CLIMATE CHANGE, AGRICULTURE AND TRADE POLICY: CGE ANALYSES AT REGIONAL, NATIONAL AND GLOBAL LEVEL

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ABSTRACT

CLIMATE CHANGE, AGRICULTURE AND TRADE POLICY:
CGE ANALYSES AT REGIONAL, NATIONAL AND GLOBAL LEVEL

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This thesis investigates the effects of climate change on the Turkish economy by using computable general equilibrium (CGE) models at regional, national and global level. The physical impact of climate change is first translated into yield and irrigation requirement shocks by using a crop-hydrology model developed for this study. Then these are introduced into the CGE models as productivity shocks to investigate their effects on the overall economy. Simulation results suggest that climate change will come into play after 2035, and its effects on the economy will get worse after 2060. The final economic effects at regional and global levels will depend on the location and structure of agricultural production.

Trade liberalization is considered as a policy response to contain the negative impact of the climate change. The results indicate that trade liberalization helps, but the positive effects are limited. International trade plays a key role in the response of the economy to the climate change shocks. Trade liberalization with the European Union is found to have positive effects on welfare of households, however these effects are low compared to the harm caused by climate change. Moreover, it was also noted that these positive effects increased as climate change effects are worsened.

At the global level, the simulation results suggest that there is a significant uncertainty about the impact of climate change on the global economy. The effects are not homogenous for different regions of the world or different sectors in a region. On the other hand, effects of trade liberalization are not affected by the uncertainty in the climate change scenarios. Our results suggest that adverse effects of climate change on welfare can be alleviated by trade liberalization in most parts of the world.

Keywords: Climate Change, International Trade, Turkey, Agriculture, Computable General Equilibrium

ÖZ

İKLİM DEĞİŞİKLİĞİ, TARIM VE TİCARET POLİTİKASI:
BÖLGESEL, ULUSAL VE KÜRESEL DÜZEYDE BİR HGD ANALİZİ

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Bu tez iklim değişikliğinin Türkiye ekonomisi üzerindeki etkilerini bölgesel, ulusal ve küresel düzeyde hesaplanabilir genel denge (HGD) modelleri ile incelemektedir. Öncelikle iklim değişikliğinin fiziksel etkileri bu çalışma için geliştirilmiş olan bir bitki-sulama modeli ile verim ve sulama gereksinimi değişimlerine dönüştürülmüştür. Daha sonar bu değişimler HGD modeline üretkenlik şokları olarak kullanılmıştır.

Sonuçlar iklim değişikliğinin 2035 yılından itibaren etkili olmaya başlayacağını, 2060 yılından sonra etkilerin ağırlaşacağını göstermektedir. Hem bölgesel hem de küresel etkiler konuma ve tarımsal üretimin yapısına göre değişikliklik göstermektedir. Uluslararası ticaret ekonominin iklim değişikliği şoklarına verdiği tepkide anahtar rol oynamaktadır. Ulusal düzeyde ticaret serbesleştirmesinin etkileri de incelenmiştir. Avrupa Birliği ile yapılacak olan bir ticaret serbestleşmesi refahı arttırmakta ancak bu artış iklim değişikliğinin sebep olduğu zararı karşılamak konusunda düşük kalmaktadır. Ancak refah artışı iklim değişikliğinin etkileri ağırlaştıkça artmaktadır.

Benzetim sonuçları küresel düzeyde iklim değişikliğinin etkilelerinin olası etkilerinin geniş bir yelpazeye yayıldığını göstermektedir. Sonuçlar dünyanın farklı bölgeleri ve bir bölgedeki farklı sektörler için değişiklikler göstermektedir. Diğer taraftan, ticaret serbestleşmesinin etkileri genellikle varsayılan iklim değişikliği senaryosundan bağımsızdır. Sonuçlar, iklim değişikliğinin olumsuz etkilerinin küresel çaptaki yapılacak bir ticaret serbestleşmesi ile hafifletilebileceğini göstermektedir.

Anahtar Kelimeler: İklim değişikliği, Uluslararası Ticaret, Tarım, Türkiye, Hesaplanabilir Genel Denge

In memory of my grandmother, Feride Dudu

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TABLE OF CONTENTS

LIST OF FIGURES

FIGURES

LIST OF TABLES

TABLES

LIST OF ABBREVIATIONS

AEZ	Agro-Ecological Zones
CDE	Constant Difference of Elasticity
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CU	Customs Union
ET	Evapotranspiration
EU	European Union
EV	Equivalent Variation
GCM	Global Circulation Model
GDP	Gross Domestic Project
GHG	Green House Gases
GTAP	Global Trade Analysis Project
I/O	Input Output Table
IPCC	Intergovernmental Panel on Climate Change
MENA	Middle East and North Africa
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Co-operation and Development
SAM	Social Accounting Matrix
TurkStat	Turkish Statistical Institute

CHAPTER 1

INTRODUCTION

Climate change has been the biggest challenge for the human kind from the dawn of her existence. Changes in the climatic conditions during the 2 million years of evolution of modern human were far more severe than the one expected in the next century. However, human kind was successful to adapt to these conditions. Since the last cyclical swings in the climate of Africa that started 500 thousand years ago and lasted until the existence of modern human, Homo Sapiens was profoundly successful in adapting to the changing climate. Today, adaptation stands as one of the most challenging problems that humans need to solve collectively to survive.

Scientific community responded quickly to the early signs of climate change to alert the global community. However, current state of knowledge about the climate change can at best be described as primitive due to the complex and uncertain nature of the problem. Some people may even claim that it is too early to be alarmed. The studies show that it will have significant impact on daily life, and the need to adapt is inescapable. Nonetheless, neither the time frame of the realization of effects, nor the sign and magnitude of the impact are known. Different tools used for impact estimation result in different conclusions; and this raises new questions. The underlying reason is the lack of detailed information that is required to eliminate the uncertainty in climate estimates; both in terms of theoretical basis and applied work. We are at the beginning of our long journey to explore the effects of climate change. However, the accumulation of knowledge is proceeding fast. Numerous studies undertook the challenge to quantify the effects of climate change at the global level and the count increases exponentially.

Adaptation to climate change is mostly an economic problem. Most important adaptation measure that our early ancestors have developed to cope with the climate change was “being economical”. Homo sapiens qualify as the most efficient organism in terms of exploiting the natural resources. We do not waste anything supplied by the biosphere. We live on crops, animals, metals and even soil and rock. This survival strategy, however, created species that are ultimately dependent on what is available. During the course of human history, all we tried to do was securing as much resources as possible to guarantee our survival. However, these activities have become so extended that they transformed the biosphere itself and started to threaten our own well-being by – at least – accelerating the course of climate change. Hence, we are back to square one. We need to once again find new ways of “being economical”, or in other words invent new strategies to interact with biosphere to avoid a possible extinction.

In this thesis we tackle the question of how climate change may affect the Turkish economy and whether the trade policy can be used as an adaptation measure to compensate the negative effects of climate change in three stand-alone papers. The main focus of this study is on Turkey, but the results can be extended at least to most of the developing economies in the region. We follow an analytical approach by relying on established theoretical frameworks and most recent data. Instead of trying to make static projections, if necessary we develop tools to describe all possible states of the future. That is to say we acknowledge the uncertainty in the estimation of physical impacts of climate change. Naturally, covering all possible future states, i.e. all the estimations of climate change impact, is not possible in a work that is limited by time and resource constraints.

In the following chapter, we exploit the increasing resolution of the climate change impact estimates to assess the effects of climate change on Turkish economy at NUTS I level. The main aim of the chapter is to present the variation in the effects over time and space and to shed light on the underlying mechanisms of economic responses. We develop two analytical models for this purpose. First, a crop hydrology model is employed to translate the physical effects of climate change to economic shocks in the form of changes in yields and irrigation requirements. Then we use a computable general equilibrium model to inquire the economic effects.

Results of the models suggest that the effects can be grouped into three periods. During the first period, which covers from 2009 to 2035, Turkish economy is not affected seriously and climate change may even have positive contributions to the economic activities. The production conditions worsen between 2036 and 2060 with the increase in the frequency of extreme events. This situation increases the probability of observing serious adverse effects. Average of the effects is also worsened. In the last period, from 2065 to 2100, economy is hit hard by the climate change. Agricultural production is mostly hampered in almost all regions.

In the third chapter, we incorporate the effects under trade liberalization by developing a recursive dynamic CGE model at the national level. Eliminating the regional detail from the model allows us to increase sectoral resolution, especially for agriculture. Both approaches yield similar results related to the impact of climate change: Amplified effects are observed in the latter two periods, and agricultural production declines significantly. International trade plays a key role in the response of the economy to the climate change shocks. Oilseeds and maize turns out to be the most affected activities. Trade liberalization with EU is found to have welfare improving effects but these effects are low compared to the harm caused by climate change. Though the effects increase as climate change effects are worsened. The main reason is the increase in the substitution possibilities under trade liberalization.

The last chapter deals with the effects of climate change at the global level. GTAP model based analysis utilizes a large set of climate change scenarios. The effects of climate change can now be described by probability distributions. Simulation results suggest that impact of climate change on global economy spans a large range of probabilities. The effects are not homogenous for different regions of the world or for different sectors in a region. On the other hand, the effects of trade liberalization are generally independent from the assumed climate change scenario. The results suggest that adverse effects of climate change on welfare can be alleviated by trade liberalization in most parts of the world. This is especially true for Turkey where welfare improvement is accompanied by an increase in GDP under full trade liberalization. However, effects of trade liberalization with EU are again found to be weak.

To sum up, our analysis suggests that Turkey still has time to take necessary adaptation measures and trade policy can be a policy to contribute to these measures by removing the constraints on the supply of good for intermediate input use and consumption. However, results also suggests that trade liberalization cannot cure all drawbacks of the changing climate by itself. Hence Turkey needs to take more adaptation measures before it is too late.

CHAPTER 2

AN INTEGRATED ANALYSIS OF ECONOMY-WIDE EFFECTS OF CLIMATE CHANGE FOR TURKEY

"Le contraire du simple n'est pas le complexe, mais le faux."

Andre Comte-Sponville

Effects of climate change in Turkey, which is already a water stressed country, are expected to be significant. The aim of this chapter is to quantify the effects of climate change on the overall economy. We use an integrated framework which incorporates the results of a crop water requirement model in a computable general equilibrium model for the period 2010-2099. Since agriculture is the most important sector that will be affected by climate change, analysis of climate change effects on the overall economy necessitates taking into account backward and forward linkages to agriculture. The CGE model establishes the links between agriculture, the other sectors, and also with the economic agents in 12 NUTS-1 regions. A crop water requirement model is used to translate the results of global climate models to the changes in yields and irrigation requirements for the period 2008-2099 at 81 NUTS-3 regions for 35 crops. The results of the crop water requirement model are then introduced to CGE model as climate shocks.

The results suggest that the economic effects of climate change will not be significant until the late 2030s; which allows Turkey to develop appropriate adaptation policies. However after 2030s, effects of climate change are significant. Production patterns and relative prices will change drastically. The economic effects differ among regions. The effects are milder in the regions where irrigated agriculture is relatively low. This suggests that climate change policy needs to be region-specific. Agriculture and food production are the most affected sectors. Increasing irrigation requirements will cause farmers to reduce irrigated production. Combined with the decline in yields, this will lead to the deterioration of agricultural production and an increase in agricultural prices. Consequently the loss in household welfare will be significant. Part of the decline in production can be compensated by imports, causing an increase in agro-food trade. Trade balance will worsen with declining manufacturing exports due to increasing cost of production.

In the following sections we will first give a survey of studies related to the effects of climate change on agriculture and overall economy for Turkey. Then we will present the modeling approach and the models that are used in this chapter. Afterwards, we will describe the data used in the models. Results and discussions will follow. We reserved the last section for concluding remarks.

2.1 Climate Change

A significant effort has been spent by scientists from various disciplines to shed light on the causes and effects of climate change in recent years (Tol, 2010). Although there are still some controversies about the details (Idso et al., 2009), it is widely accepted that the effects of climate change have already started to be felt, and the significance of the impacts is expected to increase throughout the 21st century (Agrawala et al., 2008; Parry et al., 2007; Stern, 2006). Although, a wide range of social and physical effects has been linked to climate change, the most significant effects are expected to be increasing temperatures accompanied by declining precipitation, as well as increasing frequency of climatic extremes (Stern, 2006). Hence, agricultural production, which ranks high in terms of climate dependence, is likely to be the most vulnerable sector (Fankhauser, 2005). The changes in temperature and precipitation will affect the yields in crop production, while climate related risks will increase due to increasing frequency of climatic extremes (Rosegrant et al., 2008).

Effects of climate change have already started to be observed in Turkey in the form of changes in mean temperatures, precipitation (Durdu, 2010; Kadıoğlu, 2008), growing degree days (Kadıoğlu et al., 2001), number of frost days (Şensoy et al., 2008) and frequency of climatic extremes (Şensoy et al., 2008). The effect of climate change on agricultural production in Turkey is expected to be significant since agricultural production is heavily dependent on climatic conditions. A significant part of the agricultural production is held on rainfed land making the production significantly sensitive to changes in precipitation (Kadıoğlu, 2008). Research and development of new drought resistant crop varieties are also quite limited. Further, although the share of agricultural value added in GDP has declined to 10 percent in recent years (TurkStat, 2010a), its share in employment is still significant, at 25 percent (TurkStat, 2010b). As such agriculture remains to be the most important source of income for the rural population.

The number of studies investigating the economic effects of climate change in Turkey has started to increase in recent years. These studies can be grouped in five categories: The first group consists of papers that survey the global literature and attempt to draw conclusions about the Turkish economy by analyzing the results of existing global models (Arslan-Alaton et al., 2011; Aydınalp et al., 2008; Kaygusuz, 2004; Önder et al., 2007). The work in the second group focuses on greenhouse gas (GHG) abatement policies (Kumbaroğlu et al., 2008; Telli et al., 2008; Tunç et al., 2007) and attempt to model the link between climate change and economy by evaluating the effects of different policy options. The third group of studies uses general circulation, hydrological, regional climate or crop based models to estimate the probable effects on non-economic indicators such as availability of water or growing degree days without any reference to their implications for agricultural production or economy (Durdu, 2010; Fujihara et al., 2008; Göncü, 2005; Kadıoğlu et al., 2001; Komuscu et al., 1998; Onol et al., 2009; Şensoy et al., 2008). In the fourth group, there are few studies that link the changes in climate variables under different climate change scenarios to agricultural production (Cline, 2007; Kapur et al., 2007; Özdoğan, 2011). Lastly, Dellal & Mccarl (2009) investigate the impact of climate change using a sector model with restricted coverage of agriculture, and Dudu et al. (2010) try to link climate change projections with the overall economy.

Cline (2007) presents a detailed impact analysis of climate change on 60 countries, including Turkey, by downscaling the results of five global circulation models. Cline (2007) reports that the increase in average temperature will be between 1.1°C and 1.6°C, while average precipitation will decline by 30 percent which translates to 11.8 percent decline in average agricultural yield for the period 2070-2099. This will result in 16 percent loss in the value added produced by agricultural sector (Cline, 2007: p.40 and p. 64 and p.71). Cline (2007) also reveals that the initial 1 to 2°C increase in temperature will in fact benefit the agricultural sector. However, the effects will be reversed when the increase in temperature is higher than 2°C (Cline, 2007, p. 60). The results indicate that estimates of climate change effects for Turkey have the highest coefficient of variation across different global climate models and probably are less robust to different model assumptions.

Kapur et al. (2007) attempt to link the climate change effects in Turkey to agricultural production. They employ a regional climate model to estimate the effects of climate change on wheat production for the period 2070-2099 under A2 scenario of IPCC in the Çukurova Basin, which is one of Turkey's most advanced regions in agricultural production. Their results suggest 35 percent decline in precipitation accompanied by 2.8°C increase in the mean temperature. However, they do not report any quantitative results for the probable change in wheat yield.

Recently, Özdoğan (2011) reported the results of a crop model. The impact of climate change is obtained from a GCM. The study analyzes the effects on wheat production in the Thrace region. Özdoğan (2011) reports that CO_2 effects are likely to be small and there will be a 15 to 20 percent decline in wheat yield.

Although these studies report the impact of climate change on yields or water availability, they still do not give much information about the economic effects for the agricultural sector. Furthermore, these studies also lack spatial and sectoral depth, in the sense that they merely focus on either the national level or on analyzing specific sub-regions and that they generally limit their analysis to few major crops.

There are only two well documented studies in the literature that employ economic models to investigate the implications of climate projections under different climate change scenarios. Dellal & Mccarl (2009) use a partial equilibrium model for the agricultural sector to investigate the effects of a climate change on production. Dudu et al. (2010) on the other hand uses a computable general equilibrium model to analyze effects of yield changes on the overall economy. Both models suffer from various deficiencies. In Dellal & Mccarl (2009) the average of results from a global climate model is used to estimate yield responses. The regional dimension of the model used is outdated and is not compatible with NUTS classifications of TurkSTAT. Furthermore the study runs simulations for a limited number of crops. Dudu et al. (2010), use the average of expected yield changes compiled from existing literature. The regions chosen are aggregated and they use 2003 social accounting matrix.

Consequently, there is a need for a more detailed economic analysis of climate change by combining the results of climate models with economic models at the regional level. In this chapter, we aim to improve the current modeling efforts in the literature by using an integrated approach to evaluate the effects of climate change on the overall economy of Turkey in a detailed regional setting. For this purpose, we use a crop water requirement model to translate the regionalized results of a global climate model to yield shocks and irrigation requirement changes. These changes are introduced as productivity shocks to a CGE model. The following section presents the modeling approach for the CGE model in detail and the crop water requirement model. Section 2.3 presents the data and aggregated results of crop water model. The results of CGE analysis are discussed in Section 2.4 reports. The last section is reserved for the concluding remarks.

2.2 Integrated Modeling Approach

Climate change is a complex issue and any complete assessment of its effects needs to take into account the interactions of physical, economic and social factors. Consequently, a comprehensive impact assessment requires different types of models. Complicated climate and hydrology models are needed to estimate the physical effects at the global level. The estimates from these models then need to be downscaled to smaller spatial resolutions to obtain the effects at the regional level. In addition, the interaction within an economy and the rest of the world needs to be considered in detail to have a solid interpretation of the economic effects. As mentioned before, climate change is expected to affect the economy via the agricultural sector. Hence, a special impact assessment model is required to link the results of climate models to the economic models. Therefore, complete impact analysis of climate change necessitate to integrate physical models, specific impact assessment models and economic models.

This “three pillar” approach has started to dominate the literature recently supported by the availability of disaggregated climate change data and by the increasing computational power. Global Circulation Models (GCMs) are now used extensively to make projections related to the main climatic variables under different scenarios. Although the results of these models are controversial, especially at the regional level, the mean values of the results from many available GCMs are used as a proxy. The type and specification of special impact models used to translate GCMs output to economic impacts differ according to the aim of the study. Lastly, computable general equilibrium modeling has become the standard approach to estimate the economic effects.

There is vast literature related to the agricultural and economy-wide effects of climate change. The literature survey here will be selective by considering the studies that adopted similar approach to the one adopted in this chapter. More comprehensive surveys on the integrated approach can be found in Hertel & Rosch (2010) and also in Palatnik & Roson (2009).

In their study Bosello & Zhang (2005) use a GCM that combines a crop- growth model with a global CGE model (GTAP-E). The climate scenario is endogenously produced by the economic model. The results indicate that climate change has a limited impact on agricultural sectors mainly due to the smoothing effect of economic adaptation. Bosello & Zhang (2005) are separated from the other studies since they report insignificant effects on agriculture.

Rosegrant et al. (2008) and Nelson et al. (2009) use a global food supply and demand model (IMPACT) together with a biophysical model (DSSAT) to estimate the impacts of climate change on agriculture at the global level. They report that climate change will affect human well-being negatively due to declining yields and increasing prices. Calorie availability will be worsened and child malnutrition will increase by 20 percent. They estimate that USD1.7 billion in 2000 prices is needed to offset the effect of climate change on calorie availability.

Cretegny (2009) develops a conceptual framework that uses an integrated approach at national and global level. The study presents an implementation of bottom-up and top-down approaches for integrated modeling of climate change. In the bottom-up methodology, the projected changes in climatic variables obtained from multiple GCMs are first downscaled to local levels, and then they are used to estimate the vector of impacts on key economic sectors using sector-specific impact assessment models. In the top-down methodology, the climate projections are used to derive regional sector-specific damage functions that are used to calibrate a global dynamic multi-sectoral CGE model.

Thurlow et al. (2012) investigate the effect of climate variability and climate change on Zambian economy by using a hydro-crop model (CropWAT model of FAO) for maize in Zambia together with a dynamic CGE model. They use historical climatic data and HadCM3 results from a hydro-crop model to obtain yield responses of maize under different drought and climate change scenarios. They estimate yield losses up to 50 percent in years with severe drought. The results of CGE model suggest that climate variability may result in USD4.3 billion losses over a 10-year period, leaving 300,000 people below the poverty line. Climate change effects add another USD2.15 billion to the losses; pushing 74,000 more people below poverty line.

Ciscar et al. (2009) use various impact assessment models with a CGE (GEM-E3) model. Most EU countries are modeled individually in the CGE model. DSSAT crop models have been used to quantify the physical impact on agriculture. Their findings suggest that most European regions would experience yield improvements during the 2020s, but in the 2080s average crop yield will fall by 10 percent. Southern Europe would experience relatively higher yield losses. They estimate that annual damage of climate change to the EU economy in terms of GDP loss will be between €20 billion to €65 billion implying 0.2 percent and one percent welfare loss, respectively.

Pauw et al. (2010) use a general equilibrium model to estimate the economy wide impact of production losses due to hydrological extremes in Malawi. Climate simulations are based on production loss estimates from stochastic drought and flood models. Results show that 1.7 percent of GDP will be lost due to climate change, small farmers will be affected more prominently, and food shortages are likely to affect urban households significantly.

Calzadilla et al. (2011) investigate the impact of variation in water availability due to climate change on the global agricultural production. They use a multi-sectoral global CGE model (GTAP-W) and a Global Environmental Model, which includes a dynamic river routing model (HadGEM1-TRIP), to simulate changes in temperature, precipitation and river flow over the next century under the IPCC scenarios. They report that global food production, welfare and GDP will decline. Food prices are expected to increase. They also show that countries are not only influenced by regional climate change, but also by climate-induced changes in competitiveness in the global markets.

Fernandes et al. (2012) use an agro-ecological model together with an applied general equilibrium model (ENVISAGE) to assess the impact of climate change in

Latin America. The agro-ecological model consists of crop development, soil types, water availability, abiotic factors, management and crop suitability components. The results suggest that there will be significant decline in the yields of major crops and the effects will be higher after 2050. Adaptation is partially effective in off-setting the climate change effects. Economic impacts are also significant, adding up to 1.3 percent decline in region's GDP.

All studies share two common findings. First is that climate change effects on the overall economy and particularly on agricultural production may be significant, especially for developing countries where the share of agricultural value added in GDP is high. Secondly, the effects accelerate in the second half of the 21st century, especially for developed countries. The results are region and crop specific, and aggregation at any level underestimates the effects. Adaptation policies can be effective to lessen the economic losses.

The modeling approach used in this Chapter follows the three pillar approach presented in Figure 2.1. We use the output of a GCM as an input for the crop water requirement model to estimate the yield and irrigation water requirement of different crops. Then the output of the crop water requirement model is used as an input for the CGE model in the form of productivity shocks. Details of the modeling structure are provided in the next two sections.

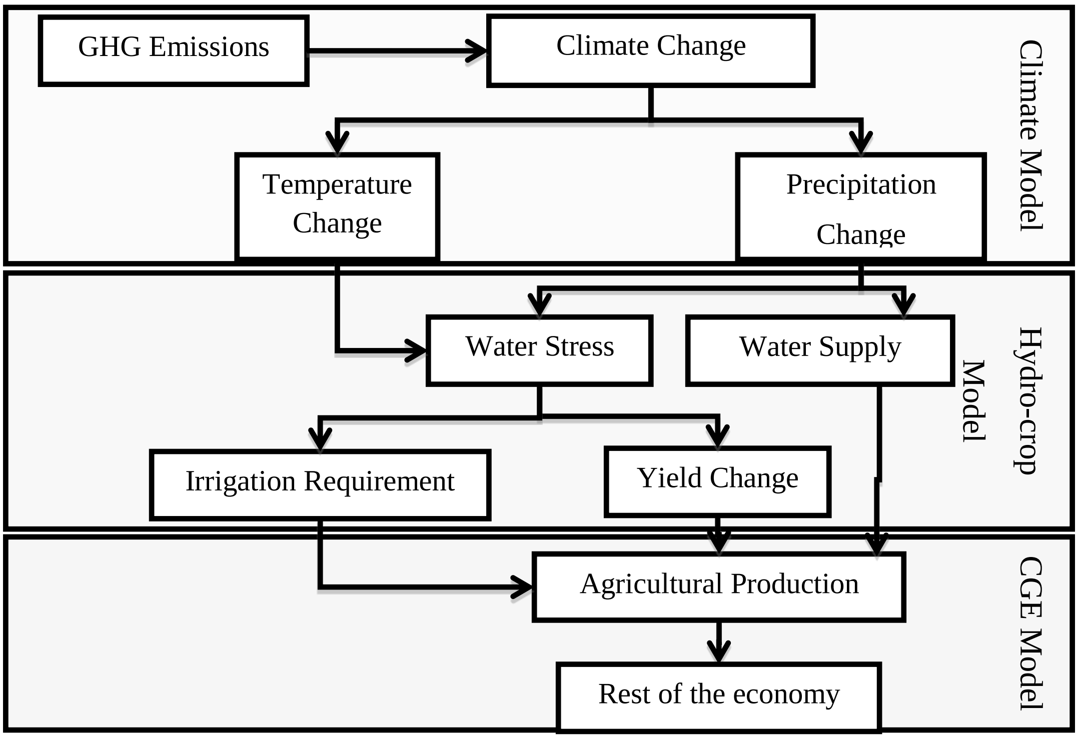
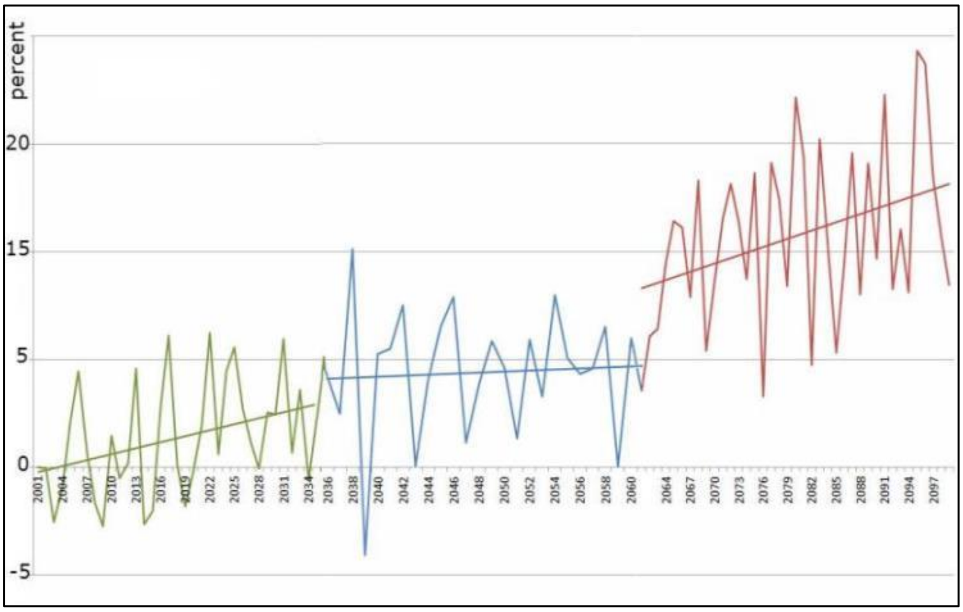


Figure 2.1: Summary of modeling approach

2.2.1 Crop Water Requirement Model

The physical effects of climate change on agricultural commodity production are generally assessed by using hydrology and crop simulation models. These models take the forecasts of the major climatic variables, i.e. precipitation, temperature and wind speed, from the global circulation models (GCM), and use them to calculate or estimate the induced yield changes. The aggregated results obtained from the crop water requirement model are presented in this section and the detailed description of the model can be found in Appendix A. The estimated changes in yields and irrigation requirements are then introduced to the CGE model as climate change shocks.

The average value of ET_0 (the reference evapotranspiration) is presented in Figure 2.2. ET_0 increases slowly until 2060. However the oscillation around the mean value increases significantly between 2035 and 2060. Significant rise in the pace of increase in ET_0 is observed from 2060 to 2075, and the variation in ET_0 remains high after 2075.



Source: Author’s Calculations

Figure 2.2: Change in reference evapotranspiration (percentage change with respect to base period)

We use the change in yields for 35 crops (for details see Appendix A) to calculate the change in agricultural value added relative to the production value of agricultural products in 2008 for each NUTS-3 regions. Then, we aggregate the results at NUTS-1 regions by using the following formula:

$$\Delta VA_{R1} = \sum_{R3 \in R1} \frac{\sum_c \Delta Y_{c,R3} . P_{c,R3} . Q_{c,R3}}{\sum_c P_{c,R3} . Q_{c,R3}} \quad (2.1)$$

where $\Delta Y_{c,R3}$ is the change in yield, $P_{c,R3}$ is the price, $Q_{c,R3}$ is the production quantity of crop *c* in NUTS-3 region *R3*.

Monthly irrigation requirements for each crop in each region and year are calculated as the deficiency between precipitation and ET_s. Area of cultivated land in 2008 is used to find a weighted sum of the total irrigation for each NUTS-1 region, and also to determine a region-wide irrigation requirement per hectare.

