Assessment of sustainability of the European Union and Turkish Agricultural sectors*

ŞÜKRÜ MOLLAVELİOĞLU**, HAKAN MIHCI***, SELIM ÇAĞATAY****, AYDIN ULUCAN*****

Jel classification: O130, O520, Q010, Q560

Abstract

The main aim of this paper is to analyze the efficiency of the Turkish agricultural sector in comparison with the European Union (EU) countries with respect to sustainability for the 1995-2005 periods. For this comparison, Malmquist index technique is used. The main findings of the current study indicate that total factor productivity increases during the 1995-2005 period mainly originating from the technological improvements for all the European countries. Furthermore, while the European Union countries total factor productivity show a 1.8 percent rise on average, the Turkish factor productivity declines nearly 2.0 per cent in the same period. As a result, one can argue that the gap between European Union countries and Turkey has widened from the sustainability perspective in the recent decade.

Keywords: Sustainability, food security, Turkish agricultural sector, Malmquist index.

Résumé

L'objectif principal de ce travail est de comparer l'efficience du secteur agricole dans l'Union Européenne (UE) et en Turquie sur le plan de la durabilité pour la période 1995-2005. A cette fin, on a utilisé la technique de l'indice Malmquist. Les résultats principaux que cette étude a fait ressortir indiquent que la productivité totale des facteurs a augmenté dans la période examinée surtout grâce aux progrès technologiques qu'ont connus les pays européens. En outre, si les pays de l'Union se caractérisent, en moyenne, par une augmentation de 1,8% de la productivité totale des facteurs, en Turquie on rapporte une réduction d'environ 2% pour la même période. Ainsi, il est possible d'en conclure que l'écart entre les pays de l'UE et la Turquie s'est creusé en termes de durabilités au cours de cette dernière décennie.

Mots-clés: *Durabilité, sécurité alimentaire, secteur agricole Turc, indice Malmquist.*

1. Introduction

Although the attempt to define «sustainable development» by the Brundtland Commission's influential report of «*Our Common Future*» in 1987 offers a general framework for that concept, to assess sustainability, more functional definitions and associated indicators could be provided[1]. In fact, the concept of sustainability involves interrelations among human being, nature and live habitat and underlines the necessity to reestablish these relations in order to improve long-term welfare of the society.

In connection with sustainable development, the concept of sustainable agriculture refers to agricultural production activities which are environmentally sensitive, socially agreeable and economically viable (Yunlog and Smith, 1994). In providing one of the most basic needs of human race, directly interfering to the functioning of nature via the production process and being the main economic activity of the rural areas, sustainability of the agricultural sector becomes a necessity from environmental, social and economic perspectives. In particular, global warming, the pressure on the water resources, soil degradation and similar environmental destructions that threaten human health and other live habitat force the implementation of the new agricultural policies. In this sense, sustainable agricultural policies come into the scene.

One of the principal characteristics of sustainable development is to ensure efficient use of resources without neglecting needs of the future generations. Therefore, efficiency in the use of the existing resources is crucial for sustainability. Similarly, sustainable agriculture underlines long-term maintenance of the efficiency of the production resources from economic and environmental aspects and emphasizes the provision of nutritional needs of the human beings. Furthermore, sustainable agriculture concentrates on the best ways of protecting environment and natural resources. To put differently, stewardship of the natural habitat is as much significant as the production and profitability in the context of sustainable agriculture (Smith and McDonald, 1998: 17; Schaller, 1993: 89-93). Additionally, sustainable agriculture diminishes the dependency of the production process on the inputs detrimental for the environment, and therefore, agriculture oriented environmental pollution is minimized (Gliessman, 2005: 11).

In the previous century, agricultural sector has chiefly been affected by the unprecedented improvement in technological change, and hence, the use of intensive technology in agricultural production elevated productivity. In par-

* An earlier version of this paper was presented to the 4th GARNET Annual Conference: «*Food Security and Sustainable Development: Challenges for the Governance of International Organization*», November 2009, Rome. We thank the participants of the Conference for their valuable comments.
** Department of Economics, Yuzuncu Yıl University, Van Turkey.
*** Department of Economics, Hacettepe University, Ankara, Turkey.
**** Department of Economics, Akdeniz University, Antalya, Turkey.
***** Department of Business Administration, Hacettepe University, Ankara, Turkey.
[1] According to De Avilla-Pires *et al.* (2000:261), the concept of sustainability has not been satisfactorily defined yet it is an extensively used modern term.

ticular, modern agriculture has become widespread in the second half of the twentieth century. Consequently, uses of fertilizer, pesticide, energy and irrigation facilities have been augmented; cultivation of land has been dramatically changed. Even though these transformations yielded to high increases in agricultural production, they created environmental problems as well. Besides, phenomena like rising world population, unlimited consumption of natural resources and presence of poverty fuelled the risks on world ecosystem. Global warming, climate change lost of biodiversity and deterioration of natural resources could be regarded as signs of such risks. As a corollary, this situation forces the reassessment of the current approaches on the production and efficient use of the resources.

