslararası rekabet ile karşılaşması kaçınılmazdır. Değişimi sağlayacak temel politika araçları; teknolojik gelişme, üretken kaynakların artırılması ve daha piyasa temelli bir yapının oluşturulmasıdır.

Eksik piyasalar veya girdi-cıktı piyasalarındaki kusurlar bu dönüşüm yolunda olumsuz etkisi olacak önemli etkenlerdir. Bu nedenle, devlet faktör piyasalarını düzenlemeli ve dışsallıkları düzeltmelidir. Kırsal alanlarda, toprak mülkiyet hakları açık bir şekilde tanımlanmalıdır. Kadastro eksiklikleri tarımsal toprak piyasasının çalışmasını engellemekte bu da işlem maliyetlerini ve dolayısıyla üretim maliyetlerini artırmaktadır. Süregelen piyasa yapıları yapısal değisimleri engellemekte ve politika araçları kümesini sınırlamaktadır. Ayrıca, bu yapılar, yeni politikaların başarı şanslarını da azaltmaktadırlar. Bu yüzden, politika reformlarını gerçekleştirebilmek için tarımsal politika ortamının kapasitesi artırılmalıdır (Çakmak, Kasnakoğlu ve Akder, 1999).

Araştırma-geliştirma ve yayım hizmetleri hızlı ve yoğun bir şekilde devlet tarafında sağlanmalıdır. Ayrıca, politikaların perspektifleri, bütün arz zincirini kapsamalıdır. Bu zincir, sırayla, girdi tedariği, üretim tekniği, üretkenlik, hasat öncesi ve sonrası teknolojiler, işletme ve pazarlama ve tüketimden oluşmaktadır. Ayrıca, tarım politikaları, amaçlara uygun ve destekleyici ticaret politikalarını da içermelidir.

Son olarak, detaylı ve güvenilir bir tarımsal veribankası oluşturulmadan, üretkenliği artırıcı politika önerileri bile sağlıklı olmayacaktır. AB'nin FADN (Farm Accountancy Data Network) veri ağı sistemi gibi bir sistemin oluşturulması çok önemlidir. Bilgi olmadan analizlerin yapılamayacağı, analizlerin nitelik ve niceliklerinin yükselmesinin yolunun eldeki verilerin nitelik ve niceliklerinin yükselmesinden geçtiği unutulmamalıdır. Üretim maliyetleri, getirileri ve üretimle ilgili her türlü veri önemlidir ve kapsamlı bir şekilde toplanmalıdır. Bu veriler, arz zincirinde, *üreticiden* hem *iç* hem de *dış* tüketiciye kadar olan bütün noktaları kapsamalıdır.