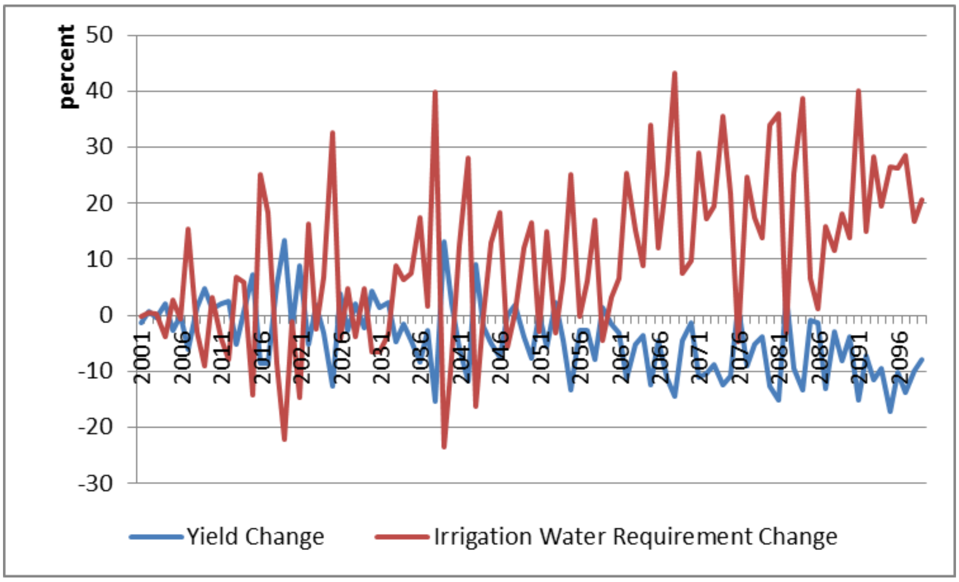
$$IRQ_{R1,Y} = \frac{\sum_{R3\in R1}\sum_{C}\sum_{M}\left(ETS_{C,R3,M,Y} - PR_{R3,M,Y}\right)A_{C,R3,2008}}{\sum_{C} A_{C,R3,2008}} \tag{2.2}$$

where $ETS_{C,R3,M,Y}$ is evapotranspiration of crop *C* under water stress in region *R3*, month *M* and year *Y*. $PR_{R3,M,Y}$ is the effective precipitation in region *R3*, month *M* and year *Y*. $A_{C,R3,2008}$ is the harvested area of crop *C* in region *R3* in 2008.

The change in the irrigation water requirement is calculated relative to the average irrigation water requirement for the period 2001-2010.

$$\Delta IRQ_{R1,Y} = \frac{IRQ_{R1,Y}}{\sum_{B=2001}^{2010} IRQ_{C,R1,B} \Big/ 10} \tag{2.3}$$

Figure 2.3 displays the estimated changes in yields and irrigation water requirements from 2001 to 2099. The changes in yields and water requirements follow slightly different trends than ET_0. Yield changes oscillate less in comparison with water requirements, which is highly dependent on precipitation. Both figures oscillate around base decade values until 2035. After 2035 the yields start to decline while irrigation requirements start to increase. Consequently, increase in irrigation requirements and decline in yields become significant after 2060. Lastly, note that variation in yields and irrigation requirements are significantly higher than the variation in ET_0



Source: Author's Calculations

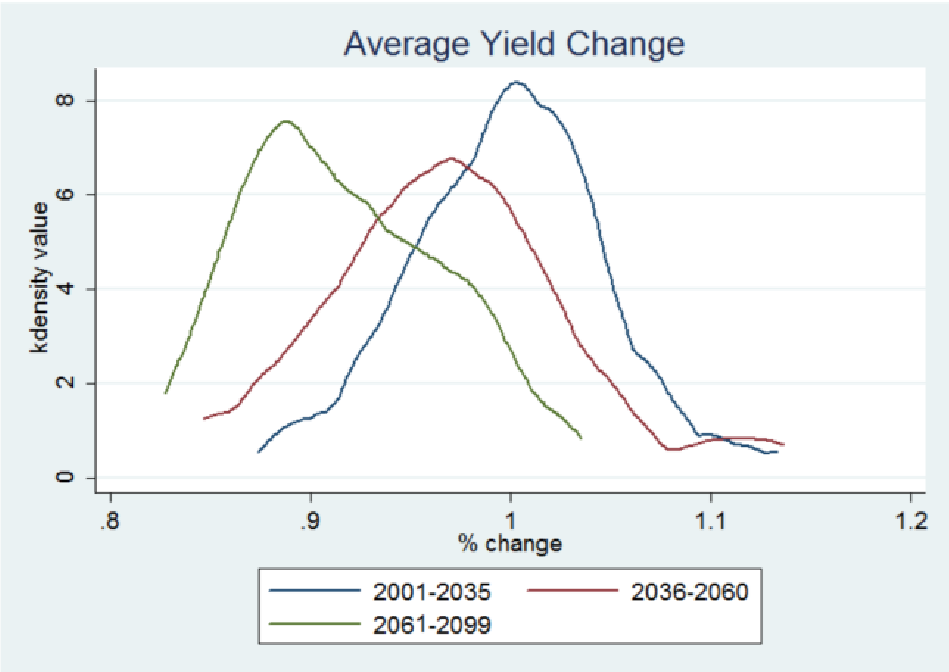
Figure 2.3: Average yield change and irrigation water requirement

A more accurate way to look at these yield changes is considering them as drawn from a probability distribution. In that case climate change will affect the mean and standard deviation of the distribution of yield changes. Effects on the economy for each period will also be drawn from a probability distribution. Figure 2.4 shows the estimated probability density[1] of the yield shocks for the periods mentioned above.

The distribution of yields shifts to the left indicating lower means for the yield shocks. The spread of the distribution, which is related to the climate risk, is also higher in the second and third period compared to the first period. In the first period the distribution is centered on zero median and almost zero mean with extreme

[1] Kernel density estimation graphs are used to visualize this approach. Kernel density estimations are smoothing methods to estimate the probability density function. We follow the methods developed in Silverman (1992) to estimate the probability distributions from the model results.

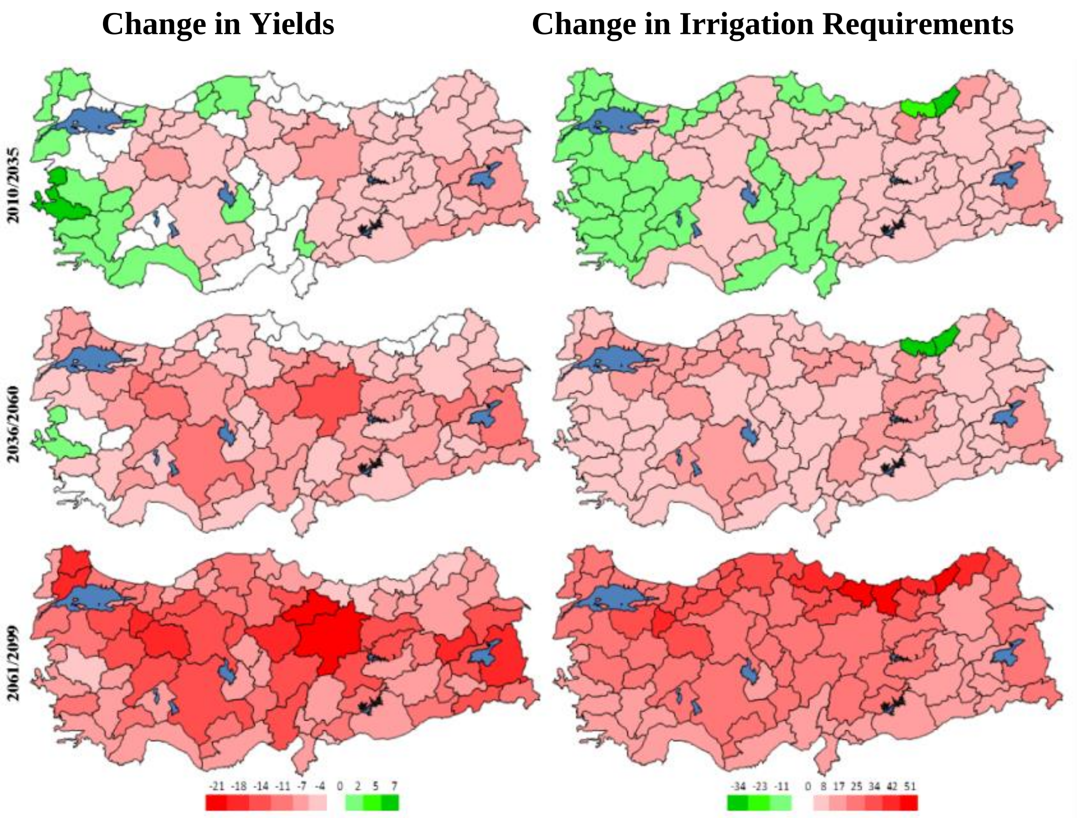
events in the range of ±10 percent. In the second period the mean is not affected much and shifts towards -3 percent. However, the extreme events spread –15 percent and 10 percent change in yields with higher probabilities assigned to the negative extremes. In the last period this pattern becomes quite significant together with a substantial decline in mean and median. Hence, it can be concluded that the climate change will both decrease the mean of the yields and increase the risk of extreme events causing significant decline in yields.



Source: Author's Calculations

Figure 2.4: Distribution of yield shocks

The spatial patterns of yield and irrigation requirement changes are given in Figure 2.5 for the periods 2010-2035, 2035-2060 and 2060-2099 and the corresponding kernel density graphs can be found in Figure B.1 of Appendix B. The spatial variation of the effects is also significant. In the Western regions, yields increase and irrigation requirements decline in the first period. That is, western regions are generally better off during the first period. In the central regions, the change in yields is generally small with lower irrigation requirements. The eastern parts, on the other hand, are likely to experience an increasing water requirement and slight declines in the yields starting from the first period.



Source: Author's Calculations

Figure 2.5: Spatial effects of climate change

In coastal zones, central regions and eastern parts of the country, the effects of climate change differ significantly in the second period. In the coastal regions, yield changes are not significant, except in the Thrace, and irrigation requirements increase slightly. Eastern parts of the country become slightly worse off with lower yields and higher irrigation requirements. However, Central regions are heavily affected from of climate change. Average yield loss exceeds 10 percent for some provinces, while decreasing trend in irrigation water requirements in the first period is completely reversed.

The difference in the effects of climate change becomes significant in the north-south axis, rather than the east-west axis. Furthermore, although the changes in yields and irrigation requirements follow approximately the same spatial pattern in the first two periods, they follow completely different patterns in the third period. The provinces that suffer from high yield loss form a belt like shape starting from Thrace, extending through the northern parts of the central regions and ending in the central parts of the eastern regions. The increase in the irrigation requirement is higher in the Northern regions, especially in the central regions and Thrace.

Our results support the findings of the other studies in the literature, both at the national and global level. The effects become more significant after 2060s. Furthermore, the effects are significant for all periods in some regions. Results also show that the variation in yields is higher than the variation in climatic conditions. This suggests that agricultural production is more prone to climatic changes and risks related to it. Lastly, as predicted by many studies the technical conditions become more favorable for agricultural production at the early stages of climate change when the increase in the mean temperature is below 2°C.

2.2.2 Regional CGE model

The Walrasian CGE model developed in this chapter disaggregates the economy into seven activities producing commodities for seven sectors in each of the 12 NUTS-1 regions. The activities are agriculture, food production, textiles, other manufacturing, energy, public services and private services. The production structure of the activities is presented in Figure 2.6. We use a three level nested production function which aggregates different factors and inputs at different levels.

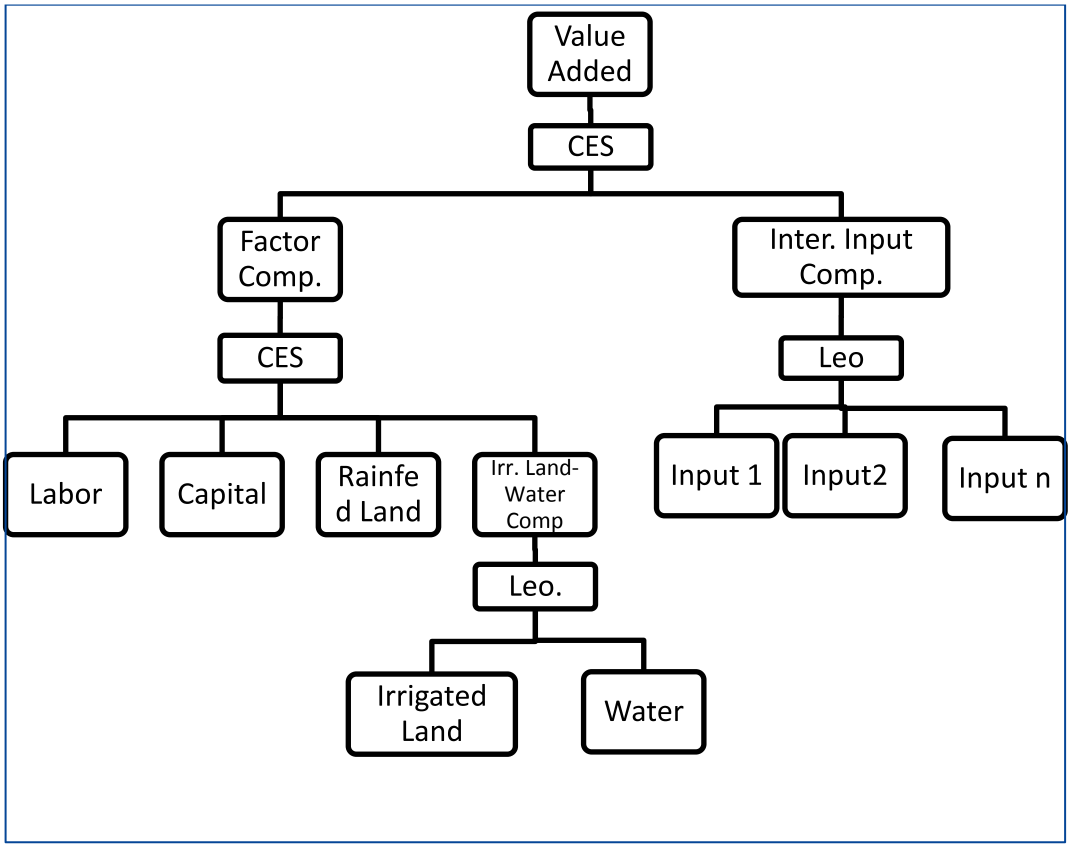


Figure 2.6: Production structure of the model

Water is introduced as a factor of production as a perfect complement to the irrigated land. Hence we introduced a Leontief nest to the production function. The composite factor that is produced at this nest enters into a CES production function with other factors. Finally this second composite value added is introduced into a new CES nest with a composite intermediate input. The composite intermediate input is produced by a Leontief nest. Since water and irrigated land are perfect complements, the price of the water-land composite is a weighted sum of prices of water and irrigated land and the weights are the Leontief coefficients.

Only agriculture use irrigated and rainfed land in production. Hence there is no additional Leontief nest of water-land composite for the other sectors. However water is employed by all sectors. Water enters directly into value added nest with labor and capital.

There is only one type of household in each region. Income generated by factors in a region is distributed to the household in the same region. Households receive income from labor, land and water, while capital income goes to firms. From this income, firms pay institutional taxes, make transfers to the rest of the world, and distribute the remainder to households together with the transfers from the government. Households use their income for consumption, leisure, savings and taxes. Households maximize a Linear Expenditure System (LES) utility function to make consumption decision. Leisure enters the utility function like any other commodity, while the wage income is included as a budget constraint. The utility maximization problem is:

$$\max U_{r,h} = \beta_0 \ln\left(L_{r,h} - \gamma_{0,r,h}\right) + \sum_{i=1}^{k} \beta_{r,i} \ln\left(QH_{i,r,h} - \gamma_{i,r,h}\right)$$
$$s.t. \ \sum_{i=1}^{k} P_{r,i} QH_{r,i} + w_{r,h} L_{r,h} = EH_{r,h} + w_{r,h} L_{r,h} = w_{r,h} T_{r,h} + YNL_{r,h} = Y_{r,h} \tag{2.4}$$

where the indice i denotes commodities, r denotes regions and h denotes the households. $QH_{i,r,h}$ is household demand for commodity i, $QFS_{r,h}$ is labor supply, $U_{r,h}$ is unemployment, $L_{r,h}$ is leisure, $P_{r,i}$ is commodity prices, $w_{r,h}$ is wage rate of labor, $EH_{r,h}$ is total consumption spending of the households, $T_{r,h}$ is the total number of working age individuals in a household. $YNL_{r,h}$ is non-labor income, $Y_{r,h}$ is total income. The above formulation suggests that households decide how many people should work to earn wages and how many of them are reserved for leisure. Unemployment is determined in the labor market as the difference between labor supply and labor demand. We assume that households neither receive leisure nor wages for unemployed people.

The analytical solution of this problem yields the following demand functions:

$$QH_{i,r,h} = \gamma_{i,r,h} + \frac{\beta_{i,r,h}}{\left(1-\beta_{0,r,h}\right) P_{r,i}} \left(EH_{r,h} - \sum_{i=1}^{k} P_{i,r} \gamma_{i,r,h} \right) \tag{2.5}$$

$$QFS_{r,h} - U_{r,h} = T_{r,h} - \gamma_{0,r,h} - \frac{\beta_{0,r,h}}{\left(1-\beta_{0,r,h}\right) w_{r,h}} \left(EH_{r,h} - \sum_{i=1}^{k} P_{r,i} \gamma_{i,r,h} \right) \tag{2.6}$$

In the above equations, $T_{r,h} - \gamma_{0,r,h}$ is the total working-age population and it is not adjusted for wages since household cannot control the total population $T_{r,h}$ or the parameter $\gamma_{0,r,h}$. Hence, following Thurlow (2008), we introduce the following "rule of motion" for total available working-age population:

$$\frac{T_{r,h,t} - \gamma_{0,r,h,t}}{T_{r,h,b} - \gamma_{0,r,h,b}} = \left(\frac{wfr_{r,t} / cpi_t}{wfr_b / cpi_b} \right)^{\eta} \tag{2.7}$$

where the *t* denotes a post-simulation values and *b* denotes the base run values, *wfr* is wage rate and *cpi* is the consumer price index. Accordingly, an increase in real wage rate increases the total available working age population, and vice versa.

Government receives tax income from activities, commodities, firms and households as well as transfers from the rest of the world. This income is used for government consumption, transfers to households and firms, government savings and transfers to the rest of the world.

Production activities make payments to commodity accounts for intermediate inputs, to factors such as wage payments and to government as net taxes. They receive payments from commodity accounts in exchange for supply of goods and services. Commodity accounts also make payments to the rest of the world for imports and to government for indirect taxes. They receive payments from households for consumption of goods and from the rest of the world for exports.

Model closure rules follow conventional neoclassical assumptions. Since simulations are designed to account for the long run climate change effects, it is assumed that the price of capital and land is fixed while their supply and demand adjust to the new equilibrium. Water is assumed to be fully employed and mobile among activities within a region and its supply is fixed. Demand for water adjusts to the new equilibrium. Consumer price index is the numéraire and hence is fixed while domestic producer price index adjusts to clean the markets. We use a balanced closure rule for saving-investment market. Investment is a fixed share of absorption and marginal propensity to save is scaled to equalize savings and investments. Exchange rate is fixed by allowing foreign savings to adjust to keep the current account at balance. The share of government demand in total absorption is also fixed. Lastly, government savings are fixed, while direct tax rates are flexible and are scaled for households and firms to sustain the balance of government accounts. Further discussion of closure rules can be found in Lofgren, Harris, & Robinson (2003).

2.3 Description of Data and Simulations

The aggregate version of the SAM (Social Accounting Matrix) used in the analysis follows from Yiğiteli (2010) who presents a national SAM of the Turkish Economy for the year 2008. The SAM developed by Yiğiteli (2010) consists of 49 production activities which produce 49 commodities using formal and informal labor, land and capital. It has five household types differentiated according to income groups. We used various data sources to regionalize the 2008 National SAM into 12 NUTS-1 regions.

The I/O table used in this model is a regionalized version of 2002 I/O table that is published by TurkSTAT (2011a). Augmented Flegg Location Quotients method (Flegg & Webber, 2000) is used to regionalize the 2002 National I/O table by using regional data on employment. The latest regional employment data available for all sectors of the model is for 2002. Hence the shares of each region in each sector are used to interpolate 2008 employment figures across regions. These employment figures are in turn used in AFLQ formula as described in Flegg & Webber (2000):

$$AFLQ_{i,j}^{R}=\begin{cases}\dfrac{E_i^R/E_j^R}{E_i^N/E_j^N}\log_2\left(1+\dfrac{\sum_i E_i^R}{\sum_i E_i^N}\right)^{\delta}\log_2\left(1+\dfrac{E_j^R/\sum_j E_j^R}{E_j^N/\sum_j E_j^N}\right) & if\ \dfrac{E_i^R/\sum_i E_i^R}{E_i^N/\sum_i E_i^N}>1\\ \dfrac{E_i^R/E_j^R}{E_i^N/E_j^N}\log_2\left(1+\dfrac{\sum_i E_i^R}{\sum_i E_i^N}\right)^{\delta} & if\ \dfrac{E_i^R/\sum_i E_i^R}{E_i^N/\sum_i E_i^N}\leq 1\end{cases} \tag{2.8}$$

where E_i^R is employment in sector *i* of region *R*, and E_i^N is national employment in sector *I*, while δ is a constant assumed to be 0.3 following Flegg & Webber (2000). a_{ij}^R that denotes the element of I/O table in *i*th row and *j*th column, is calculated as:

$$a_{i,j}^R = a_{i,j}^N.AFLQ_{i,j}^R \tag{2.9}$$

where a_{ij}^N is the national I/O share.

After calculating new regional I/O shares further adjustments are made in the SAM. Firstly, the regional coefficients do not necessarily add-up to one for an activity in a region, that makes I/O table imbalanced. To keep the balance of I/O columns, it is assumed that the deficiency (or excess) in the row sum of regional I/O table is due to the missing intermediate input trade among regions. Hence intermediate input trade among regions that make I/O table consistent is calculated by assuming that the intermediate input flow from one (exporting) region to another (importing) region is proportional with the share of exporting region in national production. Secondly, the row sums of I/O table do not necessarily add up to regional production figures. Hence regional production figures are adjusted according to new I/O table. The imbalance in the commodity accounts, which is caused by this operation, is in turn balanced by introducing inter-regional trade.

Interregional trade is the key economic link among regions. Since the data on interregional trade is scanty, it is calculated for the purpose of this analysis. The discrepancy between the production and consumption of a region needs to be supplied by other regions to keep the SAM balanced. In doing so, it is assumed that every region's supply of commodities to the other regions is proportional to the former's share in the national production. That is to say, differences in transportation costs among different regions are ignored. Regions where production exceeds consumption are assumed to consume only their own products and export the remainder to other regions. For importing regions, the imported amount is subtracted from the region's production to keep the balance between consumption and production. In other words, we assume that interregional trade is done among producers of exporting and importing region and wholesalers of importing region. Hence value added produced in a region also includes the value of commodities obtained by trade. A better alternative would have been introducing interregional trade through households but due to lack of data this option is not viable for the current model.[2]

The need for intermediate input and commodity trade among regions can be elucidated with an example. Istanbul, namely TR1, is characterized by high industrial employment and production with small agricultural employment and production. However, the consumption of agricultural products is significantly higher than the production in Istanbul due to the population size. It is impossible to satisfy the consumption in Istanbul with its own production. Hence, the discrepancy in regional supply and demand is assumed to be supplied by other regions, according to the share of the latter in national production. That is, a region with higher agricultural production supplies more agricultural commodities to Istanbul.

The need for interregional trade in intermediate goods can also be explained in the context of agricultural production in Istanbul. Istanbul has a high share in

[2] This interregional trade is neutral in the sense that, we do not introduce any behavioral assumption for wholesalers. They only transport the goods of the importing sector to the suppliers of exporting sectors and there is no transaction cost in the process. Further, we also assume that the commodities from different regions are perfectly substitutable.

manufacturing production and hence an important part of agricultural inputs is produced in Istanbul. However, since Istanbul produces small amounts of agricultural products either the intermediate input use of agricultural sector in Istanbul needs to be unrealistically high or some of the intermediate inputs need to be exported to the other regions. The distribution among regions is again proportional to the production of the exporting region. By following this logic we create a bilateral intermediate input and commodity trade matrix.

The value added for water is calculated from the rent differentials obtained from the Quantitative Household Survey (QHS) held by the G&G Consulting et al. (2005). Data for the 1,356 farm households are used to calculate the rent for irrigated and rainfed land at NUTS-1 level. Average rental rate per ha. in 2004 is projected to 2008 by assuming that the change in rent would be same as the change in wholesale price index for agricultural sector which is approximately 32 percent between 2004 and 2008. The difference between the rental rate of irrigated land and rainfed land was attributed to the irrigation, and hence that difference was used as the price of water. The value added of water in agricultural sector is calculated by multiplying the rent difference with the area of irrigated land. The payments from other sectors to water factors are calculated from TurkSTAT Municipality Water Statistics (TurkStat, 2011a).

Regional employment shares for each sector are obtained from the Annual Industry and Services Statistics (TurkStat, 2011b). Then, national employment figures reported in Regional Household Labor Force Statistics (TurkStat, 2011c) for each sector are distributed to the regions by using these shares. Total working-age population is based on the number of people between 14 and 65 years of age. Regional unemployment figures are also obtained from the Regional Household Labor Force Statistics (TurkStat, 2011c).

The regional disaggregation of the trade figures was done by using TurkStat’s Regional Foreign Trade database for 2008 (TurkStat, 2010c). Agriculture, energy, manufacturing and services are disaggregated directly by using the shares of regions in the trade of these sectors. Regional trade data for food and textiles are not available. Hence trade figures of regions are adjusted by taking into account the region’s share in the national production of the relevant sector and region's share in the trade of manufacturing. The formula used is as follows:

$$v_R = \frac{\dfrac{X_{Q\in R}}{\sum_R X_R} \dfrac{Y_{Q\in R}}{\sum_R Y_R}}{\sum_S \dfrac{X_{S\subset R}}{\sum_R X_R} \dfrac{Y_{S\subset R}}{\sum_R Y_R}} \qquad (2.10)$$

where v_R is the regional share, X is a region’s production in the sector and Y is volume of the region’s trade in manufacturing. Shares that are less than one percent are ignored. For imports, region’s share in manufacturing trade is directly used for adjustment.

Yiğiteli (2010) assumed a constant rate of tariff for all commodities. Tariffs are recalculated from the average applied tariff rates at HS6 level for 2008 (Ministry of Customs and Trade, 2011).

Consumption is disaggregated according to TurkStat (2010b) which reports distribution of household consumption according to regions and income quintiles. Households are not allowed to consume commodities from other regions. Government consumption is distributed according to the 2008 Public Accounts Bulletin (General Directorate of Public Accounts, 2010a). Government consumption in each sector is distributed according to the region's share in total government expenditures on goods and services purchases. Transfers are also distributed according to 2008 Public Accounts Bulletin (General Directorate of Public Accounts, 2010b). On the other hand, investments in different sectors are distributed according to region's share in value added.

Factor incomes are distributed according to the regions' shares in factor value added. However since capital income is distributed to the regional firms, an adjustment is made in the capital account to keep the balance of SAM intact. Firm income is then distributed to households as rent income, government as taxes and rest of the world as transfers abroad. The imbalance in the firm account is balanced by increasing the government transfers to the firm. Since this difference is generally small, the balancing procedure is not likely to affect the model results.

Profit transfers to abroad and workers' remittances from the rest of the world are distributed according to the regions' shares in the national capital income[3]. The number of people receiving pensions per region, as reported by Social Security Institution Yearbook 2008 (Social Security Institution, 2010) is used to distribute the transfers from SSI to households. Other transfers from government to households are distributed according to each region's share in the total transfers as reported in the Social Assistance and Solidarity Fund (2010). Government savings and payments to ROW made by government, as well as tax incomes of government are not distributed since these accounts are national. Tax payments of domestic institutions are distributed according to data reported by General Directorate of Public Accounts (2010a). Regions' shares are calculated using accrued tax amounts.

Some minor adjustments are done in the SAM to eliminate very small trade figures that appear in the energy trade of the North Western and Central Regions as well as food trade of the Eastern regions. Small exports are added to the S-I account. Import taxes are deducted from S-I account. A similar adjustment is done for interregional trade. Accordingly, small interregional trade is eliminated by moving these figures to the production of consuming regions. Then the difference is added to the S-I account. The sum of moved figures are added to the government savings accounts and discounted from the transfers made to the government from the rest of the

[3] The method of distribution of remittances from abroad does not have a significant effect on the model, since the share of remittances in household income is only about 0.2 percent.

world. I/O table is also adjusted for small figures. Small figures flowing from agriculture to energy and to private and public service commodities are added to the labor value added. The increase in the income generated by the labor is distributed to households. Then the household consumption is increased respectively to balance the commodity accounts.

The climate change scenario is simulated by simultaneously shocking the average yield and irrigation water requirements at NUTS-1 level. One important caveat about simulations is that they are static experiments derived from annual changes and hence the results lack any dynamic feedback effects.

2.4 Results and Discussion

Simulation results suggest that the effects of climate change on economy will be quite significant[4]. Table 2.1 shows the effect of climate change on main macroeconomic variables. Welfare indicators such as absorption and household consumption do not change significantly in the first period, but worsen in the second and third periods. The change in the second period is likely to be caused by the years with extreme conditions, while the changes in the third period are due to decline in the average technical conditions of agriculture. Although the maximum values are close to the first period, the minimum values are significantly lower. This implies that the effects of climate change in the second period may be essentially attributed to the "bad" years due to extreme climatic events, which in turn affect the economy adversely. In the third period, the negative effects become considerably higher, with vast declines in maximum values and relatively small declines in minimum values. This suggests that in the third period, the effects of climate

[4] We run statistical tests to see if the mean and variance of the total production differs across the periods. Difference between the average changes in the production value of all sectors among periods is statistically significant at 5 percent significance level.