The assurance of the efficiency in the use of the resources may not only support sustainability in the economic sense, but also encourage it from the environmental perspective via the controlling of the pollution-creating inputs. In this context, the efficient use of the pollution-creating inputs in the production process can be considered as a necessary condition for sustainability, and hence, economic and environmental targets could be simultaneously attained (De Koeijer et al., 2002: 9-10). Furthermore, assuming that sustainability is the preservation of the production capacity in the long-term, it is possible to investigate efficient use of the resources within such time span (Gomes et al., 2008:2). Moreover, it is also argued that through analyzing efficiency and total factor productivity, the assessment of the sustainability on the land scale is feasible (Lynam and Herdt, 1988).

In the light of the above considerations, the main aim of this paper is to analyze the efficiency of the Turkish agricultural sector in comparison with the European Union (EU) countries with respect to sustainability for the 1995-2005 periods. For this comparison, Malmquist index technique is used. The empirical method and the data set used in the current paper are presented in the next section. Among the variables used in this study, food security deserves special attention. Different from other variables, national and international institutions do not publish data on the food security. Nevertheless, the present paper attempts to provide data on the food security for the countries included in the analysis. This effort can be considered as one of the contribution of the present study to the current literature. The third section is devoted to test results of the two alternative models using Malmquist Index method. As usual, the last section recapitulates the main findings and concludes.

2. The Methodology and Data Set

In this section, the methodology is briefly described, and then, data set is presented to the reader.

2.1. Empirical Method

As mentioned in the introduction, the main aim of this study is to make a comparison between Turkish and EU countries agricultural sectors in the context of sustainable agriculture. To reach this aim, depending on the panel data set for the 1995-2005 periods, alternative Malmquist indices are calculated. In doing so, one can observe the changes in total factor productivities and analyze the origins of these changes.

Before proceeding, Malmquist total factor productivity (TFP) index is presented. Malmquist index is constructed by Shepherd through including distance functions to Farrell (1957)'s technical efficiency criteria. Index measures the change in TFP of two observations as a ratio of distance to a similar technology. For such a measurement, «distance function» is employed. Malmquist index can be constructed as either input or output oriented. Input-oriented model can be characterized with the production technology which attempts to minimize the input vector as a ratio when output vector is constant. Output-oriented model, however, distinguishes itself by the production technology which maximizes the expansion of output proportionately when input vector is constant (Bağdadioğlu and Ulucan, 2005:7).

Depending on Fare *et al.* (1994), output-oriented Malmquist index for t and t+1 time periods can be defined as follows:

$$M_0^{t,t+1}(y^t,y^{t+1},x^t,x^{t+1})=\sqrt{\left[\frac{D_0^{\,t}\ (y^{t+1},x^{t+1})D_0^{\,t+1}\ (y^{t+1},x^{t+1})}{D_0^{\,t}(y^t,x^t)D_0^{\,t+1}\ (y^t,x^t)}\right]} \qquad (1)$$

In the above equation, $D_0^{t+1}(y^t,x^t)$ term expresses the distance of t period observation to t+1 period technology. In this equation, while the values above 1 show that TFP is augmenting, values below 1 indicate that TFP is declining. Furthermore, Malmquist productivity index can be decomposed into technical and technological change. Such decomposition can be represented in the following way:

$$M_0^{t,t+1}(y^t,y^{t+1},x^t,x^{t+1})=\frac{D_0^{\,t+1}\ (y^{t+1},x^{t+1})}{D_0^{\,t}(y^t,x^t)}\sqrt{\left[\frac{D_0^{\,t}(y^t,x^t)\ D_0^{\,t}(y^{t+1},x^{t+1})}{D_0^{\,t+1}(y^t,x^t)D_0^{\,t+1}(y^{t+1},x^{t+1})}\right]} \quad (2)$$

The first term on the right side of the equation (2) denotes the ratio of technical efficiency in t+1 period to the period t which in turn indicates the measurement of technical efficiency. Additionally, the term in the parenthesis shows the technological change. Finally, it can be remarked that Malmquist TFP index consists of the multiplication of technical efficiency change and technological change.

2.2. Data Set

The current study uses two broad types of variables, namely input and output variables.

2.2.1. Output Variables

1. Agricultural Value Added: It is the remaining portion of the total agricultural production after deducing the value of the inputs. This variable is obtained from the data base of the *World Development Indicators* (WDI). The variable is expressed as constant US Dollars by taking 2000 as a base year.

2. Food Security: Food security is generally defined as economic, social and physically easy and permanent access to sufficient, secure and nutritious food for human beings in order to sustain healthy life and perform daily activities (FAO, 2005: 80).

To obtain food security variable, various steps are followed. First of all, it should be mentioned that the data set is fundamentally constructed focusing on the agricultural production sufficiency of the countries. At the first stage, population data according to sex and age distribution for all the countries are obtained from EUROSTAT and Turkish Statistics Institution (TSI) (TÜİK 2008). Secondly, in order to remove age distribution differentials among the countries, population data is aggregated by using adult equivalent scale[2]. After the aggregation procedure, total equivalent population is attained. Afterwards, by using average daily calorie requirements for men and women, the need for one day calorie requirement of the total population is calculated for all the countries. From this point onwards, each country's average annual calorie requirement is determined. The distribution of the basket of foods necessary for per capita daily calorie requirement is presented in the Table 1.

Table 1 – *Basket of Foods Necessary for Daily Calorie Requirement of an Adult.*

Name of the Food	Quantity (in Gram)	Quantity of Calorie
Bread	350	1 000
Flour	60	210
Dough	60	210
Rice	60	211
Meat	120	300
Liquid Oil	30	270
White Cheese	30	70
Egg	50	70
Yoghurt	350	210
Dry Pulses	50	180
Onion	50	20
Potatoes	150	115
Fresh Fruit	300	150
Fresh Vegetables	250	125
Sugar	60	240
Olive	20	29
Jam	30	90
TOTAL	2 020	3 500

Source: Baysal (1991:147).

Table 2 – *Calorie Redistributed New Basket of Foods.*

Name of the Food	Quantity (in Gram)	Quantity of Calorie
Bread	358	1 036
Flour	68	246
Dough	68	246
Meat	128	336
White Cheese	38	106
Egg	58	106
Yoghurt	358	246
Dry Pulses	58	216
Onion	58	56
Potatoes	158	151
Fresh Fruit	308	186
Fresh Vegetables	258	161
Sugar	68	276
Jam	38	126
TOTAL	2 020	3 500

Since rice, olive and liquid oil data are not available for most of the countries included in the empirical analysis; however, these foods are removed from the basket. The amount of calorie requirement for the removed foods is redistributed to the remaining foods in the basket. Calorie redistributed new basket of foods is presented in the Table 2.

Basing on the quantity of calories in Table 2, basket of foods is constructed according to annual calorie requirement of the total adult equivalent population. Then, necessary amount of food materials providing the annual calorie requirement of the constructed basket of foods are obtained. Consequently, the amount of food materials is transformed to raw material commodities using by conversion factors (DİE 2003)[3]. Therefore, minimum production quantities providing necessary annual calorie requirement of the total population are attained for all the countries. Afterwards, current production amounts at the commodity level rationed to minimum production quantities necessary for the calorie requirement[4]. The values obtained for each commodity are aggregated once more basing on the weighted average of their quantity of calories. Table 3 presents that how many times are the countries possess the production level above their minimum calorie requirement.

As the Table 3 shows, Denmark almost produces 11 times above the minimum production level necessary to provide annual calorie requirement of its population. Portugal has the minimum value of 1.5 times at the end of analysis period. Meanwhile, Turkey has the actual production level of approximately 5 times above the minimum calorie requirement. This value, in turn, is slightly higher than all the countries average.

3. Greenhouse Gas Emission: In this study, greenhouse gas emission is introduced in the model as undesirable output. The concentration of the greenhouse gas emissions in the atmosphere is commonly considered as one of the most significant factors in global warming and climate change. Greenhouse gases are particularly important for agriculture

[2] While 18 years old and above is multiplied by 1.0, 0-6 age interval is multiplied by 0.2, 7-12 by 0.3 and 13-18 by 0.5 following Deaton and Muellbauer (1986)'s method.

[3] As a raw material commodity, bread, flour and dough are converted to wheat, white cheese and yoghurt to milk, sugar to sugar beet and jam to strawberry, plum and cherry.

[4] Current production amounts for the commodities are obtained from the Food Balance Sheets of FAO.

Table 3 – *Food security.*

COUNTRIES	1995	2000	2001	2002	2003	2004	2005
Austria	3.34	3.44	3.72	3.54	3.18	3.89	3.49
Belgium	3.75	4.01	3.59	3.90	3.72	4.00	3.68
Czech Republic	5.00	4.96	5.21	4.63	3.44	5.54	4.71
Denmark	11.21	10.90	10.67	9.73	10.68	10.78	10.83
Finland	2.30	2.50	2.40	2.54	2.61	2.76	2.86
France	7.48	8.11	7.10	8.26	6.84	8.21	7.62
Germany	3.40	4.00	4.00	3.74	3.51	4.15	3.87
Great Britain	3.43	3.73	2.96	3.63	3.31	3.47	3.34
Greece	4.31	4.19	3.94	3.72	3.30	3.77	3.66
Holland	4.41	4.43	4.00	4.08	3.99	4.33	4.10
Hungary	5.95	4.89	6.33	4.90	4.02	6.95	5.81
Italy	3.06	3.13	2.89	2.93	2.64	3.13	2.98
Poland	5.55	5.31	5.18	4.76	4.29	4.86	4.22
Portugal	2.04	1.94	1.70	2.04	1.75	1.79	1.51
Spain	2.88	4.02	3.40	3.88	3.65	3.86	3.08
Sweden	2.90	3.75	3.66	3.41	3.52	3.70	3.47
Turkey	6.30	5.52	5.07	5.14	5.01	5.18	5.25

since agricultural production not only constitutes the origin of the emissions but functions as absorptive as well. The most important component of the greenhouse gases is carbon dioxide (CO_2) emissions. 82 per cent of the greenhouse gas emissions are composed of CO_2. Nevertheless, agriculture only generates 5 per cent of total CO_2 emissions. On the other hand, being another important source of greenhouse gas, methane (CH_4) constitutes 10 per cent of the total emissions. Notwithstanding, agriculture originated CH_4 gas emissions forms 40 per cent of the total methane emissions. The share of nitrogen oxide (N_2O) in total greenhouse gas emissions is approximately 7 per cent. Yet, agricultural sector produces almost 60 per cent of the total N_2O emissions (OECD, 2001: 279). Although non-agricultural sectors like industry and transportation plays a dominant role in the formation of greenhouse gas emissions, the contribution of agricultural sector should not be neglected in this respect. What is more important, absorptive characteristic of the agricultural sector should also be concerned in the attempts to prevent greenhouse gas emissions (OECD, 2001: 273-279).