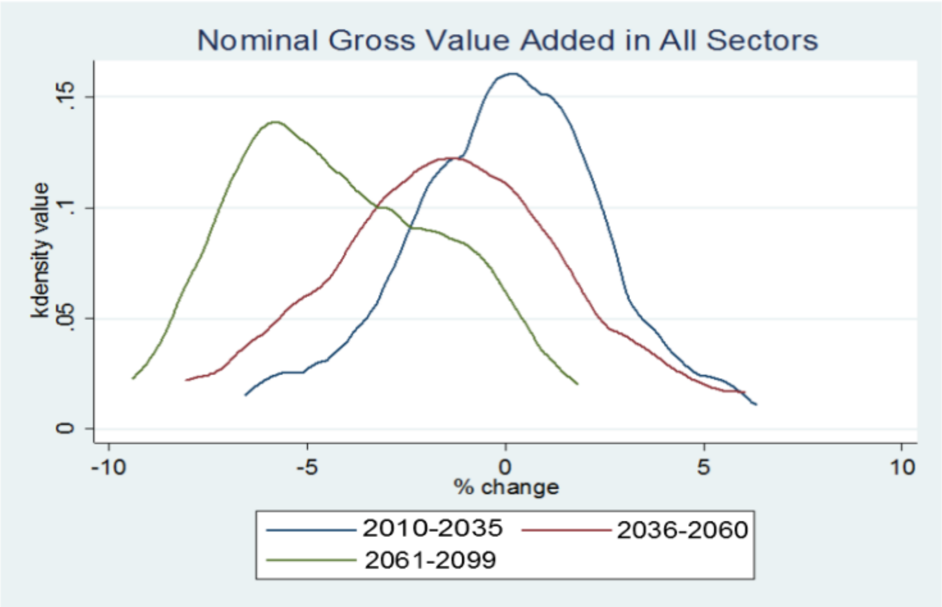
change will not only be felt through the extreme events but the average conditions will also worsen. The effect on the foreign savings and the ratio of other macro indicators to the GDP is insignificant. This implies that the change in these indicators is parallel to the change in GDP.

Table 2.1: Effects on selected aggregate variables (base values at billion TL)

		Base Level	Percentage Change								
			2010-2035			2036-2060			2061-2099		
		Billion TL.	Min.	Avg.	Max	Min.	Avg.	Max	Min.	Avg.	Max
Real	GDP	843.6	-6.46	0.10	5.96	-8.02	-1.39	5.99	-9.72	-3.99	1.70
	Absorption	996.4	-6.13	0.08	5.56	-7.61	-1.33	5.60	-9.25	-3.78	1.57
	Household Cons.	688.9	-6.59	0.09	5.98	-8.20	-1.43	6.00	-9.96	-4.06	1.70
	Export	227.2	-6.14	0.08	5.89	-7.66	-1.39	5.86	-9.20	-3.83	1.57
	Import	269.3	-5.18	0.07	4.97	-6.46	-1.17	4.94	-7.76	-3.23	1.32
	Real Exch. Rate	100	-0.28	0.01	0.28	-0.37	-0.08	0.29	-0.40	-0.18	0.10
	Dom. Price Ind.	100	-2.54	-0.01	2.11	-3.19	-0.57	2.17	-3.92	-1.59	0.48
Ratio to GDP	Investment	22.23	-0.03	0.00	0.04	-0.03	0.01	0.05	-0.01	0.02	0.06
	Private Saving	15.08	-0.31	0.00	0.27	-0.39	-0.07	0.26	-0.49	-0.19	0.08
	Foreign Saving	5.24	-0.19	0.00	0.22	-0.19	0.05	0.27	-0.06	0.13	0.33
	Trade Deficit	6.62	-0.16	0.00	0.19	-0.16	0.04	0.24	-0.06	0.11	0.30
	Gov. Saving	1.91	-0.11	0.00	0.14	-0.11	0.03	0.17	-0.03	0.08	0.21

Source: Author's calculations

The risk associated with the climate change is illustrated by the spread of change in GDP over three periods in Figure 2.7. Risk is relatively low with a mean and median around zero and higher probabilities assigned to relatively small changes in the first period. Hence the probability of observing a positive growth is high. In the second period, although the mean and median of the distribution do not change considerably, the probability assigned to the tails increases. Thus the probability of observing a negative change increases substantially. Finally, in the third period, the mean and median shift to -5 percent while the spread increases. Hence, in the third period the probability of observing a positive change in GDP is very small. Consequently, climate change does not only decrease the average growth rate but also increase the frequency of extreme events. This has quite significant implications for the climate policy. Adaptation under these circumstances implies reducing the adverse effects not only in the average but especially in negative extreme years. Hence this fact should be taken into account when making the cost benefit analysis for adaptation.



Source: Author's calculations

Figure 2.7: Distribution of nominal gross value added

Table 2.2 shows the change in household income. The average change in the household income is small for the first period while it becomes significant in the following periods. The difference between the average values gets wider in the second and third period. Furthermore, the maximum and minimum values of the change in the household income differ significantly across regions. Accordingly, incomes of the households in the western and central regions are more sensitive to the extreme climatic conditions. This is mainly due to significant decline in the prices of the factors that are more often employed by these regions, since the prices of capital and land are fixed and the share of water in the total income is quite small, the changes in household income are mainly driven by wages. The change in wages is in turn driven by the ability of firms to substitute water with labor in the non-agricultural sectors and with water-land composite in agriculture. Accordingly, the substitution is limited in Thrace, central Anatolia and eastern regions due to the low water use in the base year. These regions benefit from the increase in the water price since income generated by water goes to households. This brings about an important feedback effect. The increase in the demand for water will drive the price of water up and this will compensate the loss in household welfare due to decreasing wages in the mentioned regions.

Table 2.2: Household income according to regions (base values at billion TL)

	Base Level	Percentage Change								
		2010-2035			2036-2060			2061-2100		
	million TL.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
TR1	212,394	-11.13	0.13	10.44	-13.80	-2.50	10.45	-16.49	-6.90	2.67
TR2	41,916	-3.94	-0.14	4.21	-2.20	0.09	2.04	-3.95	-0.04	2.66
TR3	117,556	-7.71	-0.15	6.58	-9.65	-1.87	7.36	-11.60	-4.98	1.36
TR4	87,828	-7.86	0.10	7.25	-9.82	-1.71	7.39	-11.81	-4.92	1.73
TR5	89,146	-8.28	0.09	7.64	-10.32	-1.81	7.73	-12.52	-5.16	1.78
TR6	100,333	-5.74	0.10	5.35	-7.17	-1.18	5.54	-8.88	-3.61	1.30
TR7	38,343	-2.35	0.15	3.63	-2.32	0.17	2.81	-3.38	-0.45	1.45
TR8	46,688	-4.32	0.06	3.93	-4.70	-0.98	3.07	-5.57	-2.30	2.77
TR9	29,798	-2.80	0.05	2.82	-3.72	-0.80	2.26	-4.45	-1.92	0.19
TRA	21,083	-2.37	0.75	5.55	-3.46	0.69	5.44	-3.53	2.17	7.93
TRB	35,165	-1.02	0.88	3.41	-2.49	1.54	3.78	-1.10	2.94	6.05
TRC	70,180	-1.35	0.00	1.03	-1.43	-0.22	1.10	-2.01	-0.80	0.81
Turkey	890,431	-6.18	0.10	5.73	-7.66	-1.33	5.76	-9.28	-3.81	1.61

Source: Author's calculations

Climate change affects all sectors significantly, although the shocks are introduced only to the agriculture. This is a result of complex interactions among the sectors. The significant change in food production can be explained by the fact that agricultural commodities are important intermediate inputs for this sector. However, this is not the only linkage between the sectors. All sectors compete for factors and hence a change in the factor demand in one sector affects all sectors. Secondly, the sectors also interact in the commodity markets. Since all commodities are substitutable in household demand, a change in the price of one commodity affects the demand for other commodities as well. Table 2.3 reports the state of commodity and factor markets. Details for the rest of the sectors can be found in Appendix Table B.1. The average changes in the markets are not significant for the first period. There is a slight increase in production and consumption of all commodities while prices remain almost constant. The most important changes in international trade are observed in agriculture, food and textile trade. Agricultural trade increases significantly due to the increase in exports. Despite the slight increase in imports, the trade balance improves.

Food and textile sectors follow the same trend where exports increase more than imports. Imports and exports in the other sectors do not change significantly. The second significant effect in the first period is on water and irrigated land markets. Declining water requirement causes the price of water to decline and this, together with the increasing productivity of agriculture, drives the demand of irrigated land upwards.

The effects are reversed and become significant in the second and third periods. All sectors suffer from a serious fall in production. The decline is higher in agriculture. Consumption of all commodities also falls. For agriculture and food sectors, decreasing household incomes and increasing domestic prices underlie the decline in consumption. That is to say, income and substitution effects work in the same direction for these sectors. For the rest of the sectors, income and substitution effects work in the opposite direction. Declining household incomes decreases the consumption while declining relative prices increases it. Consequently, the decline in consumption is milder in non-agri-food sectors while it is higher for agriculture.

Table 2.3: Sectoral results

			Base Level[a]	Percentage Change		
				2008-2035	2036-2060	2061-2099
Agriculture	Market	Prod.	107,560	0.36	-1.69	-5.12
		Cons.	64,939	0.19	-1.15	-3.31
		Prices	1.00	-0.07	2.58	7.30
	Employment	Labor	5,018	0.08	1.54	4.52
		Irr. Land	5,261	0.78	-3.96	-13.92
		Rf. Land	16,708	0.21	1.40	3.49
		Capital	55,017	0.03	1.20	3.23
		Water	1,935	0.00	0.00	0.00
	Wage	Labor	7.68	0.00	-0.45	-1.69
		Irr. Land	0.28	1.24	0.96	0.47
		R. Land	0.33	-0.32	-0.71	-1.23
		Capital	1.09	0.00	0.00	0.00
		Water	1.00	-1.56	8.04	26.63
	Trade	Import	9,117	0.02	5.86	15.60
		Export	5,759	3.53	-5.76	-19.80
		Deficit	-3,358	-6.00	25.78	76.32
Food Production	Market	Prod.	30,330	0.11	-1.14	-3.32
		Cons.	92,422	0.08	-0.71	-2.12
		Prices	1.00	-0.06	0.64	2.05
	Employment	Labor	687	0.04	-0.55	-1.66
		Capital	21,218	0.14	-1.37	-3.99
		Water	131	0.03	0.15	0.40
	Wage	Labor	13.07	0.11	-1.11	-3.13
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.17	-1.98	-5.74
	Trade	Import	5,416	0.04	1.40	3.74
		Export	9,310	0.41	-3.89	-10.97
		Deficit	3,893	0.94	-11.25	-31.43
Total Non-Agri-food	Market	Prod.	705,713	0.06	-1.36	-3.85
		Cons.	665,690	0.06	-1.36	-3.85
		Prices	1.00	0.01	-0.51	-1.41
	Employment	Labor	15,494	0.02	-0.65	-1.87
		Capital	428,803	0.11	-1.76	-5.00
		Water	3,775	0.00	-0.01	-0.01
	Wage	Labor	17.63	0.09	-1.41	-3.94
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.16	-2.22	-6.35
	Trade	Import	275,867	0.09	-2.06	-5.69
		Export	212,184	0.00	-1.80	-4.87
		Deficit	-63,682	0.40	-2.95	-8.43

Note: [a] Production and consumption figures and quantity of water are in value added units, i.e. units that make base prices 1. Labor is in thousand persons. Rest of the base values are in million TL

Source: Author's calculations

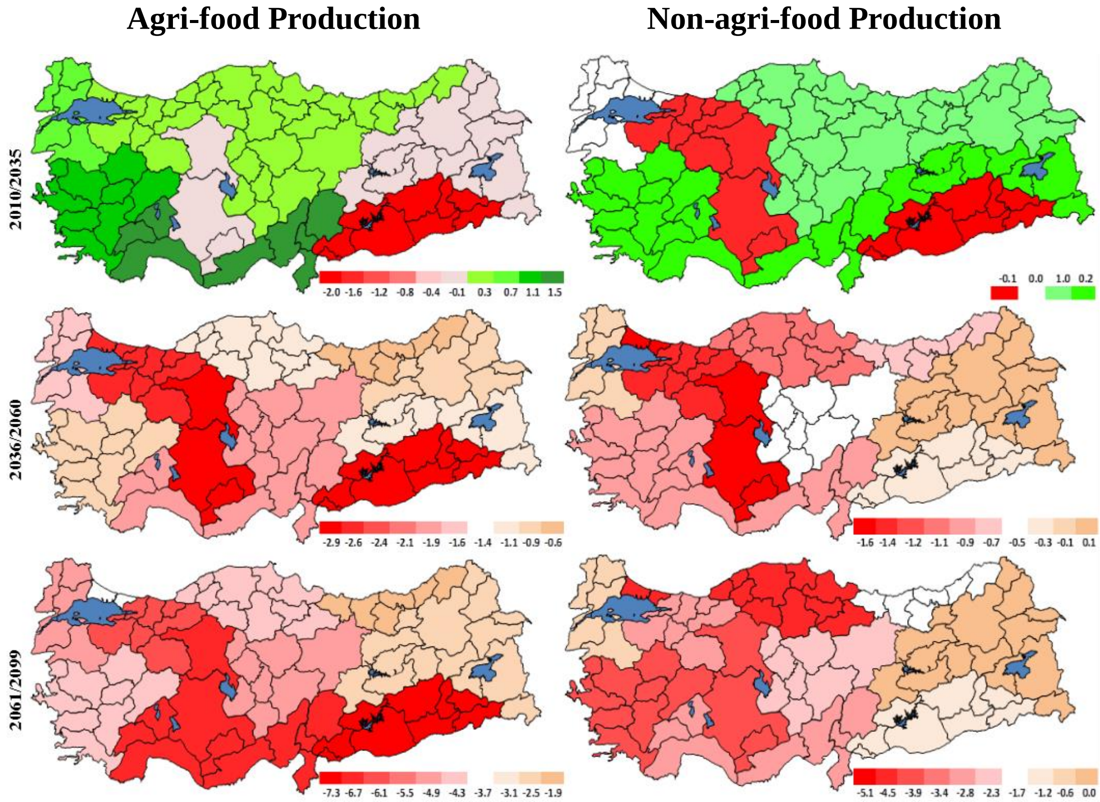
Agricultural and food prices increase while prices in the other sectors decline in second and third periods. Price changes get higher in absolute value throughout the periods. The increases in agricultural and food prices are supply driven. Agricultural production falls due to the decline in productivity of agriculture which decreases supply of agricultural products and drives agricultural prices up. This causes a negative supply shock in food production for which agricultural products are important intermediate inputs. Consequently, food prices also increase. Since all prices are relative to consumer price index, price of other commodities decline.

Effects on factor markets occur mainly through the price of water and employment of irrigated land for agriculture, in the last two periods. For the other sectors, capital plays a more significant role. Increase in irrigation requirement causes a boost in the demand and the price of water since its supply is fixed. Consequently, farmers decrease their demand for irrigated land which is perfect complement with water. Other factors are mobilized towards agriculture to compensate the decreasing TFP and water productivity. Hence, capital, rainfed land and labor employment in agriculture increase. In the rest of the sectors, there is significant decline in the use of capital and employment. Prices of labor and capital also fall since firms lay off labor due to decreasing production. Some of this labor is absorbed by agriculture with lower wages.

In the last two periods, trade is affected significantly by climate change. As production falls, imports increase and exports decline in both the agricultural and food sectors. For the rest of the sectors, both imports and exports decline despite the falling prices. These changes are driven by income and substitution effects among imported and domestic good. For agriculture and food products, income and substitution effects work in opposite direction: Since imports become relatively cheaper, demand for imported goods is favored by substitution effect while falling household income decreases it. For the rest of the sectors, since prices decline both effects work in the same direction: Domestic goods become cheaper and substitute imported goods while declining income of households further reduces demand for imports. Trade deficit deteriorates in all sectors except manufacturing. This means, the decline in imports is proportionally smaller than the decline in exports for the non-agri-food sectors. Total trade deficit increases since manufacturing is the main trading sector with 80 percent share in imports and 60 percent share in exports.

Figure 2.8 shows the spatial distribution of value added for agri-food sectors and other sectors. Although the effects in the first period are small for all sectors, there are some regional disparities. Agricultural production increases in the Mediterranean and Aegean regions, while it declines in Southeastern Anatolia. In the second period, west central regions and southeastern regions are amongst the most affected. The Mediterranean region is relatively worse off although effects are magnified for all regions in the third period. In the eastern regions, change in agricultural production is generally smaller, except for the Southeast Anatolia. In both periods, regions which are more dependent on irrigation are affected more. Thus, increase in irrigation water requirement is as important as the decline in yields in determining the final effect on agricultural production.

Effects on the production of non- agri-food sectors are determined by the strength of the link between agriculture and other sectors. The west central regions are affected significantly in the second period. In northwestern and eastern regions, the effects are slightly positive due to the weak forward linkages of agriculture with the non- agri-food sectors. In coastal regions, the decline in production of non- agri-food sectors is generally higher in the third period, except in the eastern Black Sea region. In Aegean region non-agri-food production declines quite significantly although the change in agricultural production is significantly milder. This suggests that, non-agri-food sectors in the coastal regions can substitute agricultural inputs with other inputs up to a threshold, but once this threshold is exceeded, non-agri-food sectors become more vulnerable to climate change. The effects on the manufacturing and services sectors in the eastern regions are relatively small in both the second and third periods. This is mainly due to the weak link between agriculture and the rest of the economy in these regions.



Source: Author’s Calculations

Figure 2.8: Regional production in value added units.

2.5 Conclusion

Turkey consists of regions that are quite diverse in terms of social and geographical structures. This is also reflected in the economy in the form of different consumption and production patterns. Distinct regional structures bring about a complicated network of economic relationships. In order to develop a solid understanding of plausible effects of climate change on the Turkish economy, one needs to take into account the interaction between different regional structures.

A CGE model that incorporates the regional diversity is used to discover the impact of climate change shock. Climate change is introduced in the form of changing agricultural productivity and irrigation requirements. A crop water requirement model is used to estimate these effects for the years 2010-2099. The estimated values of changes in the climatic conditions were obtained from a regionalized global climate model. The results of the climate model suggest that the effects of climate change will become significant after 2035. The average climate conditions in the period between 2035 and 2060 will get worse, mainly due to increasing frequency of "bad" years and higher irrigation requirements. On the other hand, the negative impact after 2060 will be caused mainly by deteriorating average conditions together with the increasing frequency of climatic extremes.

The effects of climate change on the economy will be witnessed through drastic changes both in agricultural production and in the relative prices of commodities. Production of agricultural and food commodities are severely affected by the shock, accompanied by considerable increase in their prices. Coastal regions are affected relatively less until 2060s, then they are significantly worse off afterwards. In all periods, the effects on the regions which use less irrigation water are milder. This suggests that the increase in irrigation requirements is as important as declining yields. A similar pattern is also observed in welfare indicators. Household in the eastern regions are affected less.

The volume of trade declines severely after 2035 and the trade balance deteriorates in all sectors, except manufacturing. As a result, the total trade deficit decreases. The need for agricultural and food imports become more severe and this may contribute in giving higher priority to food security in medium and long term policy design.

Results presented in this study are compatible with the findings of other studies at the national or global level. The economic effects are region specific. Hence, climate change adaptation policy needs to be region specific but should also consider the interaction among the regions. There are welfare gains in some regions and significant losses in others. Furthermore, the effects are also asymmetric among economic agents. As predicted by many studies, the effects become more significant after 2030s, especially in the form of increasing frequency of extreme events.

CHAPTER 3

CLIMATE CHANGE, AGRICULTURE AND TRADE LIBERALIZATION: A DYNAMIC CGE ANALYSIS FOR TURKEY

Things should be made as simple as possible, but not simpler.

Albert Einstein

In Chapter 2, we showed that the effects of climate change would be significant for Turkey especially after 2035. We will analyze the effects of trade liberalization in the form of tariff elimination as an adaptation measure to climate change in this Chapter. The model used in Chapter 2 is a static, multi-regional CGE model with only one aggregated agricultural sector. These simplifications are required to carry out the analysis at the regional level, but this framework may not be suitable to analyze the effects of trade liberalization. First, Turkey's foreign trade has a diversified structure with respect to its trading partners. Since the rest of the world is represented with a single aggregate trading partner, the tariffs are average tariffs implemented on all imports. However, trade liberalization analysis requires a finer representation of the trade structure. Secondly, an investigation of the interaction between climate change and trade liberalization requires the introduction of time dimension to observe the dynamics of the adjustments on the economy over time. Thirdly protection on the agricultural imports is not homogenous across different commodities. However, the tariff implemented on the aggregated agricultural sector in Chapter 2 is an overall average. Hence agricultural sector needs to be represented at a more disaggregated level, to capture the heterogeneity in protection. Lastly, although regional details are important for scrutinizing the effects of climate change, disaggregation of national accounts at regional level is not crucial in studying the effects of trade liberalization since the commodities produced in each region are perfect substitutes.

In this chapter, we develop a dynamic CGE model at the national level with disaggregated agricultural sector, and diversified rest of the world accounts. Then we simulate climate change and trade liberalization scenarios to evaluate the extent of trade liberalization to alleviate the adverse effects of climate change. The climate change scenario is a detailed version of the one used in Chapter 2. For the trade liberalization scenario we simulate the elimination of the tariffs imposed by Turkey on imports from EU27 countries.

World prices are likely to be affected by the climate change. However neither the sign nor the magnitude of the effect is known. In order to introduce the uncertainty about the world prices, we assume that world prices follow a normal distribution for which the mean and the variation are affected by climate change. We assume that under climate change, mean and variation of the distribution of world prices will increase reflecting the worsening average conditions and increasing climate risk. Then we use the stochastic series obtained from the simulation results to derive conclusions about the importance of the effect of climate change on world prices.

In the following section we present the structure of the dynamic model. The emphasis will be on the modifications done to the static model. A detailed description of the data used to modify the SAM will follow. Then the description of the simulated scenarios and a comprehensive discussion of the obtained results will be provided in Section 3.3. Finally, the last section will be reserved for the concluding remarks.

3.1 Description of the model

The model used in this study is an extended version of the CGE model presented in Chapter 2. The model considers production activities, households, firms, government and major trading partners of Turkey as the main economic agents and attempts to model the behaviors of these agents and their interactions in a well-established algebraic framework.

Every sector in the economy is represented with one activity that produces one commodity using labor, capital, rainfed land, irrigated land and water together with intermediate inputs supplied from the other sectors. The production function has a nested structure. The first nest is a Leontief type production function between irrigated land and water to reflect the complementarity between these two factors. The second level nest consists of two separate production functions. The first production function is a CES, and it transforms the water-irrigated land composite obtained from the first level nest and other factors of production to a composite factor. The second production function in the second nest is a Leontief production function that transforms intermediate inputs into a composite intermediate input. In the third level nest, the composite factor and composite intermediate input obtained from the second level nest are introduced to another CES production function to obtain the value added. A detailed description of the production structure can be found in Chapter 2.

The outputs of the production activities are supplied to the domestic markets as intermediate inputs, and final consumption goods as well as to the international markets as exports. Production activities pay taxes to and receive subsidies from the government.

The value added created by capital is paid to firms as income. Firms receive also transfers from the government and the rest of the world. This income is used to pay capital earnings to the households, institutional taxes to government and profit transfers to the trading partners.

Households receive directly the value added created by labor, land and water as income, while capital income is received by the firms. Households also receive transfers from the government and the rest of the world. Household income is used for consumption, to pay income taxes and to accumulate savings. Consumption is modeled with a linear expenditure system. Households receive utility from the part of the consumption that is above the subsistence level of consumption.

Leisure is also included in the utility function. We used the number of people who are in the work force but who are not looking for jobs as an indicator of leisure to overcome the calibration difficulties. People who are not in the workforce (students, housewives, retired people etc.) are taken as a proxy for the subsistence level of leisure. This approach can approximate the labor supply decision of the household, but labor force participation decision is still treated exogenously in the model, since it is impossible to endogenize the subsistence level of leisure in this framework. However, we define a "rule of motion" for the labor force participation. Labor force participation responses to changes in real wage. A detailed account of the implemented utility maximization framework can be found in Chapter 2.

Saving behavior of the household is determined by the closure rule. We assume an investment driven saving behavior at the macro level while the adjustments in absorption are spread to the all components uniformly. Hence, the share of investment in absorption is fixed; saving rates of the agents are uniformly scaled to finance the investment (Löfgren et al., 2002).

There is no behavioral assumption imposed on the government. Government collects taxes and receives transfers from the rest of the world. Government income is used for government consumption, savings, and to make transfer payments to domestic institutions and to the rest of the world. The share of government outlays in total absorption is constant. We assume that government savings are flexible while the tax rates are fixed.

Rest of the world account consists of five trading partners who supply imports and demand exports, pay and receive transfers, and invest in Turkey. Imports follow Armington specification while exports are modeled with a CET approach. Accordingly, imported commodities are not perfect substitutes of domestic alternatives and the relationship between demand for domestic and imported commodities is managed by the substitution elasticity. The share of export supply in domestic production is also managed by a constant elasticity of transformation function. Foreign savings are always equal to the difference between value of imports and exports to balance the current account. The share of transfers from and to domestic institutions in their income is constant. We assume that the foreign exchange rate for all trading partners is fixed while the foreign savings are free to adjust.

Following Thurlow (2004), the recursive dynamic process is introduced into the model through capital accumulation, productivity, population and labor force growth. The amounts of the aggregate and sectoral capital in the current period are given respectively by:

$$K_t = K_{t-1}\left(1+R_t\right) \tag{3.1}$$

$$k_{t,A} = k_{t-1,A}\left(1+r_{t,A}\right) \tag{3.2}$$

where $k_{t,A}$ denotes the amount of capital used in the activity A, while K_t is the amount of aggregate capital stock[5]. r_A is the annual growth rate of capital stock used in activity A, while R is the annual growth rate of the aggregate capital stock. The annual growth rates are calculated by

$$R_t = \frac{D_t}{K_t} - \Delta_t \tag{3.3}$$

$$r_{t,A} = \frac{d_{t,A}}{K_{t,A}} - \delta_{t,A} \tag{3.4}$$

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[5] t is the time index for all variables and parameters.

where D_t is the change in real aggregate capital stock, and $d_{t,A}$ is the change in real sectoral capital stock, while Δ_t and δ_t denote the corresponding depreciation rates. The change in aggregate capital is calculated as

$$D_t = \theta_{F,t} \frac{GFCF_t}{P_t} \tag{3.5}$$

where $\theta_{F,t}$ is the investment share of capital type F in the total investment. Since we have only one type of capital, θ_t is always 1. $GFCF_t$ is the gross fixed capital formation and P_t is the price of the aggregate capital. Gross fixed capital formation is simply the value of investment in the previous period.

$$GFCF_t = \sum_C PQ_{t-1,C} QINV_{t-1,C} \tag{3.6}$$

where $PQ_{t,C}$ is the price of commodity C, $QINV_{t,C}$ is the amount of good C used for investment. The price of the aggregate capital in Equation (5) is calculated as follows:

$$P_t = \sum_C PQ_{t,C} B_{t,C} \tag{3.7}$$

where $B_{t,c}$ are the shares of investment goods in the aggregate capital and is calculated as

$$B_{t,C} = \frac{QINV_{t,C}}{\sum_C QINV_{t,C}} \tag{3.8}$$

Lastly the sectoral capital stock is calculated by

$$D_{t,A} = \gamma_{t,A} D_t \tag{3.9}$$

where $\gamma_{t,A}$ is the investment share of the capital stock of activity A in an aggregate capital stock. $\gamma_{t,A}$ is calculated as follows:

$$\gamma_{t,A} = \frac{K_{t,A}}{\sum_A K_{t,A}} \left(1 + \beta_2 \left(\frac{W_{t,A}}{\bar{W}_t} - 1 \right) \right) \tag{3.10}$$

where β_2 is an exogenous constant that determines the mobility of capital across sectors, $W_{t,A}$ is the price of capital in sector A. $\bar{W}_t$ is the average price of capital and is calculated by

$$\bar{W}_t = \sum_A W_{t,A} \frac{K_{t,A}}{\sum_A K_{t,A}} \tag{3.11}$$

In other words, γ_A shows the share of investment in sector A adjusted for the differences in the price of capital. When the price of capital increases in a sector, a relatively higher portion of the gross fixed capital formation is devoted to that sector.

Productivity growth is introduced as an exogenous increase in the shift parameter of the top level CES production function, $\alpha_{t,A}$.

$$\alpha_{t,A} = \alpha_{t-1,A} \left(1 + \eta_{t,A} \right) \tag{3.12}$$

where $\eta_{t,A}$ is the total factor productivity growth.

Population growth causes changes in two parameters in the model, which also need to be considered: an increase in the subsistence level of consumption and an increase in the labor force. Subsistence level consumption growth is introduced as an exogenous shock to the subsistence level consumption parameter, μ_t.

$$\mu_t = \mu_{t-1}\left(1+\varepsilon_t\right) \tag{3.13}$$

where ε_t is the population growth rate. Growth in the labor force is also introduced as an exogenous change in the number of people participating in the labor force, denoted by L_t .

$$L_t = L_{t-1}\left(1+\lambda_t\right) \tag{3.14}$$

where λ_t is the labor force growth. It is necessary to distinguish between the labor force growth and population growth, since the former is generally lower than the latter. Note that the increase in labor force does not necessarily imply increasing labor force participation since labor force participation is determined by real wage.

3.2 Description of Data

The social accounting matrix (SAM) used in this Chapter involves making three modifications to the SAM used in Chapter 2. First, the SAM used in Chapter 2 is aggregated to the national level. Secondly, the agricultural sector of the SAM used in Chapter 2 is disaggregated into 13 sub-activities: wheat, maize, rice, other cereals, oilseeds, sugar beet, other field crops, fruits, vegetables, dairy, meat, livestock and other agricultural production. Thirdly, rest of the world account is disaggregated into five trading partners who supply imports and demand exports, make and receive transfers, and invest in Turkey. Non-agricultural sectors are kept intact. There are 4 manufacturing activities (food, textiles, energy and other manufacturing production) and 2 services (private and public services).