In the current study, following OECD's approach, total gross agricultural emission values of CO_2, CH_4 and N_2O is calculated as CO_2 equivalent. The equivalent CO_2 value of the three agricultural greenhouse gas expressed in metric tons is calculated using with the following formula (OECD, 2001: 277):

$$E_{CO2eq} = 1 \times E_{CO2} + 21E_{CH4} + 310 \times E_{N2O} \quad (3)$$

In this formula, E_{CO2eq} represents CO_2 equivalent of total gross agricultural emissions. E_{CO2} is the total gross agricultural emission of the CO_2. E_{CH4} and E_{N2O} are for total gross agricultural emissions of CH_4 and N_2O respectively.

2.2.2. Input Variables

1. Land: This variable covers both cultivable fields and the fields under permanent crops. In this study, the variable of land is measured as hectares.

2. Tractor: The quantity of tractor used in the production process is taken[5].

3. Fertilizer: The indicator covers commercial fertilizers such as nitrogen, phosphor and potash used for agricultural purposes. It is measured as metric tons.

4. Pesticides: This variable consists of pesticides used to eradicate insecticides, fungicides and herbicides and remaining types of other pesticides. The values of pesticides are expressed as active ingredients and measured as tons.

5. Labor: The variable includes economically active population in agriculture.

Crude statistical information about the variables is summarized in the Table 4.

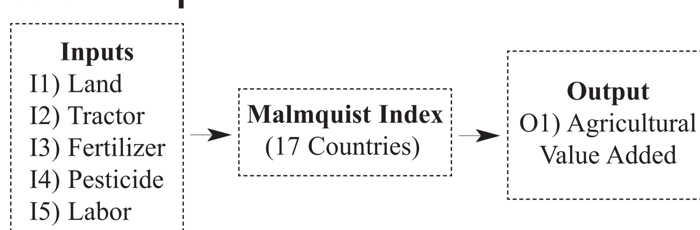
Table 4 – *Descriptive Statistical Information on the Variables.*

Variable	Unit	Maximum Value	Minimum Value	Average Value	Standard Deviation
Agricultural Value Added	Constant 2000 US$	35145568256	1718334976	11284818207	10071884144
Food Security	Ratio	11.9482	1.5066	4.5282	2.1431
Greenhouse Gas Emission	Ton	96436108.00	1.00	72815618.26	25377744.34
Land	Hector	27115000	855000	7795572	7586592
Labor	Quantity	14994000	65000	1616904	3405169
Tractor	Quantity	1866000	79304	547219	511731
Fertilizer	Ton	5064000	134000	1174807	1159809
Pesticide	Ton	120503	933	21636	27230

3. Test Results

This section consists of the test results of two different models which use Malmquist index method. While the first model only uses agricultural value added as output indicator, second model additionally takes into consideration food security as more representative for sustainable agriculture and greenhouse gas emissions for undesirable output alongside the agricultural value added.

3.1. Malmquist Model 1



[5] Horse power equivalent of the quantity of tractor is alternatively used in the empirical studies. As Coelli and Rao (2003) indicate, however, for the sample of countries where the differences in land structure exist, the use of the quantity of tractors becomes obligatory for meaningful comparisons between the countries. In comparison to other European countries in the sample, Turkey has fragmented land structure in the agriculture. Therefore, use of the quantity of tractor is preferred in this study.

According to the results of the empirical analysis presented in the Table 5, efficiency change decreased to 0.6 per cent and technological change increased to 2.7 per cent during the 1995-2005 periods. The rise in technological change also led to 2.1 per cent increase in total factor productivity (TFP). To put differently, the increase in technological change constituted the origin of the TFP improvement. Malmquist index values permanently changed at positive direction except for the years 2002 and 2003.

Table 5 – *Efficiency Change (EC), Technological Change (TC) and Malmquist Index (MI) Values for 1995-2005 Period.*

Years	Efficiency Change (EC)	Technological Change (TC)	Malmquist Index (MI)
1995	1	1	1
1996	1.000	1.001	1.001
1997	0.983	1.052	1.034
1998	1.036	0.965	1.000
1999	0.991	1.060	1.050
2000	0.944	1.085	1.024
2001	0.995	1.014	1.009
2002	1.030	0.929	0.956
2003	0.973	1.008	0.980
2004	0.972	1.163	1.131
2005	1.015	1.014	1.029
Average	0.994	1.027	1.021

The countries included in the sample is further classified into Western Europe, Eastern Europe, Northern Europe and Southern Europe basing on the production methods, features of the climate and economic structures to investigate and compare peculiar characteristics of each category[6].