The disaggregation of the agricultural sector is accomplished using the 2008 production statistics (TurkSTAT, 2012a). We assumed that input-output (I/O) coefficients of all disaggregated activities are the same as the aggregate agriculture (TurkSTAT, 2012b). We then introduced some adjustments in the I/O table. Crop production activities use only their own commodities as intermediate inputs and no other crop products. Milk and meat production activities are linked only with livestock production activity which mainly consists of livestock raising. Livestock activity uses wheat, maize and sugar beet as feed. Agricultural activities do not use any textiles or public services commodities. To balance the I/O table for the agricultural activities, we increased the intermediate input use of food production activity from the agricultural activities. Hence a significant part of the intermediate input supply of agricultural activities is used by food production. Textiles production activities use inputs only from other cereals and other field crops. The energy sector receives input from sugar beet production to reflect the small amount of ethanol production in Turkey. Minor adjustments are done to balance the other sectors in the I/O table. The value added of land is calculated from irrigated and rainfed land rent data reported by G&G Consulting et al. (2005). The share of irrigated land in the total cultivated land is obtained from the agricultural master plans of 81 provinces (Ministry of Food Agriculture and Livestock, 2012). These shares are then used to find the total irrigated land at the national level. We assume that the share of irrigated and rainfed land is the same across different crops, since there is no data at the crop level for the use of irrigated land. However we used priori information for the use of irrigated and rainfed land by specific crops. For example, the production of rice and vegetable requires irrigated land. The value added for water is calculated from the rental difference between the rainfed and irrigated land at 12 NUTS-1 level from G&G Consulting et al. (2005) and aggregated to the national level by using irrigated land data.

Agricultural subsidies are introduced to the national SAM using the OECD data as negative activity taxes. Then capital value added account is adjusted accordingly. The results are presented in Table 3.1. According to OECD (2013) the highly supported activities are livestock, other field crops, wheat and dairy. Rice and vegetables do not receive any subsidies while support for meat, fruits and other cereals are quite low.

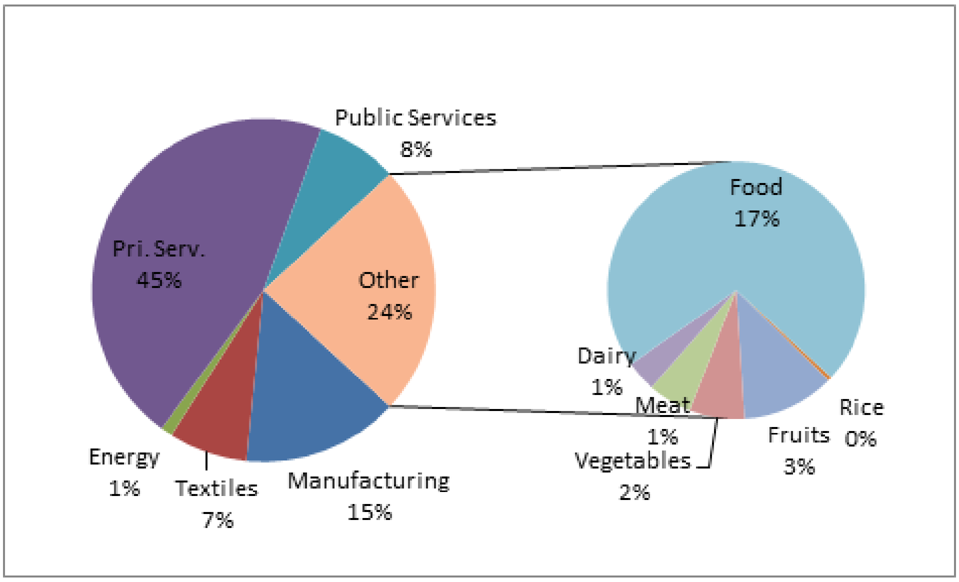
Table 3.1: Subsidies on agricultural activities (Thousand TL)

Activity	*Subsidy*	*Activity*	*Subsidy*
Wheat	673,138	Fruits	3,775
Maize	71,414	Vegetables	0
Rice	0	Dairy	310,252
Other Cereals	6,163	Meat	1,210
Oil Seeds	114,583	Livestock	853,277
Sugar Beet	16,722	Other Agriculture	49,027
Other field Crops	682,500		

Source: Authors' calculation from OECD (2011)

Households do not directly consume wheat, maize, other cereals, oilseeds, sugar beet, other field crops, livestock and other agricultural products. The outputs of these activities are used as intermediate inputs, mostly by the food production activity. Households, however, directly consume rice, fruits, vegetables and dairy products. We assume that 'government' does not consume any agricultural products. The resulting consumption pattern is given in Figure 3.1 with 'private services for the households' being the most important consumption item with a 45 percent share. Agri-food products constitute 24 percent of the total consumption; 17 percent of which is made up of processed food.

The ROW account is disaggregated into 5 trading partners: EU27, MENA, North America, Other Europe, and the Rest of the World. Imports are distributed across trading partners according to foreign trade statistics (TurkSTAT, 2012c). Minor adjustments in saving-investment account were necessary to balance the discrepancy in the trade accounts.



Source: Author's calculations from the SAM

Figure 3.1: Consumption pattern of households

Tariffs are recalculated according to the GTAP data. We made minor adjustments in the SAM since the reported amount of tariff revenue is lower than the revenue obtained when the GTAP tariff rates are implemented. The increase in tariff revenue is added to the government account while the same amount is discounted from the supply of commodities. The decline in supply is then balanced by reducing the capital value added and hence the capital income of firms is reduced. Transfers from the government to firms are then increased by the same amount to keep household income intact. Changes in capital and government transfers to firms are small relative to the initial levels of these accounts.

The tariff rates used in the model are given in Table 3.2. Although the Turkish protection against EU imports is low at the average, dairy products, meat and fruit imports are heavily taxed. High protection against the other regions is likely to favor EU products in case of trade liberalization. The main competitor of the EU27 countries in the Turkish imports market is 'other European countries'. According to the baseline data, Turkey's imports of cereals from other European countries are higher than the amount of imports of these commodities from EU27.

Table 3.2: Tariff rates according to trading partners (percent)

	EU27	*MENA*	*North America*	*Other Europe*	*Rest of the World*
Wheat	28.5			43.3	42.9
Maize			125.1		121.2
Rice	32.1	0	32.1	31.6	
Other Cereals	92.3		125.1	97.9	121.2
Oil Seeds	1.2		4.8	4.8	8.4
Sugar Beet					
Other field Crops	9.3	12.2			15.6
Fruits	39.1		24.5	35.4	59.5
Vegetables			24.5		59.5
Dairy	101.8		116.4	122.8	118.5
Meat	83.6	22.1		7	102.6
Livestock	2.0		4.9		5.3
Other Agriculture	2.3	7.1		0.1	1.9
Other Manufacturing	0		3.9	2.7	1.8
Food Production	12.3		16.9	18.9	21.2
Textiles	0		6.5		5.1
Energy	0			0	0.3
Services	0				

Source: Authors' calculation from (Narayanan et al., 2008).

Foreign savings and transfers from firms to trading partner accounts are distributed across trading partners according to the foreign direct investment data reported in the General Directorate of Foreign Capital (2009). Transfers from trading partners to households (i.e. mainly workers' remittances) are distributed according to the data reported by the World Bank (2012). Transfers from trading partners to firms are distributed according to the Turkish foreign direct investment in other countries as reported by OECD (2012). This means that that the money transferred from abroad to the firms are mainly profits of firms from abroad and they are proportional to the investment made abroad. The results are given in Table 3.3.

The remaining accounts are obtained by aggregating the SAM developed in Chapter 2 over the regions. The compilation methods and assumptions used there remained unchanged.

Table 3.3: Foreign savings and transfers (TL million)

		EU27	MENA	North America	Other Europe	Rest of the World
Transfers	from Firms to ROW	10,136	536	1,021	1,072	
	from Government to ROW	19,151	63,195			
	from ROW to Households	1,317	140	189	130	78
	from ROW to Firms	2,979	4,434	461	1,113	
	from ROW to Government			16,907	5,381	53,902
	Foreign Savings	46,745	2,472	4,709	4,945	

Source: Authors' own calculation

3.3 Trade Liberalization between EU and Turkey

Trade relationship between Turkey and the EU has been shaped mainly by the Custom Union (CU) Decision of 1996. The benefits and costs of the agreement have been the topic of many studies in the literature since then. Starting from the year 2000, a significant effort has been also devoted to understand the possible economic effects of liberalization of agricultural trade between EU and Turkey. Studies in the literature generally focus on full accession of Turkey to the EU or extending CU decision to agricultural products. So far, the results are ambiguous, but some general trends can be identified.

The foremost addressed question in the literature regarding the full trade liberalization between EU and Turkey focuses on the sign and size of possible welfare effects. Most of the studies reports around 0.5 percent welfare gain or GDP increase under various agricultural trade liberalization scenarios (Eruygur, 2006; Harrison et al., 1997; Lejour et al., 2004; Mercenier et al., 1997; Özer et al., 2009). On the other hand, a deeper integration with the EU is reported to provide higher levels of gain for Turkey. Such actions as: improving EU market access (Harrison et al., 1997), the abolition of nontariff barriers by Turkey (Mercenier et al., 1997; Zahariadis, 2002), the inclusion of Turkey in the CAP support system (Eruygur, 2006; Nowak-Lehmann et al., 2007), creating a sustainable competitive environment (Bayar et al., 2000), maintaining a flexible labor market (De Santis, 2000), improvement of the national institutions and free movement of labor (Lejour et al., 2004), taking into account the scale economies (Sulamaa et al., 2006), timing of liberalization (Acar et al., 2007), harmonization with the EU's health and safety standards (Oskam et al., 2004) are all reported to increase the gains from trade liberalization for Turkey. Depending on the modeling structure and assumptions about the way trade liberalization is implemented, it can be stated that an extension of CU to agricultural sector would result in a welfare gain between 0.5 to 1.5 percent of GDP annually. However, only a few studies report either insignificant total welfare effects (Augier & Gasiorek, 2003; Çağatay, Saunders, & Amor, 2001; Çakmak & Kasnakoğlu, 2003; Grethe, 2004) or even welfare losses (Bekmez, 2002) for Turkey.

The winners and the losers from agricultural trade liberalization are also heavily investigated. The results depend on the scale and structure of the models. Partial equilibrium models give a clear answer for the distribution of welfare gain from trade liberalization across producers and consumers. Producers are generally reported to be losing, while consumers gain (Çakmak & Kasnakoğlu, 2003; Grethe, 2004; Oskam et al., 2004). The main reason for this is the declining producer prices as a result of liberalization. However, this effect is not uniform across all producers (Oskam et al., 2004). Crop producers are generally worse off (Fellmann et al., 2011) while the effect on livestock producers' welfare is ambiguous. Çakmak & Kasnakoğlu (2003), Grethe (2004) and Eruygur (2006) report negative effects while Fellmann et al. (2011) and Leeuwen et al. (2011) report positive effects. As well, consumers' gain is not uniform. De Santis (2000) reports that urban population would be better off, while rural population is likely to be worse off under CU, although the effect on income distribution would be negligible.

Studies based on global or multiregional CGE models provide country or region specific results. The global effect of agricultural trade liberalization between Turkey and EU is found to be negligible (Sulamaa et al., 2006). Change in EU welfare is insignificant whether it is positive (Alessandri, 2000; Augier et al., 2003; Zahariadis, 2002) or negative (Acar et al., 2007; Adam et al., 2008; Alessandri, 2000; Francois et al., 2005). These effects are also not uniform within the EU. Given the fact that Turkey's main competitors for EU market access are the Southern European countries, Southern European countries are more likely to lose while northern European countries win (Nowak-Lehmann et al., 2007; Sulamaa et al., 2006).

The findings about the effects on trade are ambiguous. There is no doubt that the overall effect on volume of trade between Turkey and EU will increase (Bekmez, 2002; De Santis, 2000; Lejour et al., 2004). In some cases this is accompanied with a significant trade diversion (De Santis, 2000). Some studies report that Turkey will become a net importer of crops (Çağatay et al., 2001), while others state that crop exports will increase more than the imports (Çakmak & Kasnakoğlu, 2003; Grethe, 2004; Özer & Özçelik, 2009); others assert that Turkey will be net importer of livestock products (Grethe, 2004). Almost all find that fruits and vegetable exports will increase (Çakmak, 2007; Eruygur, 2006; Nowak-Lehmann et al., 2007).

Impacts of trade liberalization under climate change have not been subjected to any analytical studies for Turkey. However, the issue of interaction between trade liberalization and climate change has been addressed at the global scale. The main argument in the literature is that trade liberalization can alleviate the negative effects of climate change by boosting international trade. Trade liberalization is reported to have welfare improving effects (Calzadilla et al., 2011; Chen et al., 2012; Laborde, 2011; Reilly et al., 1993). However these effects are generally weak and won't compensate for the adverse effects of climate change (Randhir & Hertel, 2000; Reilly & Hohmann, 1993). Welfare gains from trade liberalization are dependent on the elimination of production and export subsidies (Randhir et al., 2000). The effects are not uniform and depend on the geographic location (Calzadilla et al., 2010; Reilly et al., 1993) and the degree of regional vulnerability to climate change (Reilly et al., 1993). Poor people are expected to be affected more from the changes (Laborde, 2011).

To sum up, trade liberalization is expected to increase the welfare of Turkey, especially through its effects on consumers. However, the findings in the literature are quite diverse and vary based on the data and method of analysis, and exclude the effects of climate change. Most of the studies rely on quite old databases such as the GTAP database with the base year being 1997, long before CU became fully functional. Almost all studies employ static models which ignore the dynamic aspects of the problem. Almost all CGE models lack a detailed disaggregation of agriculture while partial equilibrium models ignore the feedback mechanisms.

In this chapter we try to fill the gap in the literature with a detailed and enhanced modeling framework. The welfare effects of trade liberalization and its reflection in production, consumption and food security will be at the center of our analysis. We will also explore the relationship between climate change and trade liberalization to see if trade liberalization can alleviate the adverse effects of the climate change. We will address whether unilateral trade liberalization can be considered as a policy alternative to help climate change adaptation efforts of Turkey.

3.3.1 Scenario Design

To simulate the effects of trade liberalization between EU and Turkey under climate change, we run three scenarios over the period 2008-2099. First, we run a baseline scenario that mimics the growth path of the Turkish economy for the period 2008-2099. The results of the baseline scenario are used for benchmarking the other scenarios. Climate change effects on yields and irrigation requirements are then incorporated on top of the assumptions made for the baseline in the second scenario. Lastly, we introduce unilateral tariff elimination by Turkey against the EU imports as a policy response to climate change effects. Climate change and tariff elimination scenarios are run under 52 different changes in the world prices for each year. The series for world price changes are calculated using the Gaussian-Quadrature method from the historical world price series for each commodity.

We start this section with the description of the scenarios. Then the simulation results are discussed. More emphasis will be given on the results of trade liberalization scenario by benchmarking them against the results of the climate change scenario.

Baseline Scenario

The baseline is the "business as usual" scenario where we try to mimic the historical growth rate of the economy over the period 2008 and 2099. In other words, the model is calibrated to yield an average GDP growth rate of 3.5 percent, which is the average growth rate of GDP between 1950 and 2008 (TurkSTAT, 2010b). The annual population growth is assumed to be 0.9 percent. The subsistence consumption levels are automatically updated to reflect the increase in population. Labor force endogenously adjusts to the population growth by taking into account the change in real wages. The resulting change in labor supply is given in Figure C.5.

We assume that the annual total factor productivity (TFP) growth is 0.8 percent in agriculture, 1.06 percent in industry and 0.4 percent in services. We use the yield projections for wheat presented in Bruinsma (2003) and reported in Kavallari, Rau, & Rutten (2013). We assume that TFP growth in services is half of the increase in agricultural activities, while the industrial TFP growth is 2.65 times the TFP growth in services. Capital growth is endogenous in the model. The growth in capital stock is determined by the dynamics of the model. We assume that the default capital/output ratio is 4.2 [6] and the depreciation rate is 3 percent. We do not change the world prices in the baseline since we assume that world prices are changing due climate change.

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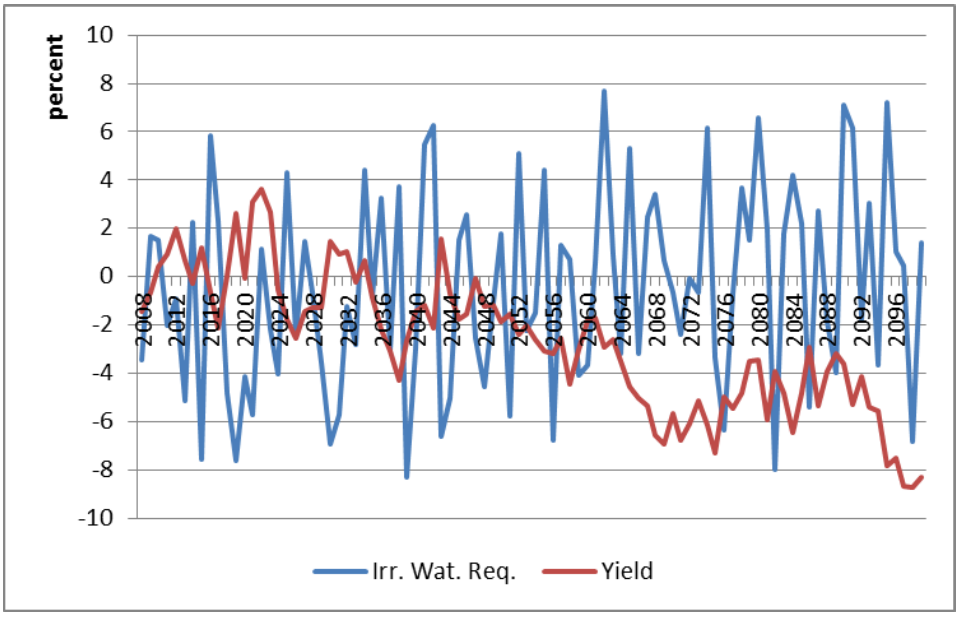
[6] We calculated 4.2 as capital/output ratio from the data published by the Ministry of Development (2012).

Climate Change Scenario

This scenario introduces climate change effects to the baseline. These effects are in the form of yield and irrigation requirement changes. They are obtained from the crop water requirement model described in Annex A for all crops at the national level. We use a 5-year moving average for the yield change since there are significant outliers for a few highly irrigated crops. This reduces the extreme events caused by frequent harvest failures foreseen by the crop model. However, deviation from the base year is still significant (Figure 3.2) and the story line for the climate change effects does not change. Yields are generally increasing between 2008 and 2035; they start to decline between 2036 and 2060. In the last period, 2061-2099, the decline in yields becomes substantial. Irrigated water requirement oscillates significantly throughout the all periods.

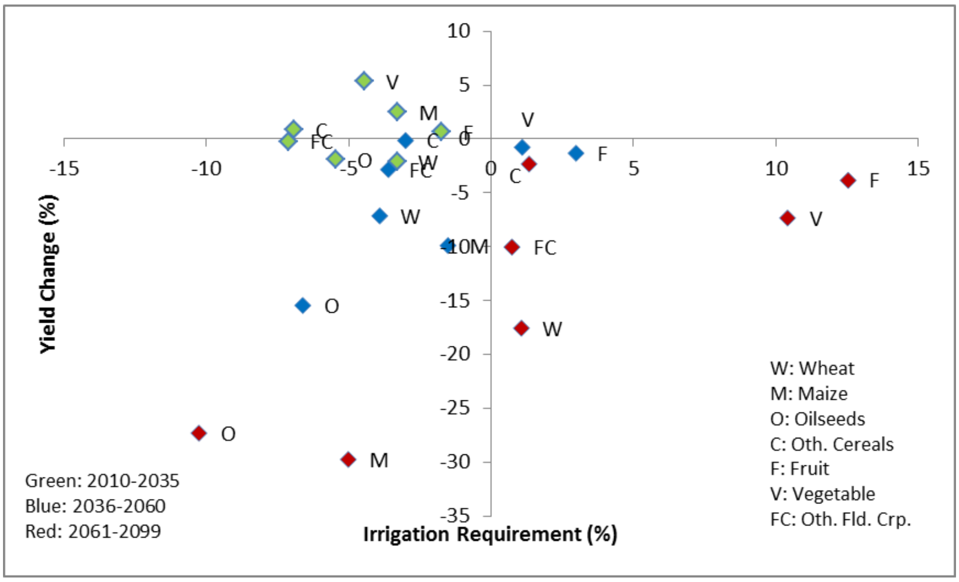
Yields of fruits and cereals are not affected much while maize and oilseeds are the most affected crops. The impact is reversed in the case of irrigation water requirements. Effects on wheat, vegetables and other field crops are significant both in terms of yields and irrigation requirements. All crops more or less follow the pattern in Figure 3.2. In the first period the change in average yields is rather small and even positive for some crops. Yields of all crops start to decline in the second period, but the magnitude of the average decline is not more than 10 percent. However, the decline becomes prominent in the last period, especially for maize and oilseeds. Yield and irrigation water requirements at the activity level are given in the Appendix Figure C.1. Descriptive statistics for the introduced shocks according to the periods can be found in appendix Table C.1.



Source: Model Results

Figure 3.2: Changes in average yields and irrigation water requirements

Figure 3.3 shows the scatter plot of average irrigation water requirements against average yield changes for each activity in each period. Crops are concentrated around the second quadrant where yield changes are almost non-negative and irrigation requirement changes are negative. In the second period, crops are located around the 45-degree line in the third quadrant, which implies a positive correlation between yield changes and irrigation water requirements. Yields and irrigation requirements decline simultaneously for all crops, except for vegetables and fruits for which irrigation requirements increase. In the last period all crops moves to the fourth quadrant where irrigation requirements increase and yields decline. The only exceptions are oilseeds and maize for which yields and irrigation requirements decline simultaneously. However note that the decline in yields is quite significant for these crops.



Source: Model Results

Figure 3.3: Yield and irrigation water requirement changes in periods

Climate change is a global phenomenon and hence it is likely to affect world prices of agricultural commodities significantly. However, it is not possible to capture this effect with a small single country model where world prices are assumed to be exogenously determined. Many studies in the literature ignore this effect. We incorporate the effects of climate change on world prices as exogenous shocks. In other words, we assume that climate change does not only affect the yields and irrigation requirements but also the world prices.

There are various studies in the literature that attempts to quantify climate-induced changes on world prices by using global CGE models. These studies generally report significant changes in world prices of major staples. However we cannot incorporate these findings in our simulations since their assumptions about the climate change are generally different from that of ours. Further these studies are generally static exercises and report world prices only for a specific year. Lastly, the reported world price changes are generally inconsistent. Hence instead of taking world price changes from other studies in the literature we use Gaussian Quadrature method to generate different world price series.

Gaussian quadrature is an approximation method for numerical integration. Weighted sum of function values at specific points in the domain of the function are used to approximate the value of the function (DeVuyst and Preckel, 1997). Gaussian quadrature method gives the weights and nodes in the following approximation:

$$\int_{\Omega} f(x)dx \cong \sum_{i=1}^{n} f(x_i) w_i \tag{3.15}$$

where $f(x)$ is a continuous function, x is the vector of independent variables, x_i is the vector of nodes selected in the domain of the integral, w_i are weights assigned to the value of the function at corresponding nodes and are called quadratures, n is the minimum number of the nodes required for a good approximation. There are various formulas in the literature to calculate the weights and nodes efficiently. Strauds method is used widely in the CGE literature (Arndt, 1996). Strauds method solves the following equation system to find nodes and weights.

$$\sum_{i=1}^{N} w_i \prod_{m=1}^{M} \left(x_i^m\right)^{l_m} = \int_a^b \prod_{m=1}^{M} \left(x_i^m\right)^{l_m} f(x)dx \quad s = 0,1,2....,d \text{ such that } \sum_{j=1}^{m} l_j \le d \tag{3.16}$$

for all combinations of nonnegative integers, l_m. d is known as the order of the quadrature. Many formulas for different orders and arbitrary dimensions of quadratures are developed in the literature. Most frequently used formulas are derived by Stroud (1957) and Liu (1997) for order 3 quadratures (Arndt, 1996), which are exact for orders smaller than 3 (Preckel et al., 2011). If Γ_k is the k[th] quadrature point with the elements $(\gamma_{k,1}, \gamma_{k,2}, ..., \gamma_{k,\mathrm{n}})$ such that $k \in (1,2,...,n)$ and if $r = 1,2,...,\lfloor n/2 \rfloor$ where $\lfloor n/2 \rfloor$ is the greatest integer smaller than $n/2$, then it can be shown that

$$\gamma_{2r-1} = \sqrt{2}\cos\left(\frac{(2r-1)k\pi}{n}\right) \qquad \gamma_{2r} = \sqrt{2}\sin\left(\frac{(2r-1)k\pi}{n}\right) \tag{3.17}$$

yields the elements of the Γ_k which is the kth quadrature. If n is an odd number then $\gamma_{k,n} = (-1)^k$. In this case weights are equal and sum up to 1:

$$w_k = \frac{1}{2n} \tag{3.18}$$

Gaussian quadrature method is used for stochastic sensitivity analysis in the CGE literature and is shown to be quite efficient in capturing the uncertainty in the parameter values (Arndt, 1996; DeVuyst and Preckel, 1997). Stochastic sensitivity analysis assumes that model parameters are stochastic variables following a distribution function. Hence the values used in the model are just one point drawn from this distribution. In this case model results are also stochastic. If we consider the CGE model as a function that relates the pre-simulation and post simulation values of the variables in the model, then the expected value and variation of the post-simulation values of the variables can be approximated by using Gaussian quadrature approach. In this way one can select a limited number of parameter sets and weights and run the model for these parameter sets. Then the stochastic properties of the model results can be derived from the output of these runs. A high variation in the values of key model variables would mean that model is sensitive to the relevant parameters.

To conduct a sensitivity analysis with respect to a symmetrically distributed random variable vector x that consists of elements $(x_1, x_2, ..., x_n)$ with mean μ and variance covariance matrix Σ, the desired quadrature is given by

$$\Phi = \mu + \Upsilon\sqrt{D} \tag{3.19}$$

where D is a diagonal matrix obtained by Cholesky factorization:

$$\Sigma = LDL' \tag{3.20}$$

Then Υ is obtained by transforming the quadrature Γ in equation (3.17) by

$$\Upsilon = \Gamma L \tag{3.21}$$

If Σ is diagonal then

$$\Upsilon = \sqrt{\Sigma} \tag{3.22}$$

Preckel et al. (2011) propose an algorithm to extend the quadratures suggested by Straoud. They propose to use two copies of the Straoud quadratures: stretching one and shrinking the other to achieve the desired broadening of the sample while keeping the mean intact and redistributing the weights (or probabilities) so that the variance is maintained. Hence they introduce an expansion factor, denoted by α , a contraction factor, denoted by β , and a probability allocation factor, denoted by *p*. The resulting quadrature is

$$\left\{ \left[pw^i, \alpha x^i \right]_{i=1}^{n}, \left[\left(1-p\right) w^i, \beta x^i \right]_{i=1}^{n} \right\} \tag{3.23}$$

Preckel et al. (2011) show that once the expansion factor, α , is chosen, the parameters β and p are given by

$$q = \frac{1-\kappa}{\alpha^4 - 2\alpha^2 + \kappa} \qquad \beta = \sqrt{\frac{\alpha^2 - \kappa}{\alpha^2 - 1}} \tag{3.24}$$

We follow this approach to capture the variation in the model's results due to the world prices. Accordingly, we assume that percentage change in real world price of each agricultural commodity follows a symmetric distribution. The mean of the distribution is assumed to be zero for all commodities in the base period. Then we assume that the mean of the distribution will increase by one, two and three standard deviations in the first, second and last period respectively. We further increase the variation in the percentage change of the world prices (i.e. diagonal elements of the variance covariance matrix) by one percent in each period. Hence in each period we assume that mean of the distribution of percentage change in world prices are increasing together with the variation in the prices. These assumptions are compatible with the recent studies in the literature (Hertel and Rosch, 2010; Valenzuela and Anderson, 2011a and 2011b; Diffenbough et al., 2012; Calzadilla et al., 2013).

Changes in the world prices of different commodities are not independent from each other. This stems from two facts. Firstly, different agricultural commodities are substitutes to some extent. Hence their prices are linked to each other. Secondly, price changes are linked to production, and production of all commodities is dependent on the same climate conditions. For example, if the price of one commodity is rising due to drought, other crops will be affected from the drought as well and their prices will also rise. To take this correlation into account we form the variance covariance matrix by using the historical correlation between the annual price changes of the commodities. We eliminate small correlations to avoid problems in Cholesky decomposition. We also assume that correlation among the percentage change of world prices of different commodities remains constant over time.

Table 3.4 shows the expected values and standard deviations of the world price shocks calculated by Gaussian quadrature method for all commodities over the three periods. Our assumptions yield world price changes that are consistent with the climate change patterns. The average percentage change increase over time is as expected. The highest increases occur in the world price of rice, wheat, oilseeds and other field crops. Variations for these crops are also high. The lowest increases, on the other hand, occur in vegetables, meat and other agricultural crops.

We run the climate change simulations by shocking the shift parameter of the top level CES production function with the yield changes, the coefficient of water in irrigated land – water nest with irrigation water requirements and the world prices with the world price change series generated by Gaussian quadrature. Hence, we run 48 simulations each with a different world price assumption. Therefore the results for the levels of the variables show the expected values. We also report the standard deviations when it is appropriate.

Table 3.4: Mean and standard deviation of the world price shocks

	Period 1		Period 2		Period 3	
	Exp. Val.	Std. Dev.	Exp. Val.	Std. Dev.	Exp. Val.	Std. Dev.
Wheat	1.01	1.46	2.01	1.46	3.01	1.46
Maize	0.62	0.76	1.62	0.76	2.62	0.76
Rice	1.27	1.67	2.27	1.67	3.27	1.67
Oth. Cereals	0.99	0.62	1.99	0.62	2.99	0.62
Oilseeds	1.72	0.95	2.72	0.95	3.72	0.95
Oth. Fld. Crp.	3.06	1.10	4.06	1.10	5.06	1.10
Fruit	-0.18	0.57	0.82	0.57	1.82	0.57
Vegetable	0.50	0.26	1.50	0.26	2.50	0.26
Milk	-0.12	0.85	0.88	0.85	1.88	0.85
Meat	5.55	0.41	6.55	0.41	7.55	0.41
Livestock	4.15	0.85	5.15	0.85	6.15	0.85
Other Agriculture	3.63	0.39	4.63	0.39	5.63	0.39

Note: Mean and standard deviation are first and second moments of distribution, respectively

Source: Author's calculations

Trade Liberalization Scenario

Under the trade liberalization scenario we assume that all tariffs implemented by Turkey on EU imports are unilaterally eliminated on top of the climate change scenario. This scenario is called “Tariff Elimination scenario (TRF)”, and eliminated tariffs are given in Table 3.5. Protection is generally high in agricultural commodities. The share of agricultural imports in the total imports from EU is low with a value of less than two percent. On the other hand, EU’s share in agricultural imports of Turkey is significant varying between 20 to 45 percent. Although agriculture is a minor item in imports from EU, EU is still the most important trading partner of Turkey. Hence trade liberalization with EU is likely to have a significant direct impact on Turkish agriculture while the impact on the rest of the economy will be through the backward and forwards linkages of agriculture with the other sectors.

Table 3.5: Tariffs imposed by Turkey (percent)

	Tariff Rate	Share of EU in total imports of commodity	Share of commodity in total imports from EU
Wheat	28.5	25.2	0.36
Maize	0	0.0	0.00
Rice	32.1	19.8	0.03
Cereals	92.3	21.9	0.02
Oil Seeds	1.2	28.6	0.39
Sugar Beet	0	0.0	0.00
Field Crops	9.3	30.4	0.03
Fruits	39.1	9.6	0.03
Vegetables	0	0.0	0.00
Dairy	101.8	39.6	0.05
Meat	83.6	12.0	0.00
Livestock	2	35.8	0.02
Oth. Agriculture	2.3	45.9	0.09
Manufacturing	0	52.3	82.69
Food	12.3	24.0	0.85
Textiles	0	28.6	2.19
Energy	0	8.0	0.00
Services	0	52.3	13.24

Source: Authors' calculation from (Narayanan et al., 2008).

3.3.2 Simulation Results

In this section we present the main conclusions from the simulation results and explore the main drivers of change in order to derive policy implications. We will present the results relative to the changes in the baseline scenario. The main results of baseline scenario are given in Appendix A.2.3. In this section, we will first give an overview of macro results of the two scenarios. Then we will focus on the effects of trade liberalization by presenting them relative to the results of climate change scenario.

3.3.2.1 Macro Results and Welfare Effects

The results obtained are largely consistent with what have been suggested in the literature and provide important insights about the main drivers of the effects of climate change. Figure 3.4 shows the expected value of the equivalent variation[7] (EV), which is an indicator of welfare gains for the households. Change in EV is between -3.3 percent and +1.3 percent of the initial household consumption for climate change scenario and -2.8 percent and 1.63 percent for the trade liberalization scenario.

EV is higher under trade liberalization compared to the climate change scenario. However, the trade liberalization is far from alleviating the negative effects of climate change. In the last period, 2060-2099, the EV is always negative under both scenarios. Though, the difference between the climate change and the trade liberalization scenarios increases as the effects of climate change worsen. This suggests that the welfare improving effects of trade liberalization are enhanced when the effects of climate change are worsened. As agricultural production becomes less productive as a result of the climate change, welfare improving effects of trade liberalization are amplified. This is mainly due to the fact that trade liberalization allows economic agents to substitute domestic and imported commodities more freely. Consumers can consume more imported commodities as a substitute to the domestic products which become relatively scarce under climate change. Producers can also substitute domestic intermediate inputs with imported inputs to compensate the decline in the productivity of land. Consequently, the more agriculture is affected from climate change the higher is the welfare improving effect of trade liberalization.

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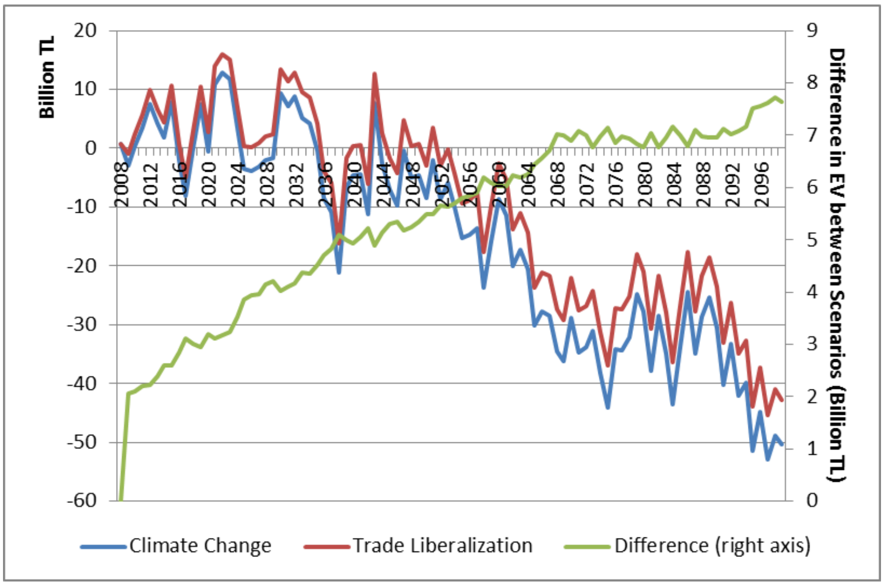
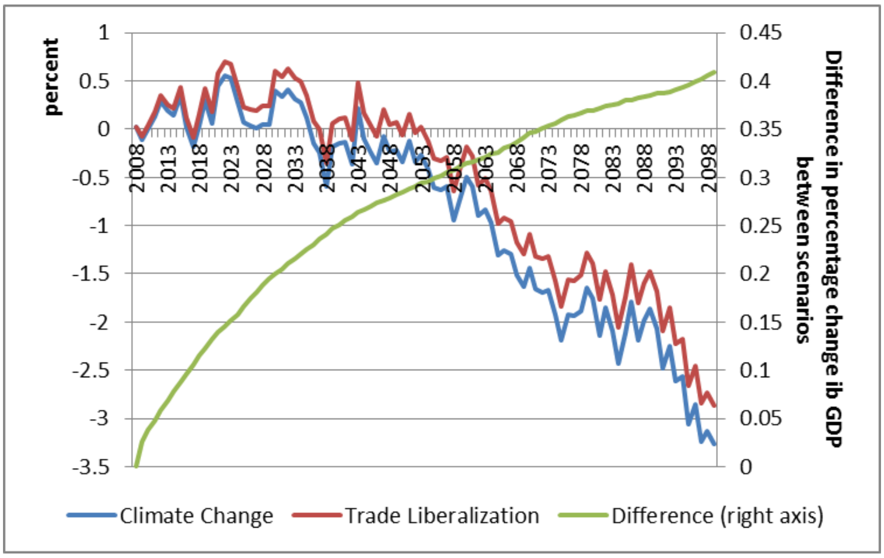
[7] More formally, EV shows the minimum payment that the consumer would require for foregoing the welfare gains under the relevant scenario (Sadoulet and Janvry, 1995).



Source: Model Results

Figure 3.4: Expected value of equivalent variation

The change in GDP is generally small until the 2060s (Figure 3.5). Changes in tariffs may not be fully reflected in the production side of the economy up to this period. The impacts of tariff elimination are generally absorbed by the substitution mechanisms in trade, consumption and production. GDP starts to decline after 2035 but the decline is significant only after 2060s. This is consistent with what is generally reported in the literature. The trends are similar to those we noted in Chapter 2. Welfare and other macro indicators follow the same path: they get better off in the first period (2008-2035), start to decline in the second period (2035-2060) and worsen in the last period (2060-2099). Thus, Turkey is likely to have time to take necessary measures for adaptation before climate change has significant impacts at economy level. Furthermore ignoring the probable adverse effects of the climate change in the second and the last period can have devastating effects and significant costs for all economic agents.

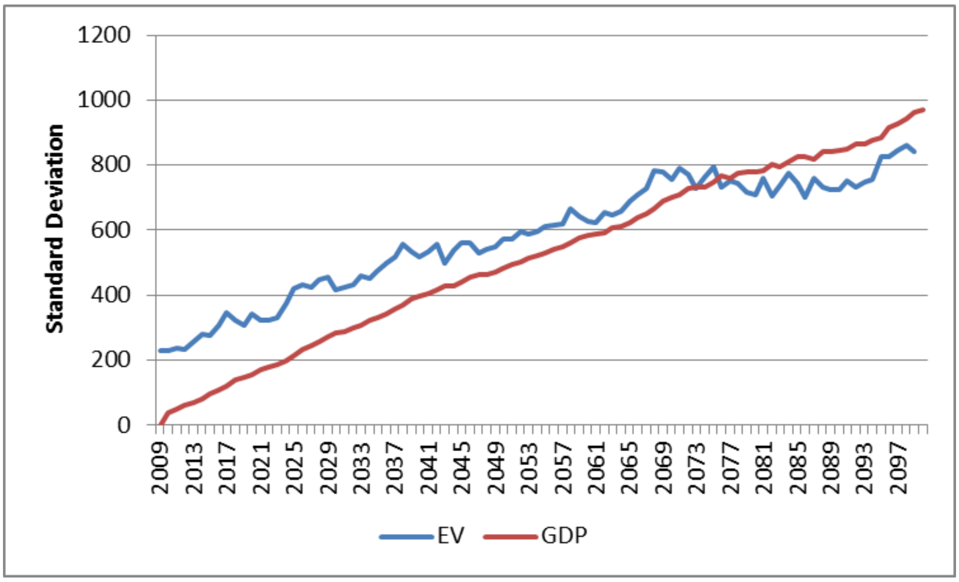


Source: Model Results

Figure 3.5: Real GDP over time (percentage deviation from baseline)

Figure 3.6 shows the evolution of the standard deviation of the GDP and the EV over time. Since we use the same world price shocks in both climate change and trade liberalization scenarios standard deviations in both simulations are very similar. Hence for the sake of clarity we will present only the standard deviations for the trade liberalization scenario.

The standard deviation of EV increases in the first two periods and it stabilizes and follows a horizontal trend after 2060s. On the other hand, although the standard deviation of the GDP starts at a low level compared to the standard deviation of EV, it increases throughout the simulation period. Thus we can conclude that although changes in world prices do not cause any further changes in the variation for household welfare in the last period, their impact on the variation of the GDP persists. This implies that changing world prices affect both the consumption and production sides in the first period and only the production side in the last period.

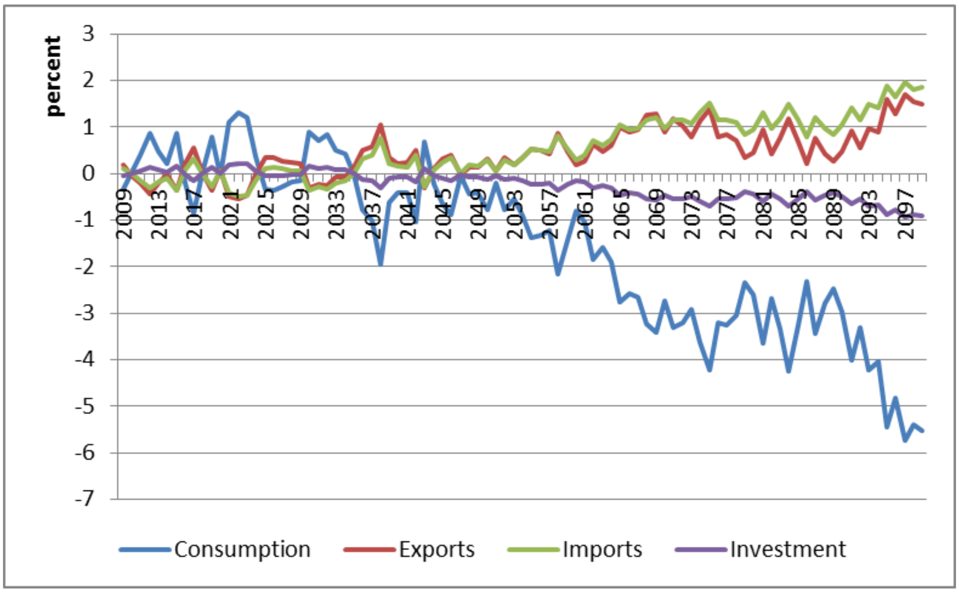


Source: Model Results

Figure 3.6: Standard deviation of EV and GDP levels over time

Figure 3.7 shows the decomposition of the changes in GDP under the climate change scenario. The most important drivers of the change in the GDP are private consumption, imports and exports. Government consumption contributes very little to the changes in the GDP and therefore its activity on change will not be reflected in this figure. Changes in fixed investments are however included, and in spite of their minimal influence at the start, their contribution becomes more significant in the last period.

The contribution of the changes in private consumption to the changes in GDP moves generally in opposite direction compared to those in trade. This is valid throughout the whole simulation period. In the first period, trade contributes negatively to the changes in GDP, implying a decreasing value of exports and an increasing value of imports in the first period. The decline in total exports is caused mainly by a decline in exports to the regions other than EU27.

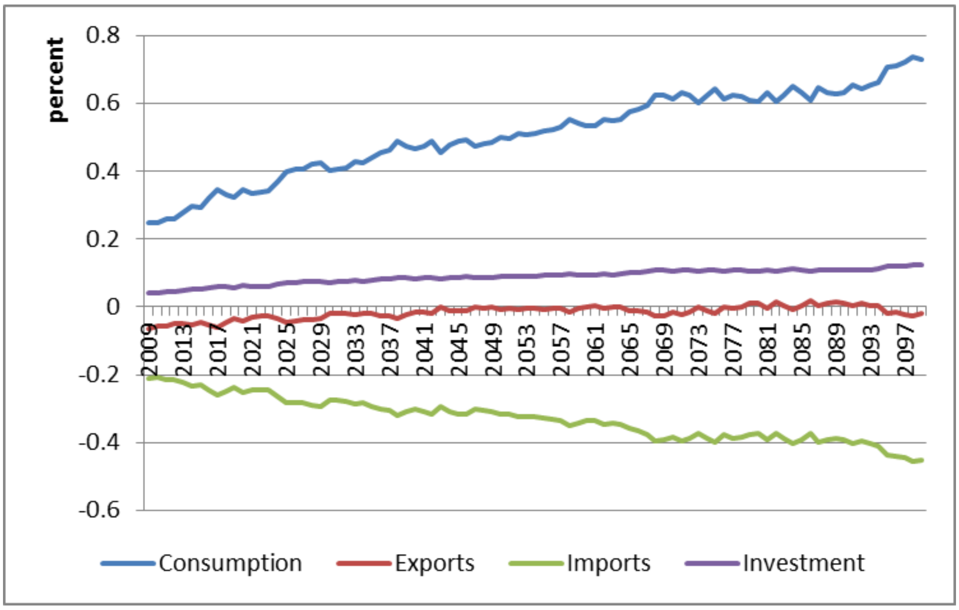


Source: Model Results

Figure 3.7: Contribution of the GDP components on the GDP change under climate change scenario (percentage deviation from the baseline)

In the second and third period, however, the effects are reversed. In the second period, the positive contribution of imports and exports are able to compensate the negative contribution from consumption. However, in the third period the combined effect of consumption and fixed investments has a stronger influence than the combined effect of imports and exports, and as a result GDP declines significantly. In the second and third periods the effects of consumption and trade are almost symmetrical around the horizontal axis since increasing exports and decreasing imports due to increasing world prices put a significant pressure on consumption. Thus consumption adjusts to handle the change in the world prices.

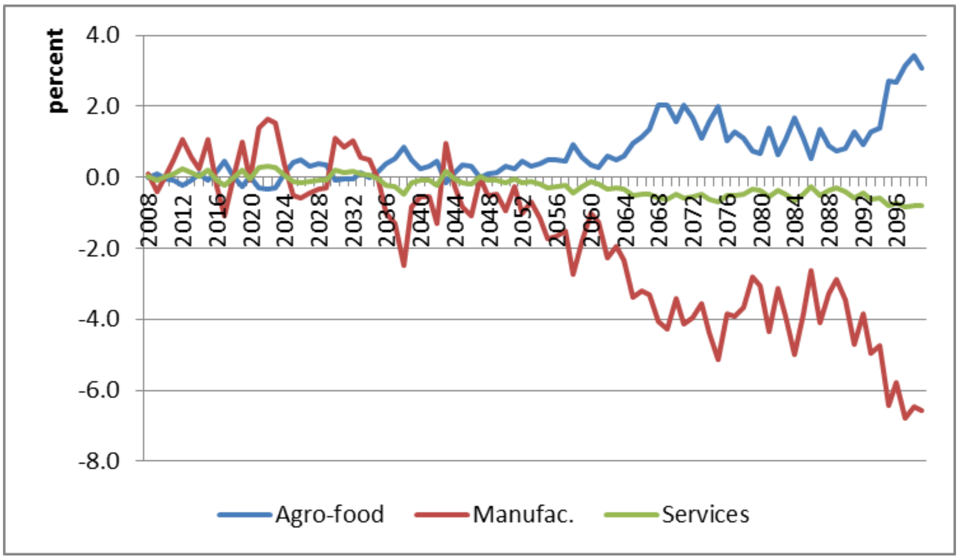
The contributions of the components of GDP to the changes in the overall GDP under the trade liberalization scenario are presented in Figure 3.8. Private consumption and fixed investments have positive impact on GDP (i.e. less negative, under trade liberalization), while exports' contribution is almost the same between the two scenarios. However, positive contribution of imports decreases under the trade liberalization scenario. That is, as import prices decline the imports are substituted with domestic commodities and this increases the consumption. The changes are weak, as they are not likely to reverse the sign of the GDP change. Hence, trade liberalization only weakly alleviates the effects of climate change in terms of GDP growth. Note that the difference gets higher over time. Hence, the benefits of trade liberalization increase as climate shocks get significant.



Source: Model Results

Figure 3.8: Contribution of GDP components to the GDP change under trade liberalization scenario (percentage deviation from climate change scenario)

Figure 3.9 and Figure 3.10 show the sectoral decomposition of the change in imports and exports under climate change scenario with respect to the baseline. Contribution of services to the change in imports and exports is small compared to the agri-food and manufacturing. The main driver of the change in imports is manufacturing, especially in the first period. The contribution of manufacturing is generally positive in the first period while it deteriorates significantly in the second and third periods.

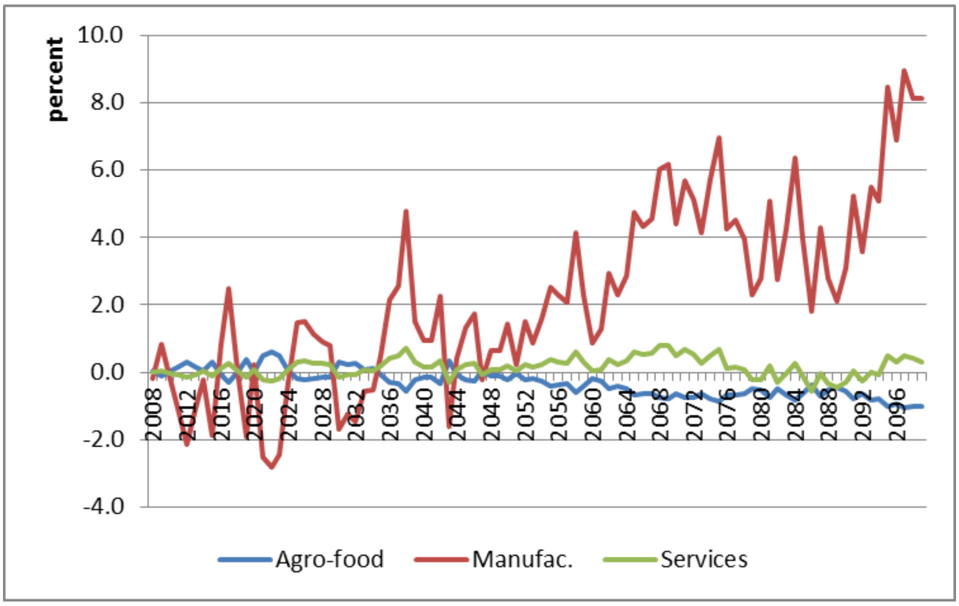


Source: Model Results

Figure 3.9: Decomposition of changes in the value of imports under the climate change scenario (percentage change from the baseline)

Agri-food imports increase the total imports especially in second and third period as the effects of climate change become significant in these periods and Turkey needs to substitute domestic products with imports. However, total imports are still declining, since increase in agricultural imports is rather limited due to the increasing world prices. In other words, Turkey substitutes manufacturing imports with agricultural imports since following the climate change effects, manufacturing sectors becomes relatively more productive and hence more competitive in the international markets.

The effects are reversed for exports (Figure 3.10). Change in export of manufacturing sector is generally negative in the first period while it increases significantly as a result of declining domestic prices of manufacturing goods and increasing world prices of agricultural commodities in the second and last periods. This boosts total exports despite the decline in agri-food exports.

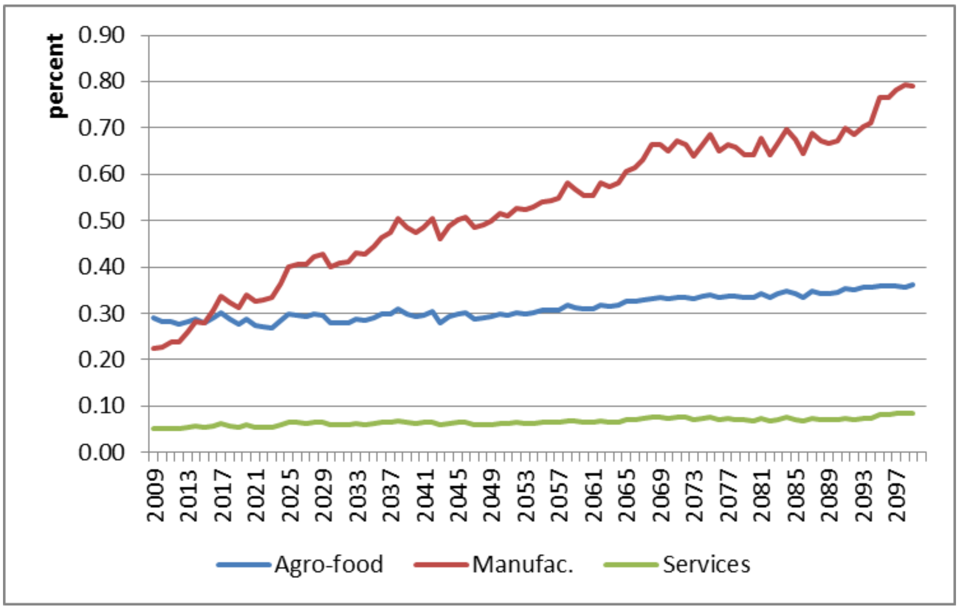


Source: Model Results

Figure 3.10: Decomposition of change in exports under climate change scenario (percentage change from baseline)

Trade liberalization does not change the contribution of sectors to trade significantly (Figure 3.11 and Figure 3.12). However, the contribution of manufacturing sector to the change in total imports starts with two percent and climbs up to eight percent. This implies that the negative contribution of manufacturing sector to the total imports decreases by 10 percent throughout the whole period. This points out the importance of the manufacturing sector for the rest of the economy to adjust the adverse effects of the climate change.

The contribution of manufacturing sector to the change in total exports decreases under trade liberalization and this effect does not follow a consistent path. The effects of trade liberalization on the contribution of agri-food imports are stable around 0.3 percent while the effect on exports is negligible.

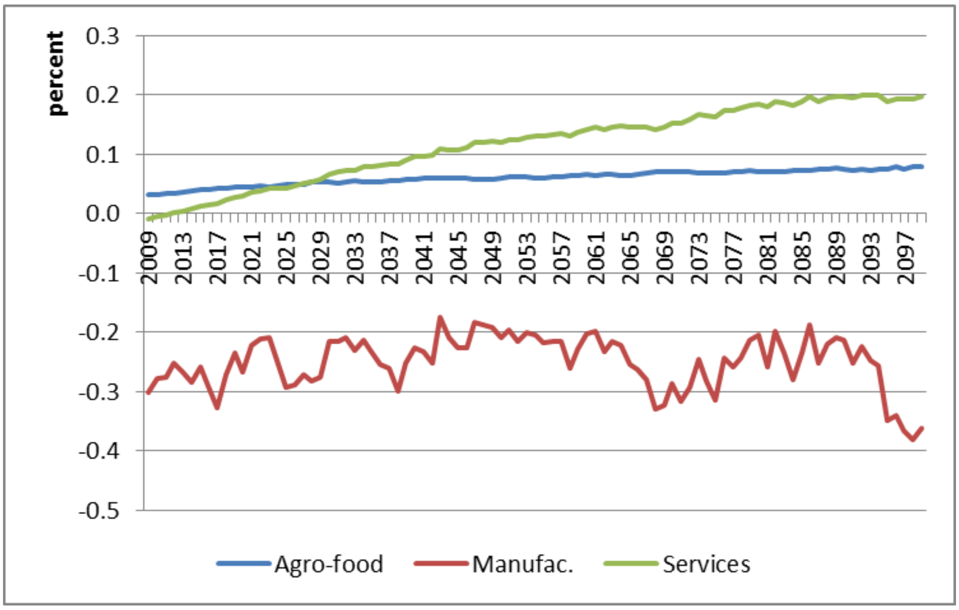


Source: Model Results

Figure 3.11: Decomposition of change in value of imports under trade liberalization (percentage change from the climate change scenario)

To sum up, effects of climate change become significant after 2035 with declining welfare and GDP. Imports are reduced substantially while there is a boost in exports, mainly due to manufacturing sector. Trade liberalization wirth EU in agricultural commodities is likely to have a limited overall effect to alleviate the adverse effects of climate change.

Welfare gains are positive but not significant enough to change the sign of the overall effects. On the production side, the total value added does not change much from the climate change scenario implying a limited feedback effect. The main drivers of change on the GDP are imports and consumption. The positive effect of declining imports on the GDP is reduced by the negative contribution of domestic demand under trade liberalization. Hence the effects of declining productivity in agricultural sector cannot be fully recovered with imports and this causes a decline in consumption which drags down the GDP.



Source: Model Results

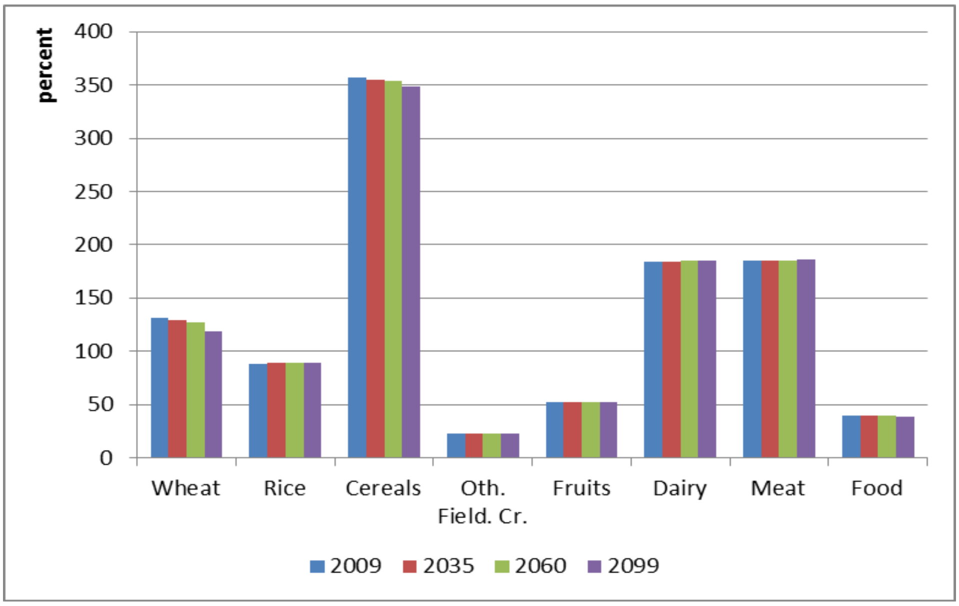
Figure 3.12: Decomposition of change in exports under trade liberalization (percentage change from the climate change scenario)

3.3.2.2 Prices and Trade

The final effect of trade liberalization on imports and exports of different sectors depends on various factors. First of all, the size of the protection is the main driving factor. Trade volume of the commodities with high protection more is likely to be affected more. Secondly the final effect also depends on the production structure. Commodities which are produced less efficiently or cannot substitute different factors or intermediate inputs easily are also likely to be affected more. Another important factor is income and substitution elasticities in household demand, import supply and export demand.

Figure 3.13 shows the change in imports of the selected commodities from the EU27. The variation over time is quite small. Imports of other cereals, which are heavily protected in Turkey, increase more than three times. Dairy and meat products follow with more than 170 percent increase. The increase in wheat and rice imports is around 100 percent. Food and fruit imports increase by about 50 percent.

These rates are directly proportional to the amount of protection presented in the baseline. The protection on other cereals, meat and dairy is between 85 and 100 percent, while wheat, rice and fruits are protected by 30 to 40 percent. Hence, the more a product is protected, the more the increase in its imports after the trade liberalization. The standard deviation of the changes in imports is quite small (between 0 and 7) compared to the expected value (see Appendix Figure C.7).