Table 6 – *EC, TC and MI Values for Different Country Categories.*

Country Category	Efficiency Change	Technological Change	Malmquist Index
Western Europe	1.003	1.035	1.038
Eastern Europe	0.993	1.019	1.012
Northern Europe	1.000	1.028	1.028
Southern Europe	0.980	1.026	1.005
General	0.994	1.027	1.021

The data in Table 6 suggests that the highest increase in efficiency change occurred in Western Europe with 0.3 per cent through the analysis period. On the other hand, efficiency change decreased in Eastern and Southern Europe in the same period. The highest decline (2 per cent) is observed in the Southern European category where Turkey is also included in it. Meanwhile, technological change reveals positive impacts for all the categories. As it is expected, highest increase is observed in Western Europe and lowest one in Eastern Europe. Also, total factor productivity (TFP) increased for all the country categories. While the highest improvement is noticed in Western Europe with 3.8 per cent, the lowest increase realized in Southern Europe with only 0.5 per cent. Although technological improvement is much more pronounced in Southern Europe relative to the Eastern Europe, since the decline in the efficiency change for the latter category is lower, the increase in TFP of the Southern European countries remained below that of Eastern European countries.

Additionally, the present study also concerns with the cumulative values of each country category in order to analyze long-term effects of the EC, TC and MI changes. Table 7 is prepared for this purpose.

Table 7 – *Cumulative Values for Country Categories.*

Country Category	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
West	1.000	1.030	1.000	1.411	1.000	1.452
East	1.000	0.934	1.000	1.202	1.000	1.124
North	1.000	1.000	1.000	1.316	1.000	1.316
South	1.000	0.818	1.000	1.287	1.000	1.053
General	1.000	0.937	1.000	1.309	1.000	1.224

During the whole analysis period (1995-2005), Malmquist index value raised 22.4 per cent and attained to 1.224. While a decrease of 6.3 per cent occurred in the efficiency change, impressive increase of 31 per cent materialized in the technological change. Hence, the origin of rise in the TFP can be totally attributed to the technological change.

Besides country categories, the study attempts to compare Turkey with European countries in the context of efficiency and productivity. To reach this aim, EC, TC and MI changes are monitored for EU countries average and Turkey. In Table 8, EU countries average values are compared with the values of Turkey.

Table 8 – *EC, TC and MI Values of EU Countries and Turkey.*

Country Category	Efficiency Change	Technological Change	Malmquist Index
EU Average	0.994	1.029	1.023
Turkey	0.987	0.993	0.981

According to the results, Turkey's efficiency change declined to 1.3 per cent. Similarly, technological change also diminished to 0.7 per cent during the analysis period. Therefore, a reduction of 1.9 per cent in TFP is observed for the country. As to the EU average, although efficiency change is decreased, 2.9 per cent raise in technology change is detected for the same period. Consequently, TFP is augmented to 2.3 per cent.

Moreover, cumulative values for Malmquist index indicate a 22.4 per cent increase for all the countries. While the increase in EU countries average realized as 25.8 per cent,

[6] Western European countries include Austria, Belgium, France and Germany. Although Holland is a Western European country, the country at the same time shows the characteristics of the Northern European countries with respect to agricultural production methods, and therefore, it is included within this category. Other Northern European countries are Denmark, Finland, Great Britain and Sweden. Eastern European countries consist of Czech Republic, Hungary and Poland. Southern European Countries' category covers Greece, Italy, Portugal, Spain and Turkey.

Turkey manifested a decline of 17.7 per cent (See Table 9). From this finding, one can argue that EU countries advanced in the implementation of the sustainable agricultural policies for the 1995-2005 periods. Unfortunately, Turkey could not demonstrate a satisfactory performance and even regressed in the same area.

Finally, to evaluate sustainable development performance of every country through time, cumulative Malmquist index values are presented in Table 10 for all the countries.

Table 9 – *Cumulative Values of EU Countries and Turkey.*

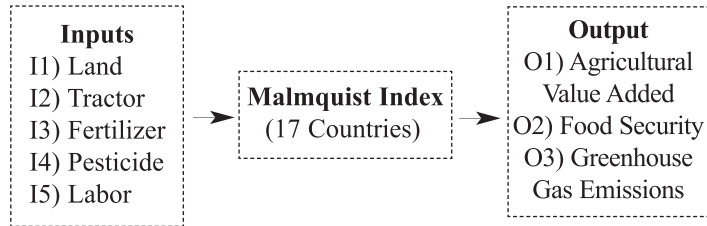
EU Countries and Turkey	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
EU Average	1.00	0.942	1.00	1.336	1.00	1.258
Turkey	1.00	0.879	1.00	0.935	1.00	0.823
All the Countries	1.00	0.937	1.00	1.309	1.00	1.224