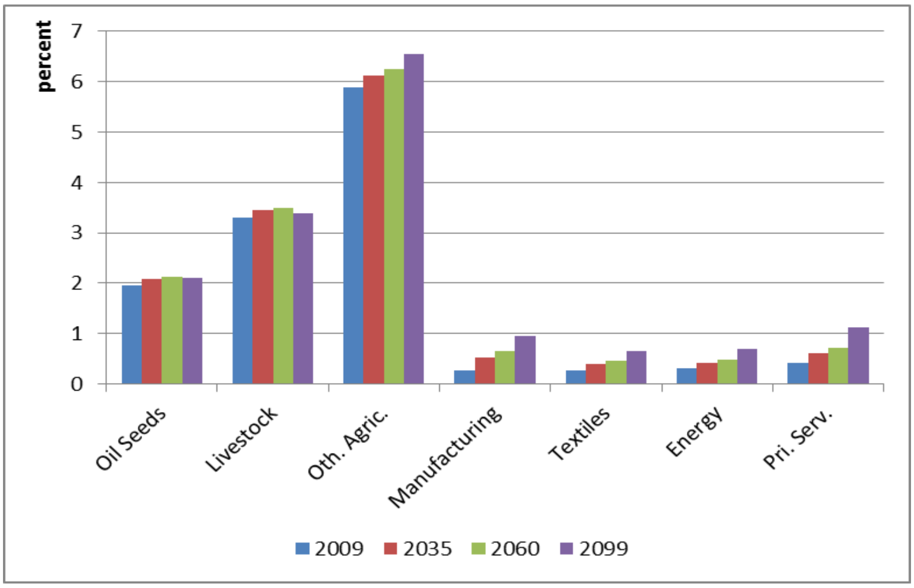


Source: Model Results

Figure 3.13: Change in imports from EU27 for highly affected agricultural commodities (percentage deviation from climate change scenario)

The large increase in the imports of other cereals is caused mainly as a result of the low trade level with EU27, and the trade volume does not increase much under the climate change scenario. Hence, the percentage change relative to the climate change scenario is quite high. Furthermore, production cost of other cereals is higher compared to the other agricultural products. Hence, once the import price of other cereals declines as a result of trade liberalization, cheaper imports largely substitutes domestic production. Factors of production are mostly diverted to oilseeds and maize production from the production of other cereals. A similar argument is also correct for the imports of dairy and meat products. The high percentage changes are mostly due the low level of trade under the baseline which does not change much under the climate change scenario. However, since meat and dairy sectors' main inputs are agricultural products that become relatively cheaper (see Figure 3.18) as a result of trade liberalization, the increase is not as high as the one observed in imports of other cereals.

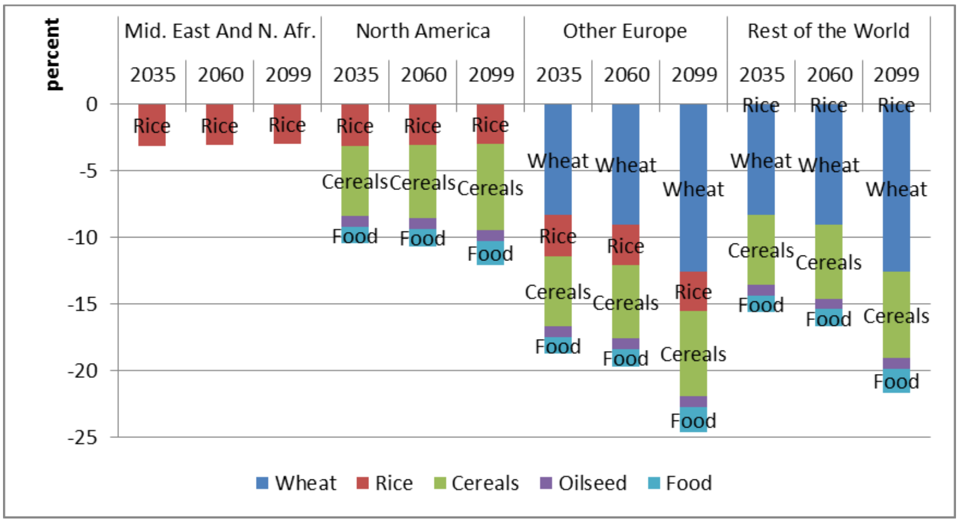
Effects on other sectors are rather small (Figure 3.14). Relatively small effects on imports of oilseeds, livestock, and other agricultural sectors' are mostly due to low protection on these commodities (e.g. between one to two percent). Although the change in the non-agri-food sectors is not as significant as that of the agri-food sectors, they are mostly increasing. These small changes are as a result of feedback effects in the economy. Increase in household consumption due to the increasing incomes is the driving factor. Although there are slight increases in production, most of the increase in household consumption is supplied by imports.



Source: Model Results

Figure 3.14: Change in imports from EU27 for other commodities (percentage deviation from climate change scenario)

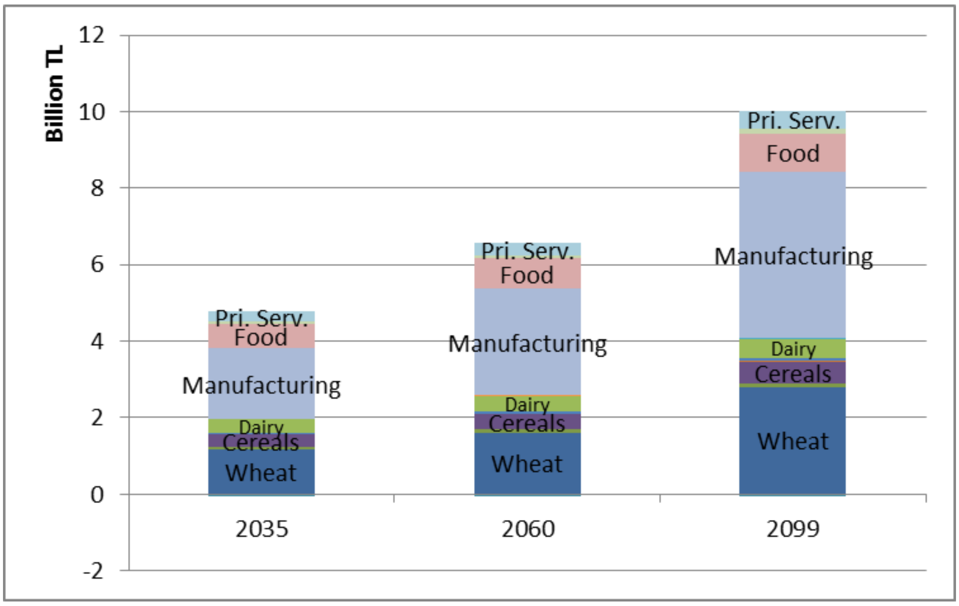
Significant increase in the imports of agricultural products from the EU27 results in a decline of imports from other trading regions (Figure 3.15). This trade diversion is caused by two effects of trade liberalization. Firstly, as import prices from EU27 fall, imports from the other regions become non-competitive. Secondly, declining import prices cause domestic prices to decrease making domestic products more competitive relative to imports from other regions. Cereals, wheat, rice, other field crops and food are the most affected commodities by the trade diversion. Trade diversion becomes more evident over time especially for wheat and other cereals, both of which are significantly affected by climate change.



Source: Model Results.

Figure 3.15: Change in imports from other regions (percentage deviation from climate change scenario)

Figure 3.16 shows the sectoral decomposition of the change in the imports. Contribution of services to the total imports is relatively small compared to those of manufacturing and agricultural sectors. Almost half of the increase in total imports is due to manufacturing sector in all periods. Contribution of agri-food imports is close to the contribution of manufacturing imports. The most significant contribution to total imports arises from the imports of wheat, dairy products, other cereals and food sectors. Contributions of oilseeds and maize imports are negative under trade liberalization but the negative contribution is relatively higher in the last period.



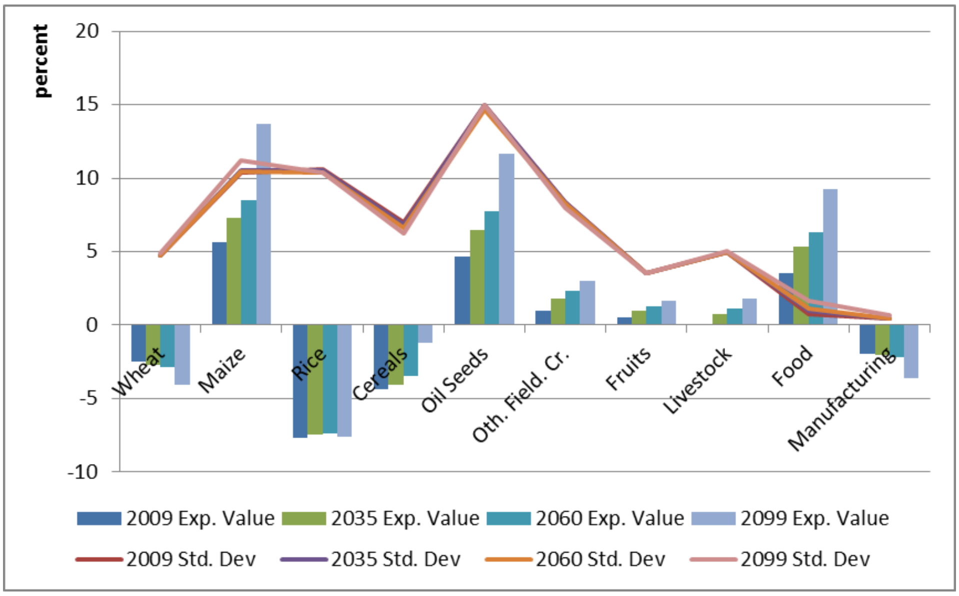
Source: Model Results

Figure 3.16: Change in total imports (difference from the climate change scenario, TL Billion)

The change in exports[8] is given in Figure 3.17. Under trade liberalization, exports of maize, oilseeds and other field crops and food increase significantly, while exports of rice, cereals and manufacturing declines. The effects get more pronounced over time as the effect of climate change increases. The increases in the exports of maize, oilseeds, other field crops and food are mainly driven by the declining domestic prices due to the elimination of tariffs. This effect gets significant over time as

[8] The change in exports is same for all regions due to the constant CET elasticity assumption.

climate change reduces the production of these commodities significantly and causes more import substitution. Manufacturing exports decline slightly following the small increase in domestic prices. However, exports of wheat, rice and cereals decline despite the fall in their prices. Decline in exports of these commodities is due to the decreasing production. Moreover, it should be noted that the imports of these commodities increase significantly. Contrary to what is observed for the other crops, the cost structure of wheat, rice and cereals makes those less competitive compared to other agricultural activities under climate change. Eventually they cannot compete with other activities for the factors of production, especially land.



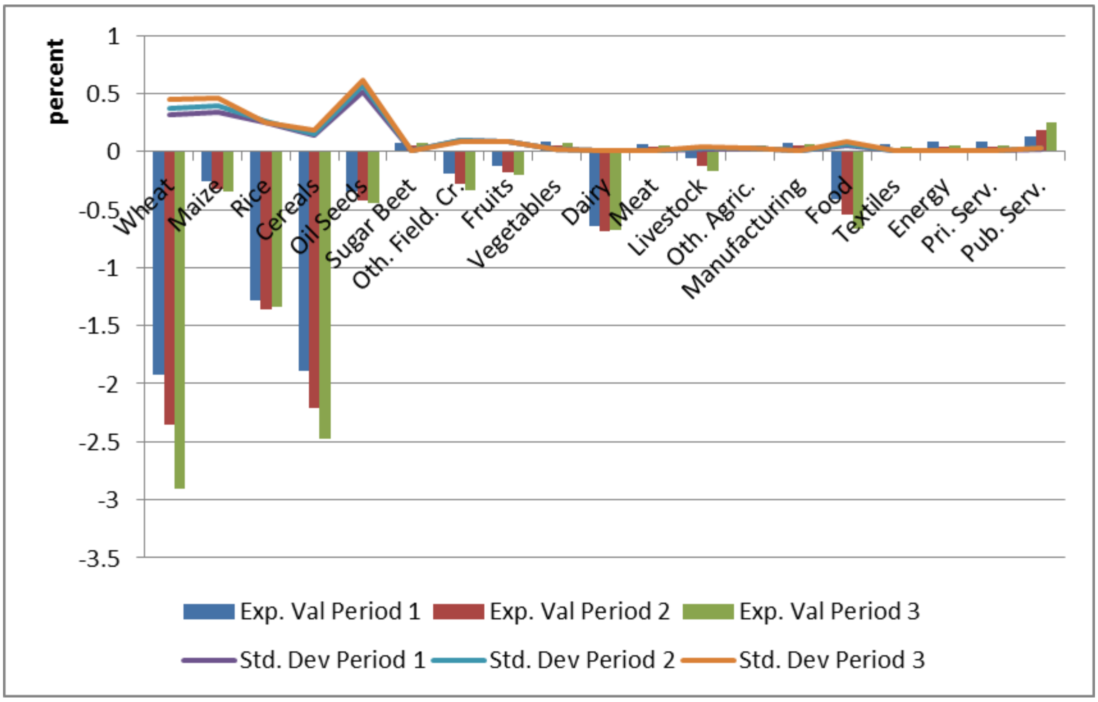
Source: Model Results.

Figure 3.17: Change in exports (percentage deviation from climate change scenario)

Standard deviation of exports does not change over time but it varies significantly across crops. Standard deviation is significantly higher than what was expected for all crops, implying that Turkish exports are sensitive to the changes in world prices. Hence we can conclude that exported crops face higher climate risk.

Domestic prices can adjust depending on the market conditions dictated by trade liberalization. Households demand shifts to the imports which become relatively cheaper due to the elimination of the tariffs. Decline in demand for the domestic goods decreases the domestic prices. However, indirect effects work on the other direction. Decline in domestic prices may cause exports to become more attractive. Consequently, the final effect depends on the substitutability of the domestic commodities with the imports and demand elasticity of exports. If a commodity is not traded or has low protection then the effect is negligible, since the only impact is through income and substitution effects on household demand.

Prices decline for all agricultural commodities except sugar beet, vegetables, meat and other agriculture (Figure 3.18). Small positive changes in the prices of these commodities can be explained by the fact that sugar beet and meat are not traded while protection on vegetables and other agriculture is quite low. The decline in the prices of other commodities is higher over time, with the most significant changes being observed for wheat, rice and other cereals for which export demand also declines. Small changes in the prices of oilseeds, other field crops and fruits are due to increasing export demand after the trade liberalization. Prices of commodities of non-agricultural sectors also increase but the changes are negligible.



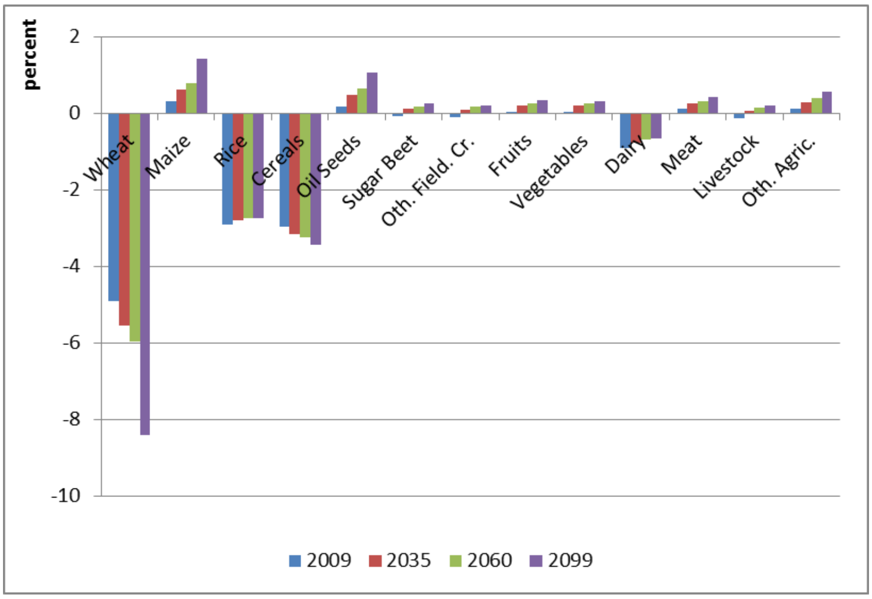
Source: Model Results

Figure 3.18: Domestic prices of agricultural commodities (percentage deviation from climate change scenario)

Standard deviations of the domestic prices under the different world price assumptions are higher for wheat, maize, rice, cereals and oilseeds. Low expected values and high standard deviations for maize, cereals and oilseeds prices suggest a significant variation and hence sensitivity to the changes in world prices. The standard deviations are quite low for other commodities. This implies the fact that the variations in world prices of the agricultural commodities are not transmitted to the domestic prices of the manufacturing and services sectors. This holds true even for the sectors such as food processing and textiles which have strong linkages with agriculture.

3.3.2.3 Production, Employment and Food Security

The effect of trade liberalization on agricultural production is significant (Figure 3.19). Cereals are generally more affected compared to the other activities. The production of wheat, rice and other cereals declines while the production of maize and oil seeds increases. Moreover, declines pertaining to the production of highly protected cereals seem to be substantial: between 2 and 4.5 per cent. In general, as effects of climate change are worsened, the declines get higher, especially for wheat.

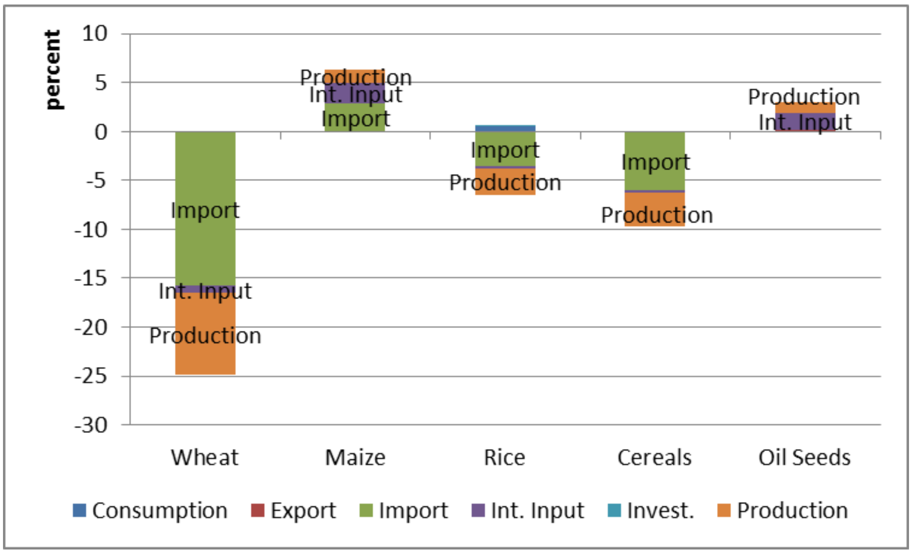


Source: Model Results

Figure 3.19: Change in agricultural production (percentage deviation from climate change scenario)

The main driver for the change in production is substitution of imports with domestic products (Figure 3.20). The contribution of production and imports on the change in the amount of composite commodity is negative for the commodities of which production declines. This implies the fact that a decline in production and increase in imports. Although one may expect export demand to increase and drag up the production, this effect remains limited.

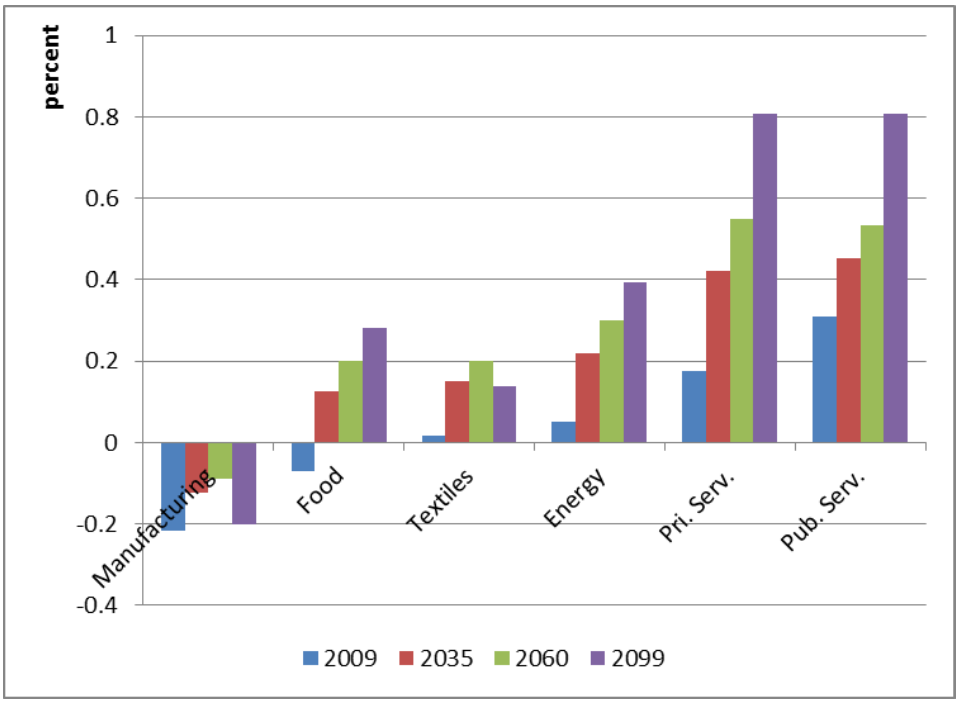
The upsurge in maize and oilseeds production is significant especially in the final period of the simulations. The main drivers of this upsurge are the substitution of domestic products with imports, and the increasing demand for maize as an intermediary input. The production of oilseeds increases due to the increasing demand as an intermediate input. Hence, the impact of trade liberalization on agriculture is quite diverse depending on the commodity, and it is determined more by the structure of production, rather than the structure of demand.



Source: Model Results

Figure 3.20: Decomposition of the change in agricultural production in 2099 (percentage deviation from climate change scenario)

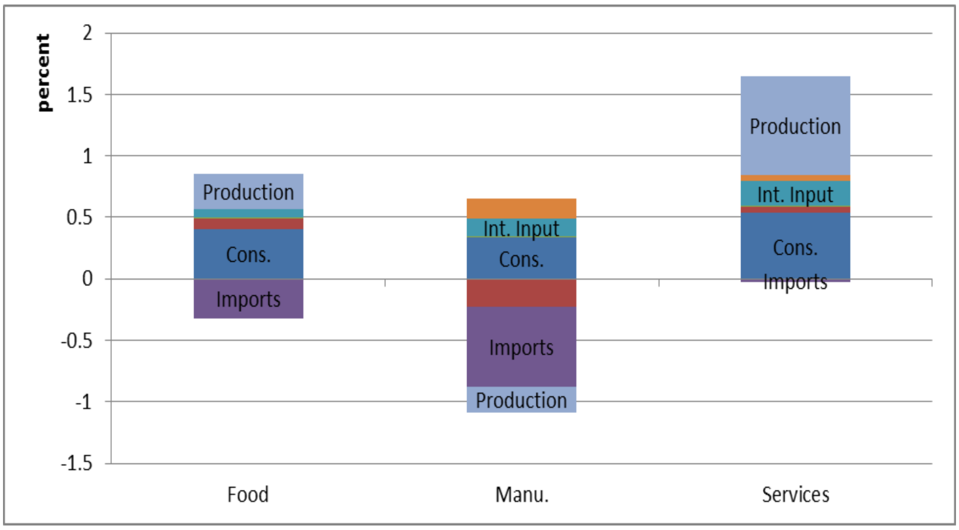
The effects of trade liberalization on the production of other commodities are small (Figure 3.21). The production of manufacturing products and services declines while the production of food increases. The latter is due to the fact that agricultural commodities which become relatively cheaper are the main inputs for the food production.



Source: Model Results

Figure 3.21: Change in production of non-agricultural commodities (percentage deviation from climate change scenario)

The effects on production of non-agricultural sectors are also higher in the final period. The main driver for the change in the production of manufacturing sector is also the substitution of imports with domestic products (Figure 3.22). Decreasing demand for exports, due to increasing relative price of manufacturing goods, also plays an important role in decreasing the production. The combined effect of these two factors dominates the positive contributions of increasing investments and intermediate input demand.

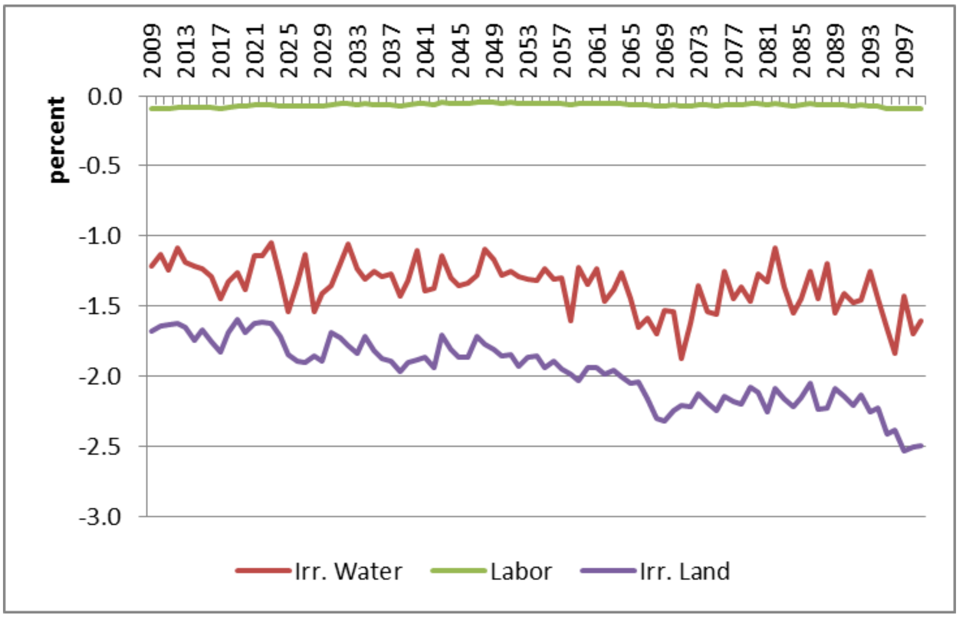


Source: Model Results

Figure 3.22: Decomposition of change in quantity of composite good in 2099 for non-agricultural sectors (percentage deviation from climate change scenario)

Changes in the use of factors under trade liberalization scenario are given in Figure 3.23. The use of capital, rainfed land and industrial water is predetermined by the closure rule which assumes a full employment for these factors. Growth in the supply of rainfed land and industrial water is determined by the growth of capital since we assume that the growth of these factors is equal to the 25 percent of growth of capital.

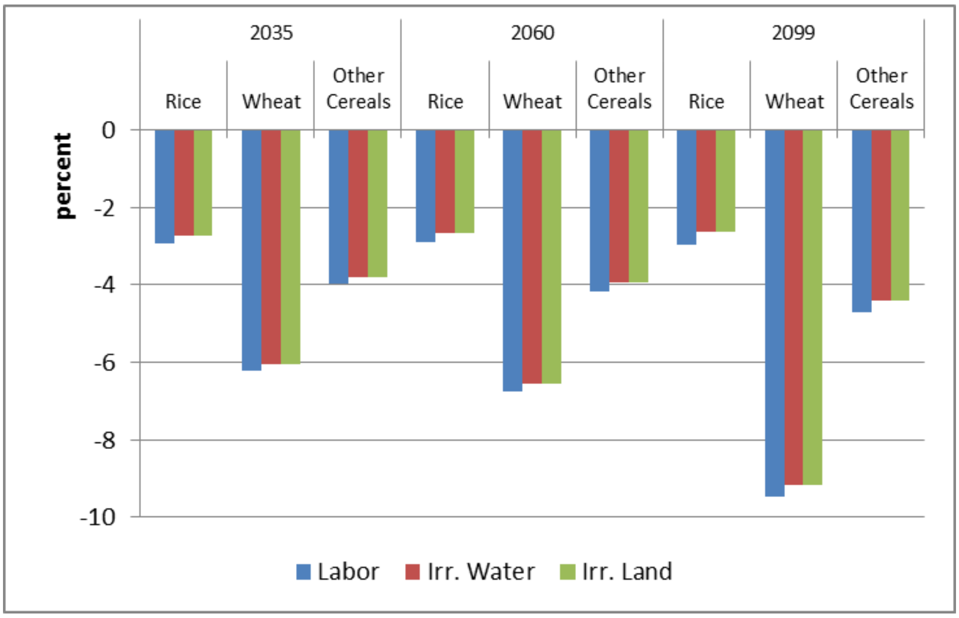
In the model, the use of irrigated land, irrigation water and labor is considered endogenous and is therefore not governed by the closure rules. Employment of irrigated land and irrigation water declines significantly under trade liberalization. The main reason for this fall is the decline in the production of rice, wheat and other cereals. As these sectors become uncompetitive under climate change due to the decreasing productivity, they substitute land and water with other factors or inputs. Consequently these factors are employed less.