Table 10 – *Cumulative Values of the Countries.*

Country	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
Austria	1.000	0.825	1.000	1.133	1.000	0.933
Belgium	1.000	1.096	1.000	1.506	1.000	1.654
Czech Republic	1.000	0.805	1.000	1.282	1.000	1.035
Denmark	1.000	1.212	1.000	1.652	1.000	1.849
Finland	1.000	1.000	1.000	1.002	1.000	1.002
France	1.000	1.109	1.000	1.529	1.000	1.698
Germany	1.000	1.122	1.000	1.517	1.000	1.696
Great Britain	1.000	0.823	1.000	1.491	1.000	1.231
Greece	1.000	0.670	1.000	1.349	1.000	0.904
Holland	1.000	1.000	1.000	1.169	1.000	1.169
Hungary	1.000	0.890	1.000	1.390	1.000	1.236
Italy	1.000	1.116	1.000	1.427	1.000	1.591
Poland	1.000	1.138	1.000	0.975	1.000	1.109
Portugal	1.000	0.659	1.000	1.457	1.000	0.960
Spain	1.000	0.848	1.000	1.345	1.000	1.138
Sweden	1.000	1.000	1.000	1.222	1.000	1.222
Turkey	1.000	0.879	1.000	0.935	1.000	0.823
Average	1.000	0.937	1.000	1.309	1.000	1.224

The best performers among all the sample countries during the analysis period are Belgium, Denmark, France, Germany and Italy. In the same period, Austria, Greece, Portugal and Turkey manifested considerable reductions in their total factor productivities. The highest regression is monitored for Turkey with 17.7 per cent. The reductions of 9.6 per cent, 4.0 per cent and 6.7 per cent are found for Greece, Portugal and Austria respectively.

3.2. Malmquist Model 2



In addition to the output indicator in the first model, food security which can be considered as one of the significant variables to concern with sustainable agriculture at the aggregate level and greenhouse gas emission which is the principal component of the climate change are also integrated in the model in order to reach more meaningful and discussable results to assess efficiency of the agricultural sectors in EU and Turkey from the sustainability perspective.

According to the empirical results of the second model, MI values are augmented to 1.6 per cent on the average during the 1995-2005 periods. Comparing with the first model where food security and greenhouse gas emission are not taken into account, the change remained relatively limited. The rise in technological change is more pronounced in the first model whereas the reduction in efficiency change is relatively low in the second model. Similar to the first model, the rise in TFP can be wholly devoted to the technological change. Although technical efficiency entailed a reduction of 0.4 per cent, the occurrence of 2 per cent increase in technological change yielded an increase of 1.6 per cent in TFP as shown in Table 11.

Changes in efficiency, technology and Malmquist index for different country categories in Europe are presented in the Table 12.

Depending on the findings in the Table 12, the most striking improvement is observed for Western Europe with 10.7 per cent increase. The rise in the MI of the Northern European countries could not be ignored either. Controversially, Eastern European countries experienced a decline of 1.7 per cent on the average in their total factor productivities. Compared to the first model, all the country categories' productivity performance increases in the second model where food security and greenhouse gas emission is included except the Eastern European category. Therefore, it can be argued that relatively developed countries are in a better position with respect to sustainable agriculture.

On the other hand, Western Europe is the only country category showing an increase in its efficiency

Table 11 – *EC, TC and MI Values for 1995-2005 Period (Model 2).*

Years	EC	TC	MI
1995	1	1	1
1996	1.001	1.008	1.009
1997	0.995	1.041	1.036
1998	1.024	0.981	1.004
1999	0.987	1.039	1.026
2000	0.969	1.052	1.019
2001	1.002	0.998	1.000
2002	1.029	0.947	0.974
2003	0.989	0.976	0.965
2004	0.979	1.114	1.091
2005	0.983	1.056	1.038
Average	0.996	1.020	1.016

Table 12 – *EC, TC and MI Values for Country Categories (Model 2).*

Country Category	Efficiency Change	Technological Change	Malmquist Index
Western Europe	1.005	1.025	1.107
Eastern Europe	0.998	0.997	0.983
Northern Europe	0.996	1.026	1.077
Southern Europe	0.986	1.023	1.031
General	0.996	1.020	1.016

Table 13 – *Cumulative Values for Country Categories (Model 2).*

Country Category	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
West	1.000	1.056	1.000	1.285	1.000	1.356
East	1.000	0.975	1.000	0.972	1.000	0.949
North	1.000	0.962	1.000	1.297	1.000	1.249
South	1.000	0.871	1.000	1.259	1.000	1.097
General	1.000	0.957	1.000	1.221	1.000	1.168

Table 14 – *EC, TC and MI Values of EU Countries and Turkey (Model 2).*

Country Category	Efficiency Change	Technological Change	Malmquist Index
EU Average	0.996	1.022	1.018
Turkey	0.987	0.993	0.981

Table 15 – *Cumulative Values of EU Countries and Turkey (Model 2).*

EU Countries and Turkey	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
EU Average	1.00	0.962	1.00	1.240	1.00	1.193
Turkey	1.00	0.879	1.00	0.935	1.00	0.823
All the Countries	1.00	0.919	1.00	1.077	1.00	0.991

change. In other categories, efficiency change diminished during the analysis period. The highest decline is realized for Southern European countries where Turkey is also included in. As for technological change, parallel to TFP, all the categories exhibit moderate increases except the Eastern Europe where small decline is observed.

In order to examine long-term effects, cumulative values of Malmquist index are presented in Table 13. According to the results of the Table 13, MI values increased to 16.8 per cent on the average for the analysis decade. Compared to the first model where food security and greenhouse gas emission are not concerned with, the increase in the factor productivity remained low. The highest increase is observed in Western Europe with 35.6 per cent. The rise in Northern European countries is not negligible either (almost 25 per cent). In Eastern Europe country category, however, productivity diminished more than 5 per cent during the whole period.

Furthermore, efficiency positively changed for only Western European countries. Moreover, technological change attained positive values for all the categories except Eastern Europe.

Similar to the procedure used for the model 1, EC, TC and MI values are examined for Turkey and EU countries in model 2 as well. In the Table 14, EU countries average values are compared with the Turkish values.

As to the findings presented in the above table, a non-negligible decline of 1.9 per cent occurred in TFP of Turkey. Controversially, TFP in EU countries increased to 1.8 per cent during the analysis period owing to 2.2 per cent rise in technological change. The findings of the Model 2 are not radically different from those of the Model 1 for Turkey. Nevertheless, the values for EU countries are relatively low in the context of technological change and Malmquist index. Therefore, one can suggest that food security and emissions are not quite significant variables for Turkey's productivity performance. Such variables, however, affect EU countries to a great extent.

Additionally, MI cumulative values for EU countries present an increase of 19.3 per cent. This increase mainly originated from the rise of 24 per cent in technological change since efficiency change reduced during the analysis period. The picture is not optimistic for Turkey. Turkish TFP diminished 17.7 per cent in the same period mainly due to the 12.1 per cent decline in efficiency change. It should be noticed that a decrease of 6.5 per cent in technological change also contributed the reduction in the factor productivity for the 1995-2005 period (See Table 15).

Finally, cumulative Malmquist index values for all the countries are calculated to demonstrate their performance in the context of sustainable development. Table 16 is constructed for this purpose.

The best performers among all the sample countries during the 1995-2005 periods are Denmark, France, Germany and Italy. In particular, Denmark realized a great leap in TFP through concerning with the sustainable agriculture. In this period, Austria, Czech Republic, Finland, Greece, Hungary and Turkey displayed significant declines in their total factor productivities. Among these countries, highest reductions are monitored with 19.8 per cent in Hungary and 17.7 in Turkey.

Table 16 – *Cumulative Values of Countries (Model 2).*

Country	EC		TC		MI	
	1995	2005	1995	2005	1995	2005
Austria	1.000	1.000	1.000	0.953	1.000	0.953
Belgium	1.000	1.000	1.000	1.232	1.000	1.232
Czech Republic	1.000	1.000	1.000	0.959	1.000	0.959
Denmark	1.000	1.000	1.000	1.945	1.000	1.768
Finland	1.000	1.000	1.000	0.873	1.000	0.873
France	1.000	1.109	1.000	1.529	1.000	1.698
Germany	1.000	1.122	1.000	1.517	1.000	1.696
Great Britain	1.000	0.823	1.000	1.491	1.000	1.231
Greece	1.000	0.660	1.000	1.417	1.000	0.937
Holland	1.000	1.000	1.000	1.055	1.000	1.055
Hungary	1.000	0.825	1.000	0.971	1.000	0.802
Italy	1.000	1.116	1.000	1.427	1.000	1.591
Poland	1.000	1.125	1.000	0.987	1.000	1.111
Portugal	1.000	0.913	1.000	1.246	1.000	1.137
Spain	1.000	0.848	1.000	1.345	1.000	1.138
Sweden	1.000	1.000	1.000	1.210	1.000	1.210
Turkey	1.000	0.879	1.000	0.935	1.000	0.823
Average	1.000	0.957	1.000	1.221	1.000	1.168

4. Concluding Remarks

Above all, the current study attempted to construct a data on the food security. Following a relatively complex procedure, minimum production level to provide yearly calorie requirement of the countries are obtained. It should be mentioned that this calculated data is functional to decide each country's food sufficiency level. According to the findings of the current study, Denmark produces 11 times above the minimum production level necessary to provide annual calorie requirement of its population. On the other extreme, Portugal only has the minimum value of 1.5 times in 2005. Additionally, Turkey has the production level of approximately 5 times above the minimum calorie requirement. This value is higher than all the countries average. Notwithstanding, a decline of 1 per cent is observed from 1995 to 2005. Although, no urgent threat is detected for Turkey in the context of food sufficiency, the trend should be closely monitored since the country's poverty ratio exceeded to 30 per cent in 2007 for the people living in the rural areas (TÜİK 2008).

Meanwhile, depending on the results of Malmquist index, one can infer that TFP rose in general during the 1995-2005 period. The origin of this increase can be safely attributed to technological change. With the modification of the model via introducing two additional output variables namely food security and greenhouse gas emission, the rise in TFP relatively diminished.

When the focus of the analysis shifts on the regional level, the highest improvement is observed in Western and Northern European countries during the analysis period. On the contrary, productivity changes remained limited for Eastern and Southern European countries. Such distinction seems to coincide with the differences in the development level of each country category. More specifically, it can be argued that relatively more developed country categories of Western and Northern Europe exhibit good performance with respect to sustainable agriculture.

The comparative analysis between EU averages and Turkish agriculture reveals that while a rise of 1.8 per cent in total factor productivity is inspected for EU, a decline of nearly 2.0 per cent is realized for Turkey. From this finding, one can suggest that the gap between European Union countries and Turkey widened in the analysis period.