Source: Model Results

Figure 3.23: Total factor employment (percentage deviation from climate change scenario)

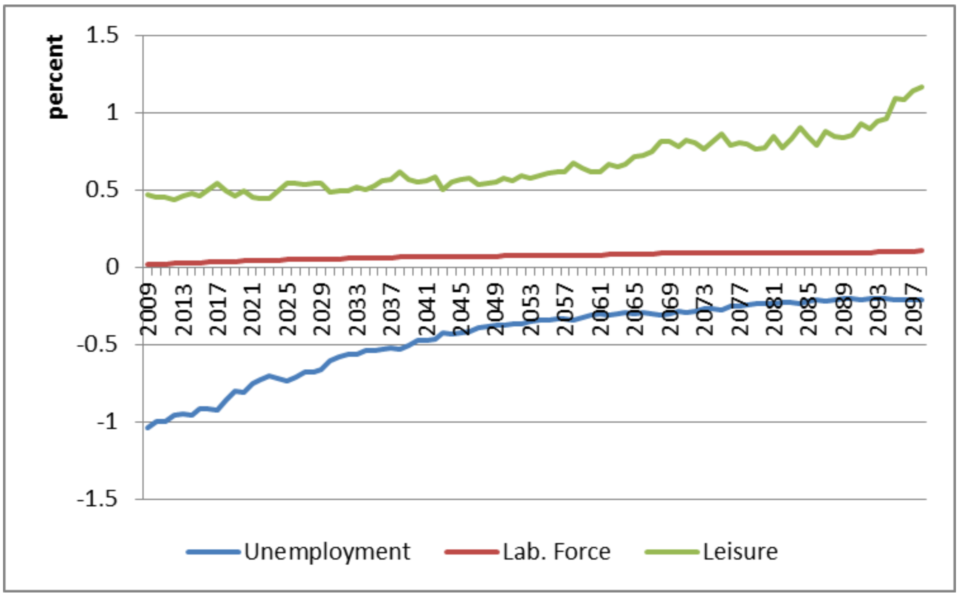
Wheat, cereals and rice are the sectors that are most affected from in terms of change in factor employment. The impact of climate change on the production of these sectors is also highest. The significant decline is mostly due to the substitution of intermediate inputs with the factors of production, especially with irrigated water and irrigated land. As factors become less productive, producers change their production techniques to reduce the employment of factors. However, since the capital, rainfed land and industrial water are fully employed, the substitution occurs between irrigated land - irrigation water composite and intermediate inputs (Figure 3.24). Labor that is outlaid from these sectors is absorbed by other sectors which increase their production. However, irrigated land and irrigation water is mostly left unemployed.



Source: Model Results

Figure 3.24: Factor use in selected sectors (percentage deviation from climate change scenario)

Unemployment declines at a slow pace over time (Figure 3.25). The reason for observing declining unemployment together with a decline in employment of labor in all sectors is mainly due to the declining labor supply by households. The labor force increases slightly as a result of an increase in real wages, however the leisure demand by households also increases, especially in the final period. This means that a significant part of the increasing population does not participate in the labor market. This also means that household will limit the supply of labor to avoid a significant decline in wages under the trade liberalization. Instead, "new comers" contributes to the household utility as leisure. Consequently, unemployment rate declines together with the employment. The increase in leisure demand is mainly due to the income effect. Actually, increase in the consumption of leisure is not higher than the increase in the consumption of the other commodities.

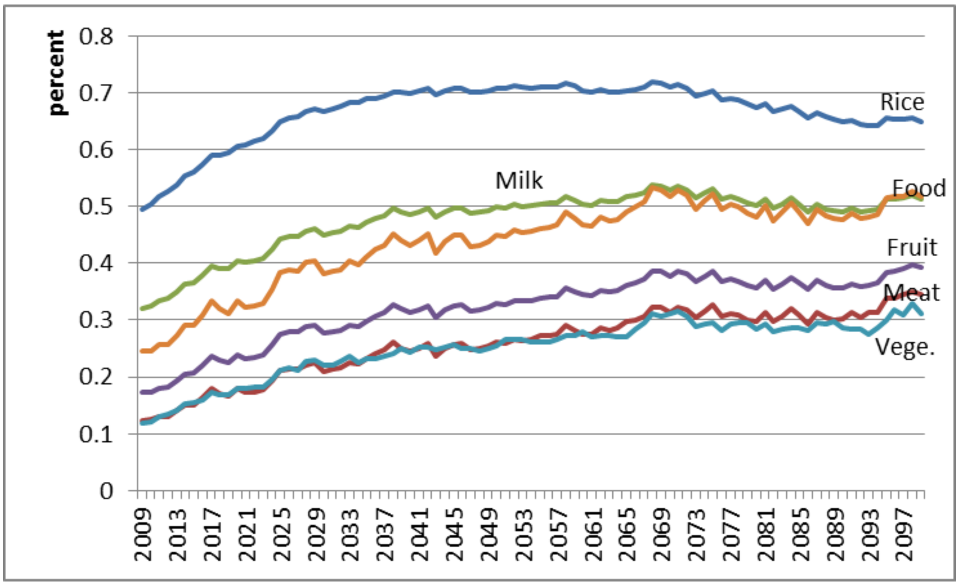


Source: Model Results

Figure 3.25: Unemployment, labor force and leisure (percentage deviation from climate change scenario)

Consumption increases under trade liberalization as a result of declining agri-food prices and increasing (or at least non-decreasing) household incomes (Figure 3.26). However the increase is not uniform across commodities. The consumption of agri-food products increases at an increasing pace in the first two periods. In the final period the increase stabilizes.

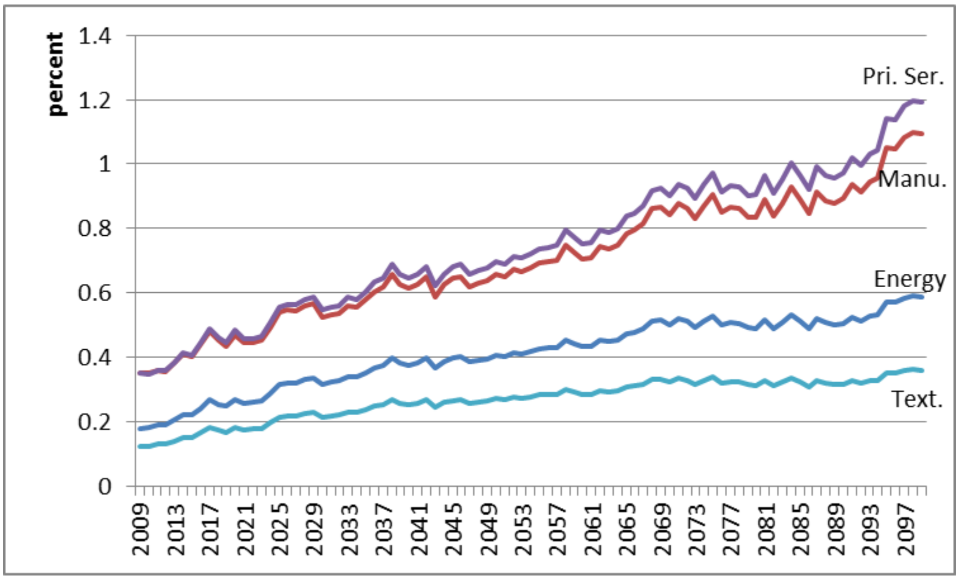
The most significant increase is in rice, meat, milk and processed food. Protection is very high in the first three of these commodities and thus tariff elimination causes their prices to decline significantly. Therefore household demand for these commodities increases significantly following the trade liberalization. On the other hand, price of processed food declines due to the the declining costs of this sector as the price of the main intermediate inputs of this sector, e.g. agricultural commodities, declines.



Source: Model Results

Figure 3.26: Trade liberalization impact on agri-food consumption (percentage deviation from climate change scenario)

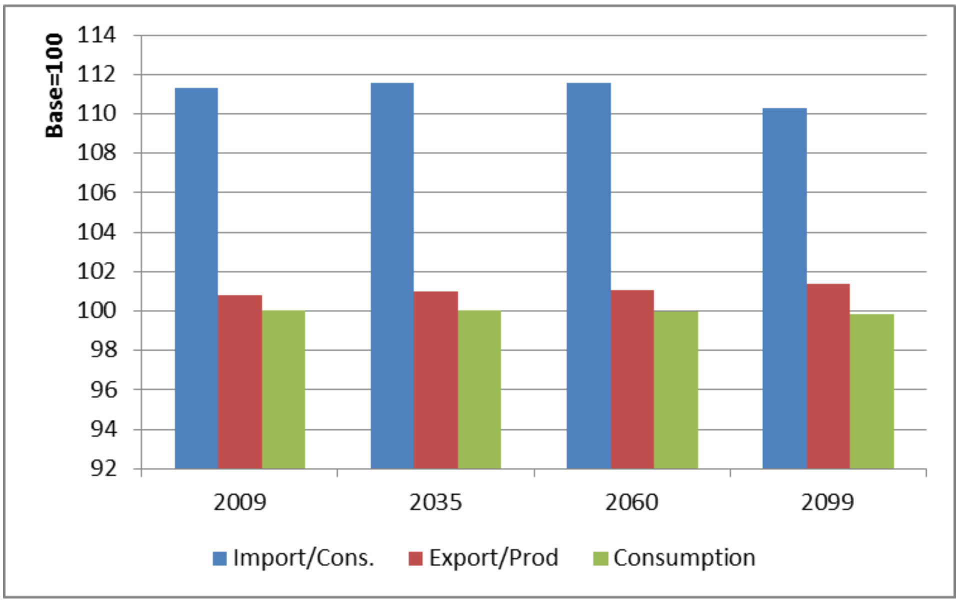
The consumption of manufactured goods and services maintain their increasing pace even in the final period (Figure 3.27). Manufacturing and services constitute almost 60 percent of the total consumption; hence the increase in their consumption is normal despite the slight increase in their prices. Lastly, the increase in the consumption of energy and textile commodities starts at a much slower pace and almost stabilizes at the end of first period.



Source: Model Results

Figure 3.27: Trade lib. Impact on non-agrifood consumption (percentage deviation from climate change scenario)

Increasing food consumption ensures the availability of more food for the population and can be considered as an indicator of increasing food security (Figure 3.28). Net exporter position of Turkey in food in the baseline does not change much under trade liberalization. The ratio of food exports to imports declines to approximately 1.45 in the first two periods, and to 1.20 in the second period as compared to the 1.60 and 1.3 in the climate change scenario. As mentioned above, this is mainly due to a higher increase in food imports compared to the food exports. The share of imports in consumption increases and larger part of the production is exported. However the difference between the value of imports and production, and the values of exports and consumption also increases. This leaves more intermediate inputs for the food industry and hence improves food security.



Source: Model Results

Figure 3.28: Food security indicators (percentage deviation from climate change scenario)

3.4 Conclusion

In this chapter we analyzed the effects of elimination of tariffs imposed on agricultural imports from EU under a climate change. For this purpose we simulated climate change and trade liberalization scenarios, by taking into account possible effects of climate change on world prices. The results show that climate change can cause a GDP loss as high as 3.5 percent. Main drivers of the loss in GDP due to climate change are the significant decline in private consumption, and up to two percent increase in imports.

Elimination of tariffs on imports from EU alleviates the negative effects of climate change only marginally for Turkey as is the case for many other regions in the world. The increase in welfare due to trade liberalization is very small compared to the loss caused by climate change. However, benefits from trade liberalization increases as the climate change effects worsen, especially after 2060. This is due to the fact that under trade liberalization the economic agents have more substitution possibility both in production and consumption.

Main adjustment mechanism of the economy under trade liberalization works through the substitution intermediate goods with factors of production, as well as substitution of domestic goods with imported goods. This causes significant changes at the sectoral level. Wheat, rice and cereals are the most affected commodities from trade liberalization, under climate change. They lose competitiveness against alternative commodities both in domestic and international markets, since the climate change reduces their yields substantially. Their production, exports and prices decline simultaneously and substitution of domestic production with imports is highest in these commodities.

Maize, oilseeds, fruits and processed food benefit from trade liberalization. Their production and exports increase, domestic prices decline while imports remain unchanged or increase slightly. Factors of production are directed towards the production of these commodities as they become relatively more competitive after the climate shocks.

Imports from the EU27 countries increase significantly and this causes domestic prices to decline in the trade liberalization scenarios. Consequently, production of agricultural commodities falls. Since the decline in domestic prices is lower than the tariffs imposed to the other trading regions, prices of agricultural imports from the other regions increases. This causes aggregate imports to decline. Hence, trade liberalization with EU causes an “overcrowding” effect and decreases imports from other trading regions. Food consumption increases under trade liberalization. As a result, trade liberalization increases food security.

The findings from the simulation exercises suggest that although overall welfare effect of trade liberalization is limited, it increases the economy’s ability to adapt by fostering reallocation of scarce domestic resources to more efficient sectors. This occurs as imports and domestic commodities become more substitutable.

The analysis in this chapter provides several paths for the improvement of the model’s structure and scenario design. For instance, other countries will also be affected by the climate change, and this is likely to be reflected in their demand for Turkish commodities and their supply of commodities to Turkey. This can change the implications of climate change and trade liberalization for Turkey. Secondly, bilateral trade liberalization with the EU is not the only policy option for Turkish policy makers. Trade liberalization with the other countries/regions can have amplified effects. Lastly, analysis in this chapter uses the results of only one GCM to calculate the economic shock parameters; however various estimates by different GCMs are available. The results can be altered by different climate change scenarios reported by different GCMs. In the next chapter, we will extend our analysis to the global scale to compare various trade policy alternatives for Turkey by taking into account the results of different GCMs.

CHAPTER 4

TRADE POLICY AS A GLOBAL ADAPTATION MEASURE TO CLIMATE CHANGE

Simplicity is the ultimate sophistication.
Leonardo da Vinci

The physical effects of climate change in different parts of the world will depend on various factors including geographic location, soil type, and land use pattern. Nevertheless, the atmosphere is globally shared making climate change a global issue. The outcome of the climate change include more frequent heat waves, droughts, extreme precipitation, and related impacts (such as wild fires, heat stress, vegetation changes, and rising sea level); all of which will be regionally dependent (Karl et al., 2003). The impact on a country's economy will differ according to the country's mitigation and adaptive capacity which is in turn determined by many economic and social factors including its development status, income distribution, structure of production, and integration to the international markets. Hence the final impact of climate change will be determined by the interaction of various regional effects throughout the world. One important link for this worldwide complex interaction is international trade. The effects in a country can be spread to other regions or can be accommodated for by the international markets. Thus, to complement our analysis in the previous chapters, we extend our analysis to see how the relationship between trade liberalization and climate change would change when taking into account these global dynamics.

Economic effects of climate change at the global level have been the topic of a vast literature. Various methods have been employed to translate the physical effects to economic shocks. The most popular way has been through the introduction of climate change shocks to the agricultural sector as changes in yields and/or irrigation requirements. Although no consensus has been reached in these studies, some general results can be derived. The results suggest an average negative welfare effect between one percent to two percent of GDP at the global level (Calzadilla et al., 2010; Tol, 2012). The effects are generally considered weak due to the smoothing of economic adaptation (Arndt, Chinowsky, et al., 2012; Bosello et al., 2010). They display some diversity depending on location, time, sectors and social groups. Country level analyses suggest more significant effects, both positive or negative, especially in the Middle East (Sowers et al., 2010; World Bank, 2010), Africa (Arndt, Farmer, et al., 2012; Pauw et al., 2010; Thurlow, Dorosh, et al., 2012; Thurlow, Zhu, et al., 2012) and South Asia (Thurlow, Dorosh, et al., 2012).

The impact of climate change depends highly on the adaptive capacity of the social groups or countries considered. Crop pattern, long-run assets such as physical infrastructure, investment capacity in adaptation measures are reported to be important factors (Arndt, Chinowsky, et al., 2012). Poor people and small farmers, as well as most developing countries are more vulnerable to adverse effects (Bosello et al., 2005; Thurlow, Zhu, et al., 2012). Sectoral effects are also diverse. Most studies report negative effects on agriculture (Bosello et al., 2005; Calzadilla et al., 2010; Nelson et al., 2009; Rosegrant et al., 2008), while some (Tol, 2012) present possible positive effects. The effect on agriculture is mostly felt through water availability (Nelson et al., 2009). Hence drought resistance of major crops grown in a region, cropping pattern and farm structure are important in determining final effects on agriculture. The effects can vary, not only among different crops, but also among different varieties of the same crop (Thurlow, Dorosh, et al., 2012).

Negative effects on agricultural production bring about food security concerns (Arndt, Farmer, et al., 2012; Calzadilla et al., 2011; Dell et al., 2008; Nelson et al., 2009; Rosegrant et al., 2008). Poorer households (Thurlow et al., 2009) and urban population (Pauw et al., 2010) are hit the hardest by food shortages under climate change. Child malnutrition is likely to increase with declining calorie intake (Nelson et al., 2009; Rosegrant et al., 2008).

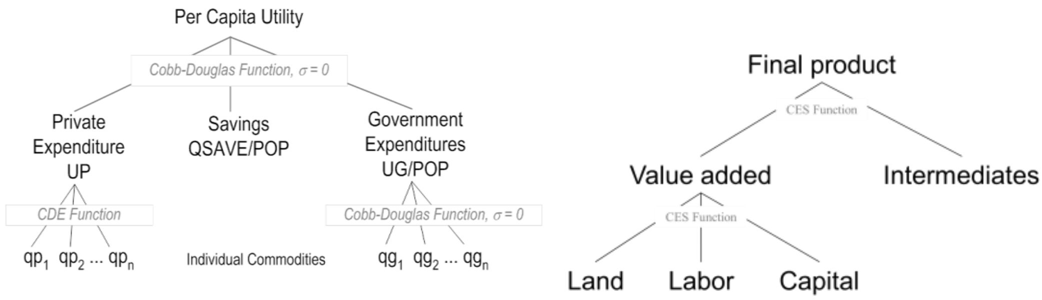
The link between trade liberalization and climate change has been the analyzed by a few studies. The main argument in the literature is that trade liberalization can alleviate the negative effects of climate change by boosting international trade. Trade liberalization is reported to have welfare-improving effects (Calzadilla, Rehdanz, & Tol, 2011; Chen, McCarl, & Chang, 2012; Laborde, 2011; Reilly & Hohmann, 1993). However these effects are generally weak and are not sufficient to compensate for adverse effects of climate change (Randhir & Hertel, 2000; Reilly & Hohmann, 1993). Welfare gains from trade liberalization depend on the elimination of production and export subsidies (Randhir & Hertel, 2000). The effects are not uniform and depend on the geographic location (Calzadilla et al., 2010; Reilly & Hohmann, 1993) and the vulnerability of the region to climate change (Reilly & Hohmann, 1993). Changes are expected to affect more the poor people (Laborde, 2011). The studies that consider the effects of trade liberalization under climate change do not report any specific results or implications for Turkey.

In this chapter we will analyses the effects of climate change at the global level and evaluate the effects of various trade policies as an adaptive measure by using the GTAP model. GTAP is a detailed global CGE model that is used extensively in the literature for trade policy analysis. Our version has 16 regions and 15 activities that are aggregated from the GTAP 7 database. We follow the same approach adopted in Chapter 3. We first introduce yield shocks based on 25 different climate projections to obtain our baseline and then analyses the consequences of different trade liberalization scenarios by benchmarking the simulation results to these baselines. The rest of the chapter is organized as follows: Section 4.1 summarizes the modelling approach and data. Then, a detailed description of scenarios follows. In section 4.3 we present the simulation results. The final section is reserved for concluding remarks.

4.1 Modelling framework: GTAP Model

GTAP is a multi-regional global static CGE model that represents the behavior of households, producers and governments in each region following the standard assumptions of the general equilibrium theory. Figure 4.1 shows the basic structure of consumption and production in GTAP model. Households are utility maximizing agents that receive all income generated in the economy. They spend it on private consumption and save according to a Cobb-Douglas utility function. Income is generated by skilled and unskilled labor, land, capital and natural resources that are owned by households as endowments. Private consumption is distributed between different commodities according to a non-homothetic Constant Difference of Elasticity (CDE) implicit expenditure function, while government consumption is distributed by a Cobb-Douglas function. Government consumption decision is done by households' utility maximization decision. Therefore tax revenues return back to households as income. Households also consume imported commodities both for private and government consumption. Imported commodities are bought directly from the rest of the world. The consumption of imports is modeled with Armington specification. Hence imports and domestic consumption are not perfect substitutes. The saving decisions of household are made at the same time as their consumption decisions. The sum of the savings accumulated by the households in all regions is distributed among regions and sectors according to the price of capital. Hence, savings drive investments and the model closure is essentially neo-classical in nature. Investments change only the capital stock of the sectors and are not related to technological change or productivity.

Producers are profit-maximizing agents that produce various commodities according to a Constant Elasticity of Substitution (CES) production function by using intermediate inputs and factors supplied by households. Firms use both domestic and imported intermediate inputs and the substitution between these two follows the Armington specification.



Source: GTAP (2011)

Figure 4.1: Structure of consumption and production in GTAP Model

A detailed documentation of the model can be found in (Hertel, 1997) and (Brockmeier, 1996). A graphical representation of the GTAP model structure can be found in the Appendix Figure D.1. We use GTAP database Version 7 that consists of bilateral trade, protection and transport data as well as national accounts of 113 regions that spans the entire world for the year 2004. We also used the Land Use Data Base[9] of GTAP, which consists of a disaggregation of agricultural production and a harvested area by agro-ecological zones (AEZ). It covers 57 sectors, four types of factors and one type of household. Turkey is represented as a single region in GTAP database. For this study, we aggregated the data of 16 regions and 15 sectors (see Table 4.1) to keep the analysis focused on Turkey.

[9] Land use data is based on FAO's 2004 data on production, harvested area and price. The AEZ structure is based on the SAGE database which consists of 6 categories identified by the length of growing period (LPG), and divides the world into three climatic zones, namely: tropical, temperate, and boreal.

Table 4.1: Regional and sectoral aggregation in the GTAP model

Regions	*Sectors*
Oceania	Paddy, rice
East Asia	Wheat
Southeast Asia	Coarse grains
South Asia	Vegetables, Fruits
Canada	Oilseeds
United States	Sugar crops
Rest of Latin America	Other crops
Brazil	Dairy, Livestock
OECD Europe	Extract
Rest of the Middle-East	Vegetable oil
Eastern Europe	Other processed food
Former-USSR	Textile, Apparel
Turkey	Manufactures
Rest of North Africa	Utilities, Construction
Morocco	Services
Sub-Saharan Africa	

4.2 Scenario Design

We simulate four scenarios to analyze the effects of trade liberalization under climate change. We first simulate a set of baseline scenarios (BASE) for each climate projection and introduce only the climate change shocks. Then we run three trade liberalization scenarios for each one of these baselines: Bilateral trade liberalization between EU and Turkey (EU); world-wide trade liberalization in agriculture (AGRI); and world-wide trade liberalization in all commodities (FULL)[10].

Quantification of the physical effects of the climate change is accomplished generally by using General Circulation Models (GCMs) that incorporate various

[10] We also simulated agricultural trade liberalization with EU scenario but we will not present the results here, since they are not very different from the full trade liberalization with EU scenario. Negligible difference between the two scenarios is due to already low protection on non-agricultural products because of the Customs Union Decision. See Chapter 3 for details.

global climate scenarios. There are several GCMs that try to project the future state of the climate at the global level (Randall et al., 2007). However, the results and conclusions of different GCMs diverge substantially (Fischer et al., 2005; Schönwiese et al., 1987; Stern, 2006). One can think of these different results as a description of different probable futures. If we imagine the realized future as a draw from a probability distribution, then the results of different GCMs can be considered as a sampling from this probability distribution which is defined by the mean and variation of the main climatic variables such as temperature and precipitation. Since the yield estimates are functions of these climate variables, they can also be considered as stochastic variables that also come from a probability distribution. Consequently, using the results of as many GCMs as possible will increase the accuracy of the estimates by making it possible to span a large number of probable futures.

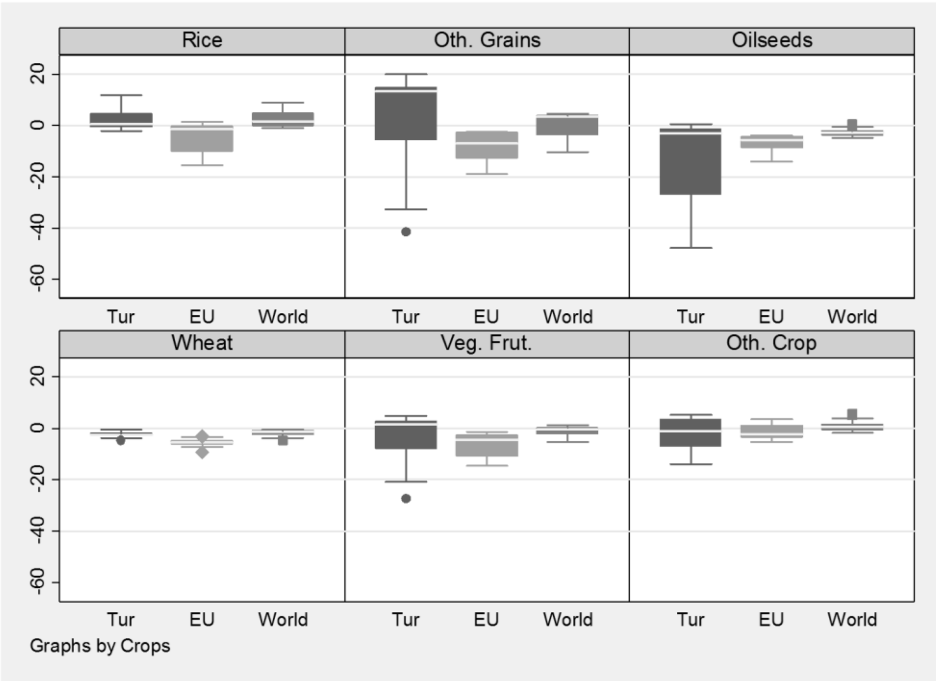
The set of scenarios that are used by GCMs creates another source of variability in the state of future climate. These scenarios are generally composed of various assumptions about the economy (GDP and population growth, consumption and production patterns, energy use, GHG emissions etc.) and society (political systems, international relations, culture, life style etc.). Assumptions are generally supported by a storyline that is, in turn, backed up by expert opinion and/or results of various qualitative or quantitative analyses. Hence, even if only one GCM is used, each simulated scenario will provide results that would reflect one draw from the probability distribution of future state of the global climate. The most popular set of scenarios about the future state of the world are developed by IPCC emission scenarios (Bates et al., 2008).

Following this line of reasoning, we collected estimates of future yield changes caused by climate change from two different sources: IFPRI Food Security CASE Maps database (IFPRI, 2012) and the Integrated Model to Assess the Global Environment (IMAGE) Project’s database (IMAGE Team, 2009). Both sources use an integrated approach to derive yield changes from the results of different GCMs under different climate scenarios. The IFPRI database provides global projected yield impacts for six crops (rice, wheat, maize, cassava, groundnut, and soybean) with a wide range of scenario specifications for five year increments over a period ending in 2050. The effects of climate change are translated to yield shocks by using a biophysical model. The climate scenarios introduced to the crop model follow from two different GCMs (namely CSIRO and MIROC) used to simulate pessimistic, optimistic and normal versions of A1B and B1 SRES scenarios. The database also supplies results of pessimistic, optimistic and normal versions of a perfect mitigation scenario. Hence IFPRI database contains yield estimates for 15 different probable futures. A detailed description of the models and the database can be found in Nelson et al. (2010).

The IMAGE database provides global yield impacts for 14 crop categories under four SRES scenarios (A1B, B1, A2, and B2), and covers 17 regions/countries until 2100. The projected yield impacts are generated via terrestrial models in the IMAGE framework which are coupled to the LEITAP model, by using input data such as CO_2 concentration, cloudiness, temperature and precipitation as projected under each SRES climate scenario. IMAGE contains the impact of 10 different climate change scenarios. Detailed description can be found in Hoogwijk et al. (2005) and Bouwman et al. (2006).

The autonomous productivity growth, which exists in both models as an exogenous TFP increase, is deducted from the yield change estimates. The regional and crop dimensions of the yield shocks calculated from these databases are aggregated to synchronize them with the dimensions of GTAP. We used average yield changes weighted according to the production area of different crops in different regions. We also treated the change in the yields of irrigated activities separately by giving a relatively higher share to them in the weighting.

The distribution of yield changes for Turkey under all climate scenarios is given in Figure 4.2. Average yields of oilseeds, wheat and other crops decline while the average yields of rice, other grains and vegetables and fruits increase. The increase in average value is quite susceptible due to high variability in the yield changes of these crops in different climate scenarios. For grains, the minimum change is around -35 percent, while it is lower than -20 percent for vegetables and fruits. The variability in yield change is generally higher for Turkey compared to the EU and the world averages, except for wheat. However the distribution is right skewed for all crops except rice which means that the probability of optimistic scenarios is higher.



Source: Authors' Calculation from Hoogwijk et al., (2005) and Bouwman et al., (2006)

Figure 4.2: Distribution of yield changes for Turkey, EU and World (percentage change)

Yield changes for the EU are generally negative but less volatile. Thus, Turkey is likely to be affected more by climate change compared to the rest of the world. The distributions of yield changes for the other regions are given in Figure D.2. The estimates are in line with the expectations, in the sense that adverse effects on Africa and Middle East are higher compared to the other regions while Oceania and Canada turns out to be benefiting from climate change in terms of yield changes.

We introduce these yield changes as productivity shocks to the respective sectors and regions. The results are then used to obtain 25 different baselines, which in turn are used as the benchmark of the trade scenarios. Trade liberalization scenarios are run on top of each baseline separately to obtain 25 different results for each trade scenario. The first trade scenario is based on bilateral tariff elimination between Turkey and European countries. Then we simulate global trade liberalization in agricultural trade by eliminating tariffs imposed in all regions on agricultural commodities. Lastly, we eliminate all tariffs imposed on all commodities by all regions to analyze the effects of a full global trade liberalization scenario.