Nevertheless, the occurrence of the productivity regression in Turkish case can mostly be attributed to efficiency change rather than technological one. Therefore, the country has the opportunity to perform better with respect to sustainable agriculture through the improvements in the efficiency. In other words, without realizing sound technological changes, Turkey has the chance to conform the requisites of sustainable agriculture via the enhancement in the efficiency of its production structure. Yet, technological advances should not be ignored at all for long-term productivity growth and development perspectives.

The empirical analysis also offers valuable results in association with the cumulative Malmquist index values. As to these results, EU countries achieved an increase of approximately 20 per cent on average in their total factor productivity owing to the improvement in the technology during 1995-2005 periods. In the same period, the picture is wholly contrasting for Turkey. Both efficiency and technology changes are on the negative direction, and consequently, total factor productivity of Turkey deteriorated to more than 17 per cent. This situation obviously jeopardizes the performance of the country with respect to sustainable agriculture. To put differently, the already existing gap between EU countries and Turkey extended in width in the recent decade.

To sum up, in order to alleviate the efficiency problem and to close the productivity gap, Turkey should deal with the structural problems like efficient use of water resources, combating with soil erosion, implementing sustainable land and water management, improving soil quality, spreading organic agriculture throughout the country, revising the agricultural support policies. Last but not least, the country should overcome the economic crisis and establish a stable economic and equitable social structure.

References

Bağdadioğlu, N. and Ulucan, A., 2005. «Financial Efficiency of the Turkish Textile and Clothing Industry before the 2005 Trade Liberalisation», *Eurasian Review of Economics and Finance*, 1(4): 1–21.

Baysal, A., 1991. *Genel Beslenme (General Nutrition)*, Ankara: Hatipoğlu Yayınevi.

Coelli, T.J. and Rao, D.S.P., 2003. «Total Factor Productivity Growth in Agriculture: A Malmquist Index Analysis of 93 Countries, 1980-2000», *International Association of Agricultural Economics (IAAE) Conference* in Durban, August, 16-22.

Deaton, A. and Muellbauer, J., 1986. «On Measuring Child Costs: With Applications to

Poor Countries», *Journal of Political Economy*, 94(4): 720–744.

De Avila-Pires, D. F., Mior, L. C., Aguiar, V. P. and De Mello Schlemper, R., 2000. «The Concept of Sustainable Development Revisited», *Foundations of Science,* 5: 261–268.

De Koeijer, T. J., Wossink, G. A. A., Struik, P. C. and Renkema, J.A., 2002. «Measuring Agricultural Sustainability in terms of Efficiency: the Case of Dutch Sugar Beet Growers», *Journal of Environmental Management*, 66: 9-17.

DİE (Turkish Statistical Institute), 2003. *Tarımsal Ürünlerde Teknik Dönüşüm Katsayıları ve Ürün Denge Tabloları 1989-1995 (Technical Conversion Factors and Food Balance Sheets in Agricultural Products 1989-1995)*, Devlet İstatistik Enstitüsü, Yayın No: 2733, Ankara.

FAO, 2005. «The State of Food and Agriculture» *Food and Agriculture Organization of The United Nations*, Rome, FAO Agriculture Series No.36.

Fare, R., Grosskopf, S., Norris, M. and Zhang, Z., 1994. «Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries», *American Economic Review*, 84(1): 66-83.

Farrell, M. J., 1957. «The Measurement of Productive Efficiency», *Journal of the Royal Statistical Society*, Series A (General), 120(3): 253–290.

Gliessman, S. R., 2005. «Agroecology and Agroecosystems», Jules Pretty (Ed.), *The Earthscan Reader in Sustainable Agriculture*, London: Earthscan, 104–115.

Gomes, E. G., de Mello, J. C. C. B. S., Souza, G. S., Meza, L. A. and Mangabeira, J. A. C., 2008. Efficiency and Sustainability Assessment for a Group of Farmers in the Brazilian Amazon, *Annals of Operation and Research*, Springer Science and Business Media, LLC 2008, 1-15.

Lynam, J. and Herdt, R., 1988. «Sense and sensibility: Sustainability as an Objective in International Agricultural Research», *CIP-Rockfeller conference on farmers and food systems*, Lima, Peru.

OECD, 2001. *Environmental Indicators for Agriculture*, Methods and Results, Volume 3, Paris.

Schaller, N., 1993. «The Concept of Agricultural Sustainability», *Agriculture, Ecosystems and Environment,* 46: 89–97.

Smith, C.S. and McDonald, G.T., 1998. «Assessing the Sustainability of Agriculture at the Planning Stage», *Journal of Environmental Management*, 52: 15–37.

TÜİK (Turkish Statistics Institution), 2008. *İstatistik Göstergeler 1923–2007 (Statistical Indicators, 1923-2007)*, Türkiye İstatistik Kurumu, Yayın No: 3206, Ankara.

TÜİK (Turkish Statistics Institution), 2008. *2007 Yoksulluk Çalışması Sonuçları (The Results of 2007 Poverty Study)*, Haber Bülteni, Türkiye İstatistik Kurumu, Sayı: 192, Ankara.

WB, 2007. *World Development Indicators*, the World Bank, April 2007.

Yunlong, C. and Smith, B., 1994. «Sustainability in Agriculture: A General Review», *Agriculture, Ecosystems & Environment*, 49(3): 299–307.