Table 4-2: Summary of scenarios

Trade scenario	Description
BASE	Climate change only
EU	Climate change + Tariff elimination on all tradable commodities between OECD Europe + Eastern Europe and Turkey
AGRI	Climate change + Global tariff elimination on all agricultural tradable commodities
FULL	Climate change + Global tariff elimination on all tradable commodities

4.3 Results and discussions

4.3.1 Effects of Climate Change

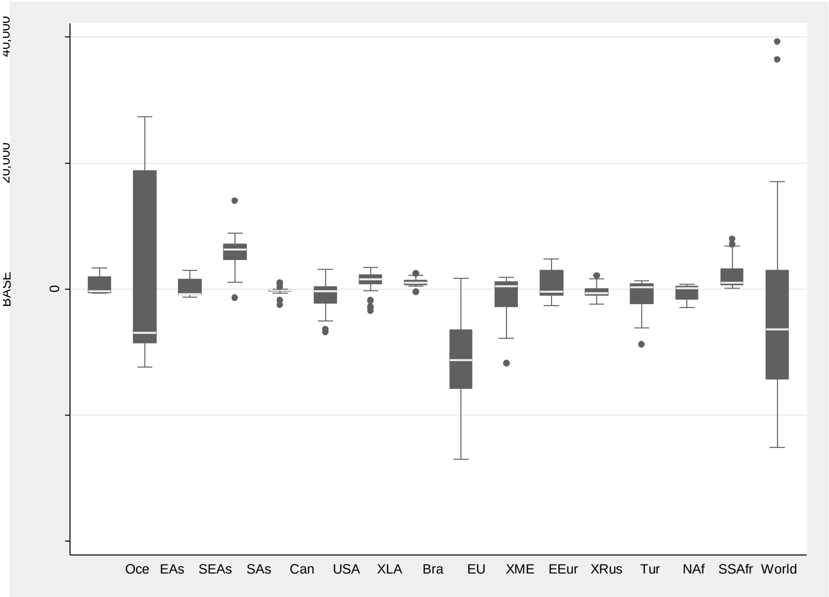
The distribution of the equivalent variation (EV) is given in Figure 4.3 as a box plot[11] for all regions. The global EV varies quite significantly for the different

[11] The vertical line at the end of spikes shows the upper and lower adjacent values. The box covers 25th and 75th quintiles. The white line inside the boxes shows the value of median. The dots outside the spikes show outliers.

climate change scenarios. The minimum is about a $20 billion loss, while the maximum is as high as a $40 billion gain. The median of world EV is reduced to about a $9 billion loss[12] when the two extreme outcomes are considered as outliers. The maximum welfare loss is around 0.1 percent of the global consumption, which is also small. However, it is important to note that the world EV is sum of the EV for different regions, and therefore a small impact at the global level does not necessarily imply negligible effects at the regional/country level. For example, for Turkey and the EU maximum welfare losses are around 0.3 percent of initial consumption level, which is much higher than the global average. East Asia and Europe are the most adversely affected regions. In all regions, the median EV is generally negative except South Asia and South America. On the other hand, for Sub-Saharan Africa[13], South Asia and Latin America almost the whole distribution is above zero implying a high probability of welfare gains for these regions. These regions are actually benefiting from climate change and the productivity shocks implemented to the agricultural production of these regions is generally positive (see appendix Figure D.2). For the rest of the regions the distribution of the EV spans both negative and positive values, suggesting an uncertain outcome but the distribution is not very dispersed and is centered around zero.

[12] This corresponds to 0.04 percent of the initial world consumption.

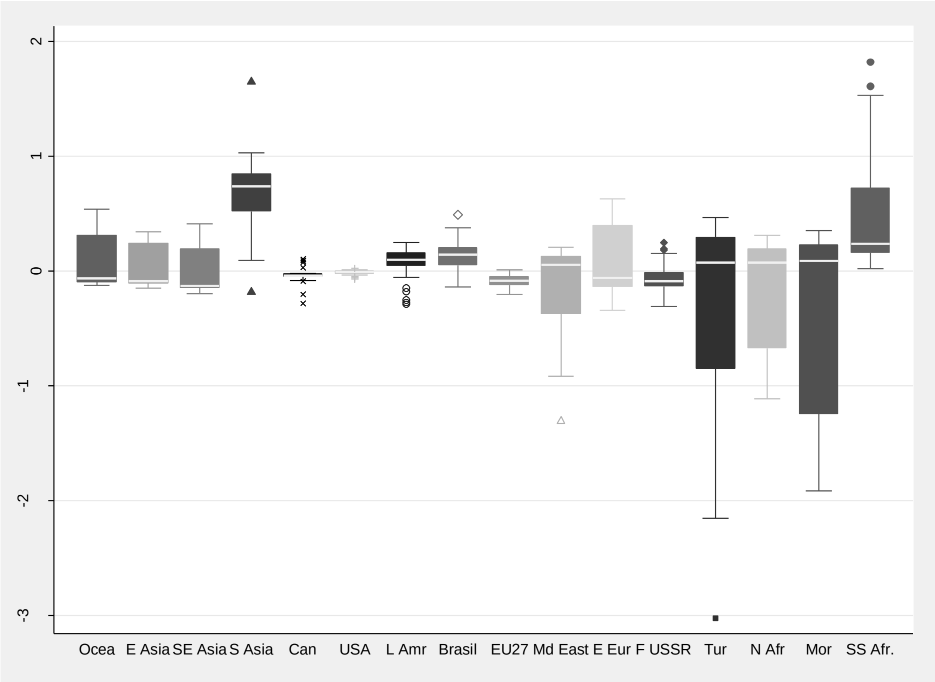
[13] The performance of GCMs is quite questionable for Sub-Saharan Africa. Precipitation projections which are the main driver of the change in yields are particularly unreliable. Hence the positive effects in Sub-Saharan Africa can be due to the bias in GCMs. A comparative analysis of controversial results of different GCMs in Sub-Saharan Africa can be found in Müller (2009).



Source: Model Results

Figure 4.3: Distribution of EV for all regions in the model under baseline scenarios (USD million)

Changes in regional GDPs are more significant and have more disperse distributions (Figure 4.4). GDPs in South Asia and Sub-Saharan Africa increase under all climate scenarios, while the impact is small for USA, Europe and the Former USSR countries. The benefits from climate change are high for the former group while agriculture constitutes a relatively smaller part of the economy in the latter. However for Oceania, East and South East Asia the median value for the GDP change is slightly negative although the absolute value of positive changes in GDP are higher than the absolute value of negative changes. In Middle East and North Africa (including Turkey), the change in the median value is slightly positive but the negative changes are higher than the positive changes in absolute terms.

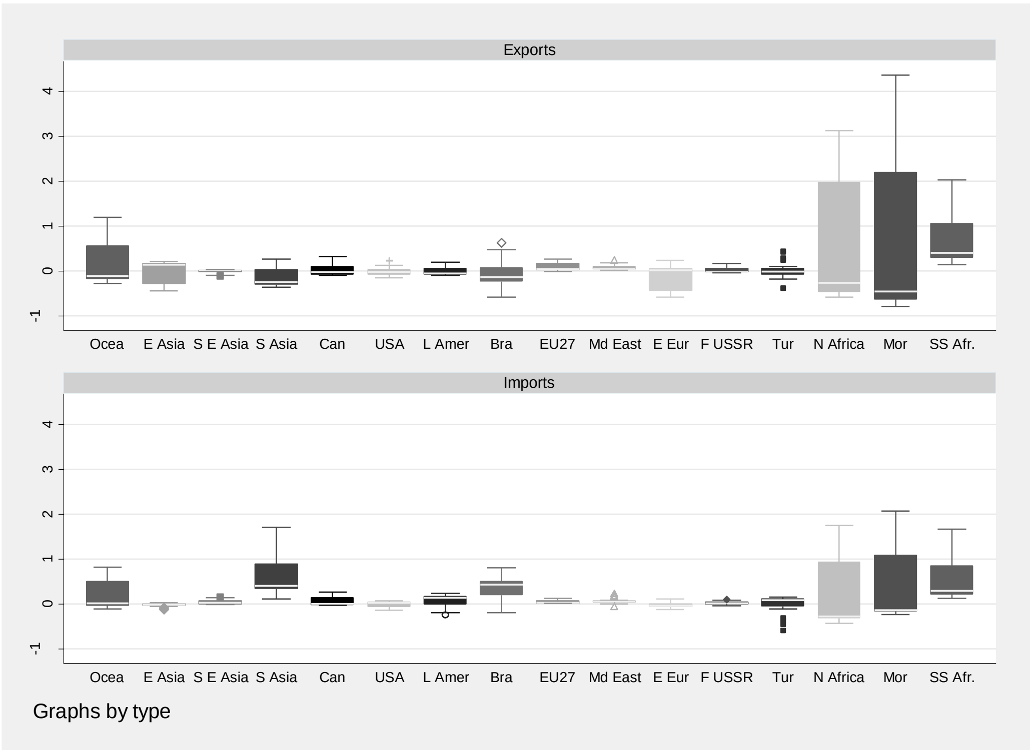


Source: Model Results

Figure 4.4: Change in GDP under climate change scenarios (percentage change)

Impact of climate change on international trade is rather limited. Distribution of the changes in imports and exports under climate change scenarios is given Figure 4.5. Change in international trade is non-negative for most of the regions. The impact is highest in North and Sub-Saharan Africa. These regions are among the most affected and vulnerable regions. The results suggest that exports will increase more than the imports in these regions as a result of increasing world price. In Turkey, the effects on the aggregate imports and exports are insignificant and indeterminate with slight decline in imports and slight increase in exports. Note that the regions suffering from negative impact increase their exports by benefiting from increasing world prices. Increase in imports suggests a substitution of imported commodities with domestic commodities to sustain consumption. No correlation is observed between the welfare gain under climate change and increase in aggregate imports. In Sub-Saharan Africa and Southeast Asia changes in EV and aggregate imports are both positive.

Overall, the welfare impact of climate change is negative for most of the regions but more pronounced in East Asia and Europe. The variation across the climate scenarios is high implying a significant degree of uncertainty. In South Asia, Sub-Saharan Africa, and Latin America welfare is improved mostly due to increasing imports and exports. Global trade liberalization improves the welfare of all regions and partially alleviates the negative effects for most of them.

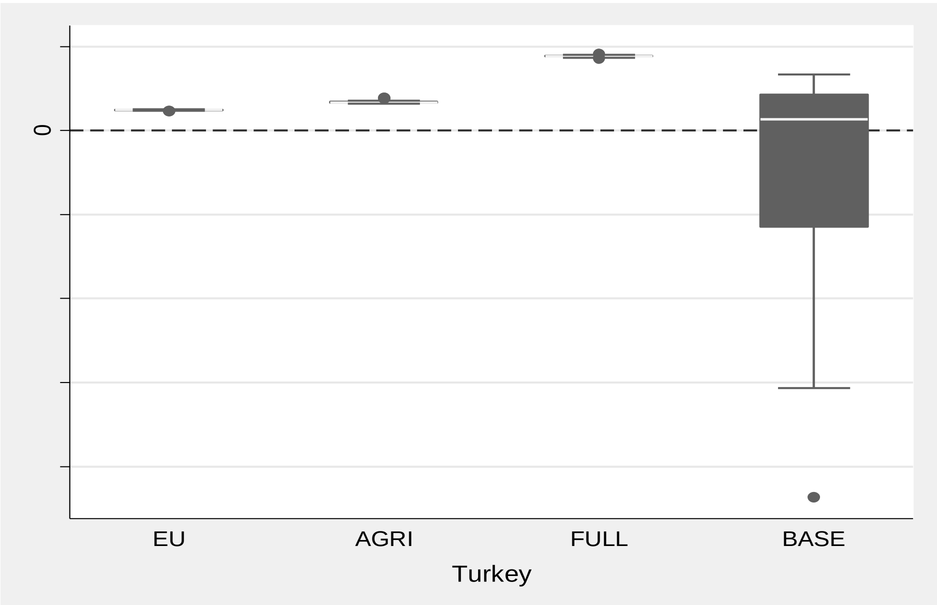


Source: Model Results

Figure 4.5: Change in aggregate imports and exports under climate change scenarios (percentage change)

4.3.2 Effects of Trade Liberalization

The distribution of welfare effects under trade liberalization and the baseline scenarios for Turkey is given in Figure 4.6. Firstly, note that the variation in EV is very small across the different baselines. Hence, the effect of trade liberalization on welfare is independent of the selected climate scenario. The effects of trade liberalization scenarios are magnified with the extent of liberalization. The welfare gain under the FULL scenario is higher than the negative effects of climate change for almost 75 percent of the climate change scenarios. However, gains from AGRI or EU scenarios are weak and hardly compensate for the losses observed under most of the climate change scenarios. The variation in the EV is very small across different climate change scenarios. Hence, welfare effect of trade liberalization is independent of the selected climate scenario. The effects of climate change on agricultural productivity do not change the structure of the global economy.

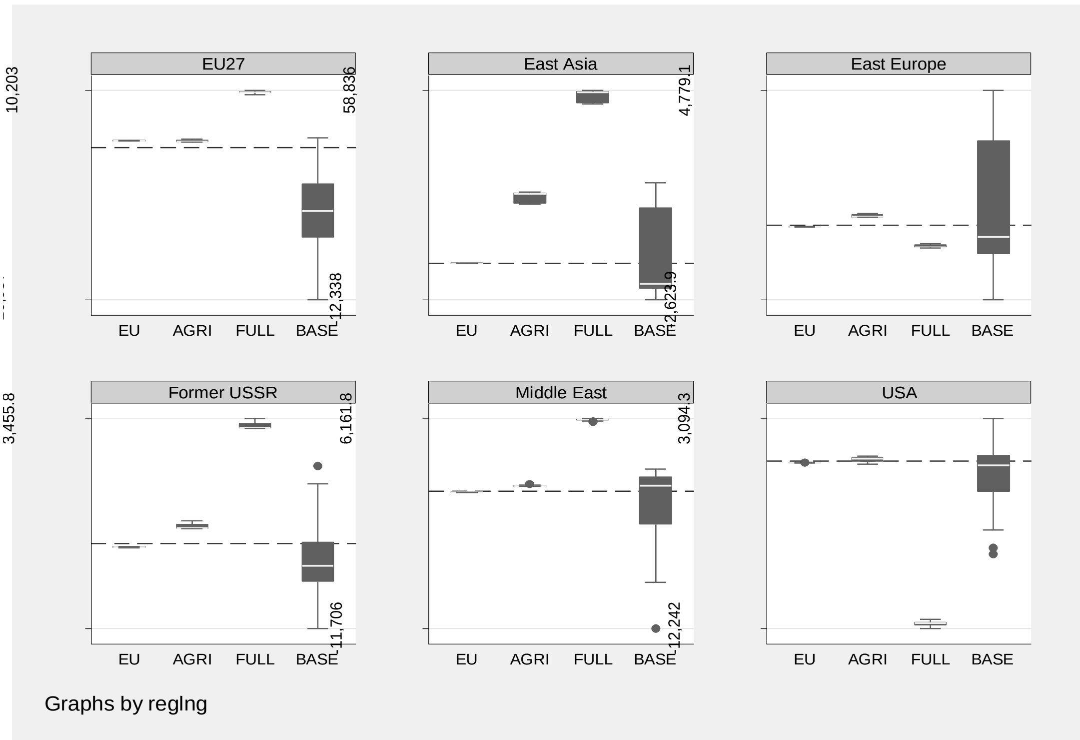


Source: Model Results

Figure 4.6: Distribution of EV for Turkey under all scenarios (million USD)

The EVs of Turkey's major trading partners under trade liberalization are displayed in Figure 4.7. The EV is generally positive under all trade liberalization scenarios for Turkey. However, as expected this is not true for all countries and regions. For example, gains for the USA from agricultural trade liberalization are close to zero while they are negative under full trade liberalization. Gains in the EV for the EU, East Asia and Middle East due to full trade liberalization are positive, and they are likely to recover the losses caused by climate change at least for the 75 percent of the climate scenarios.

Agricultural trade liberalization alleviates the welfare loss in East Asia. The effects are limited for other regions. The effect of trade liberalization between the EU and Turkey is also limited and hardly alleviates the negative impacts of climate change.

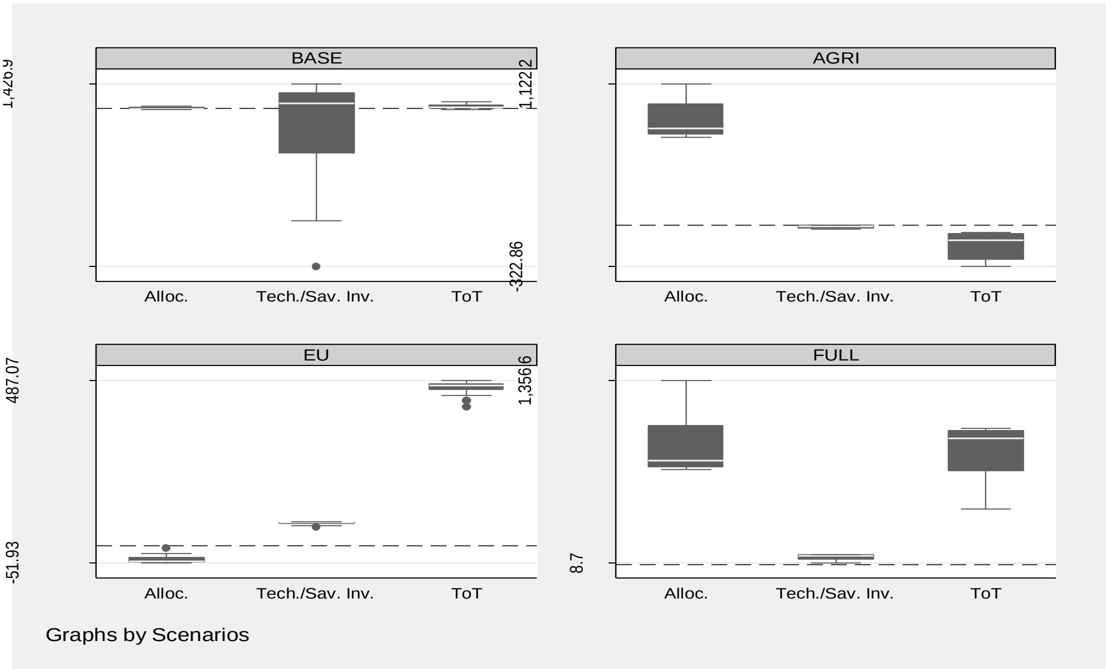


Source: Model Results

Figure 4.7: Distribution of EV for main trading partners of Turkey under trade liberalization scenarios (million USD)

The decomposition of the change in EV for Turkey according to the main drivers, namely allocative efficiency, technological efficiency and terms of trade, is presented in Figure 4.8. Contribution of changes in investment and saving to the total EV is generally small. Under climate change, technological change is the major contributor to the change in EV. This contribution is generally negative, although the median value is slightly above zero. This is expected since climate change scenarios are introduced as negative productivity shocks in the agricultural sector. Terms of trade effect is generally driven by the changes in export prices for Turkey (see appendix Figure D.10 for the decomposition of the terms of trade effects). Under the AGRI scenario, the terms of the trade effect is negative. Since Turkey is a net exporter of the agricultural products, declining world prices has a negative terms of trade effect on the Turkish EV. However, the sign of terms of trade effect is reversed under the FULL scenario as the positive effect of declining world prices of the manufacturing and services trade dominates the negative impact due to agricultural trade. Under the EU scenario, the effect of terms of trade effect becomes positive and constitutes the largest part of the EV change. The effect is again driven by the change in export prices. The allocative efficiency contributes positively to the EV under the global trade liberalization scenarios since the removal of tariffs eliminates a significant distortion. Under the AGRI scenario the positive effect of allocative efficiency is higher than the negative effect of the terms of trade effect. The contribution of allocative efficiency does not change much under the FULL scenario. More than 80 percent of the contribution of allocative efficiency is comes from other crops sector under both AGRI and FULL scenarios. Other crops sector is heavily protected and has a significant share in the agricultural trade. The most important difference between the two scenarios is observed in the livestock and processed food sectors which form more than 25 percent of the allocative efficiency contribution under the FULL scenario. However, allocative efficiency declines due to the declining use of production factors under the FULL scenario, while it increases under the AGRI scenario. These two opposing effects cancel each other out and the contribution of allocative efficiency ends up being close to zero. Under the EU scenario, the contribution of allocative efficiency to the

EV is insignificant, although it is slightly negative. The decline is mostly due to the negative effects in the manufacturing and textile sectors. The highest positive contribution comes from the processed food, vegetable oils and fruits & vegetables sectors (see Appendix Figure D.9).



Source: Model Results

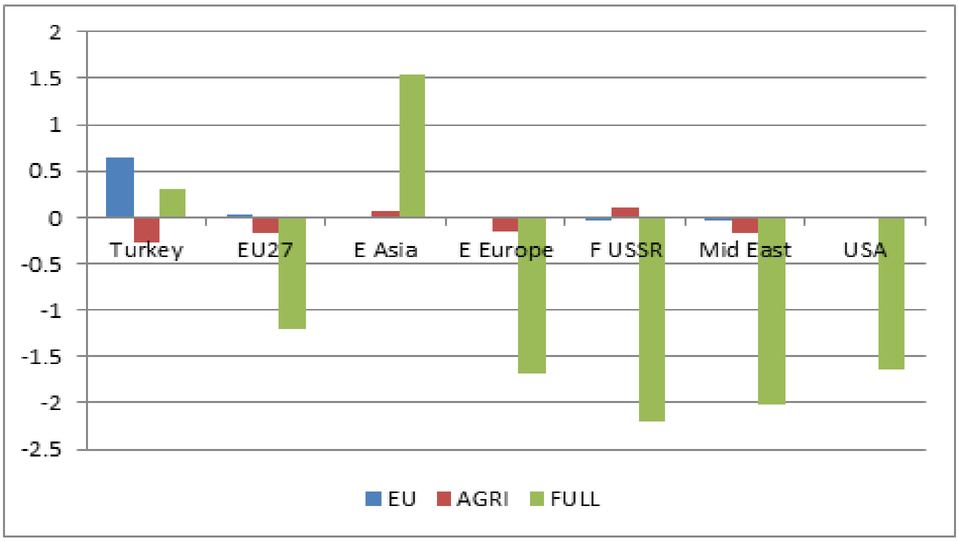
Note: Tech./Sav. Inv. shows effect of technological change for BASE and effect of investment change for the other scenarios. Alloc. shows allocative efficiency effect and ToT shows terms of trade effect.

Figure 4.8: Decomposition of EV for Turkey (million USD)

The change in Turkey's GDP and those of her trading partners is given in Figure 4.9. Turkish GDP increases under the EU and the FULL scenarios while it declines under the AGRI scenario. The change in GDP for third countries is negative under the EU scenario as expected. For Turkey's main trading partners, the changes in the GDP are also insignificant under the AGRI scenario; only East Asia and the Former USSR countries see a slight increase in their GDP. East Asia is the only region that benefits from the FULL scenario together with Turkey. The increase in the East

Asian GDP is greater than 1.5 percent. The rest of the regions see significant GDP losses. The highest decline is noted for the former USSR countries with more than a two percent decline.

Private consumption and trade are the main drivers of the change in GDP for Turkey (Figure 4.10). The contribution of exports is positive while contribution of imports is negative on the GDP implying a simultaneous increase in exports and imports. Private consumption increases under the EU and FULL scenarios, while it declines under the AGRI scenario. Under the EU scenario, although the effects are small, the positive contributions of exports and consumption dominate over the negative effect of imports and private consumption on the GDP. Furthermore, the contribution of investments is positive and relatively high under the EU scenario. This implies an increasing return of capital in Turkey after trade liberalization with EU.



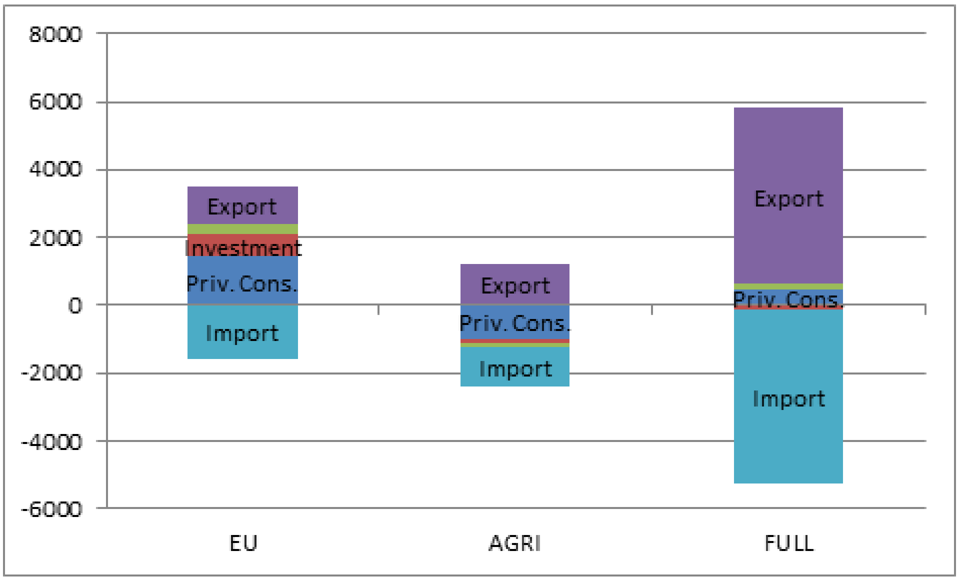
Source: Model Results

Figure 4.9: Average change in GDP for Turkey and her trading partners (percentage change)

The decreasing contribution of private consumption to the change in the GDP under the FULL scenario is the main reason for the smaller change in the GDP compared to the one observed for the EU scenario. Under the AGRI scenario, private consumption declines and together with the increasing imports, dominates the positive effects of the increase in exports.

The immediate effect of tariff elimination for Turkey is the decline in world prices, which in turn affects the import and export prices. Under the EU scenario, the decline in import prices is negligible, while export prices increase, but the change is still under one percent. The increase in the export prices of non-agri-food sectors is even smaller. The variation in the changes of export prices over climate scenarios is given in Appendix Source: Model Results

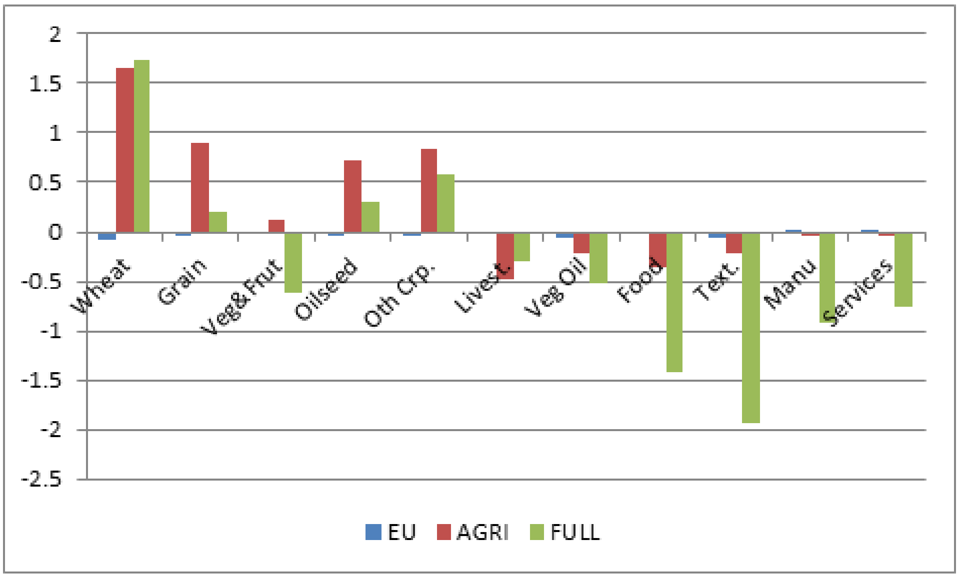
Figure D.12. The variation is quite low for all products except rice, which is traded thinly in the world, and also between the EU and Turkey.



Source: Model Results

Figure 4.10: Decomposition of GDP change for Turkey (difference from baseline average, million USD)

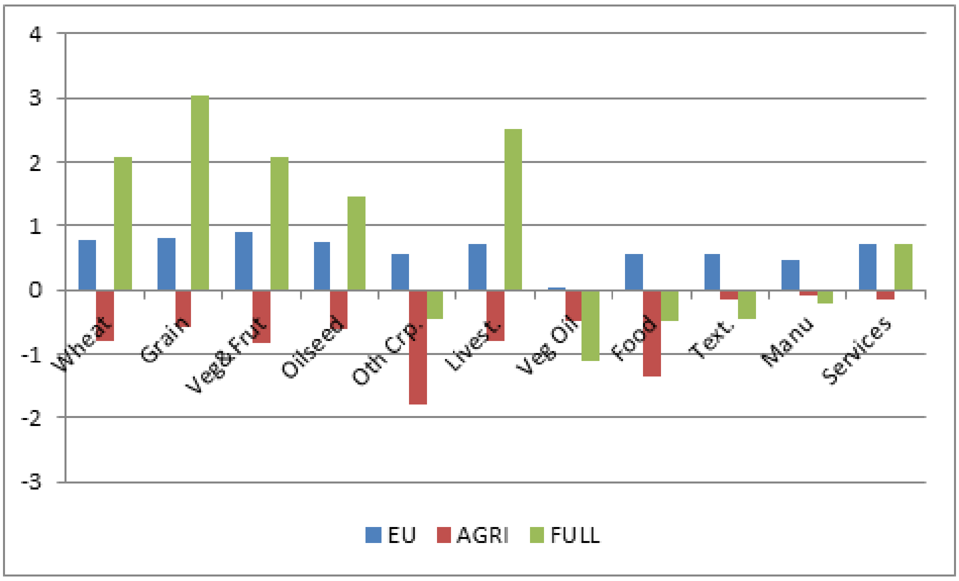
Changes in the export and import prices are relatively higher under both the AGRI and FULL scenarios. The changes are mainly driven by the change in the world prices after the trade liberalization. Import prices increase for all sectors, except vegetables & fruits, under both scenarios (Figure 4.11). Global scale trade liberalization increases the world price for agricultural commodities. This is mainly due to the increasing demand for agricultural products as intermediate inputs. Increasing production (see Appendix Figure D.21) by the food, manufacturing and services sectors shifts up the global demand for the agricultural commodities. Since a significant part of agricultural imports is used as intermediate inputs (60 percent to 95 percent), the demand for these commodities increases causing import prices to increase. Domestically produced commodities substitute for the imports. This in turn causes consumption to increase as the production in the other sectors that use agricultural commodities as intermediate input increases, accompanied by a decrease in the domestic prices. As a result the price of agricultural imports increases. Note that for fruits and vegetables, a relatively smaller share of imports is used as intermediate inputs with 35 percent, and hence the effect of tariff elimination remains dominant for these products.



Source: Model Results

Figure 4.11: Average Change in Turkish import price index under trade liberalization scenarios (percentage change)

Export prices change significantly for agricultural commodities, as a result of tariff elimination (Figure 4.12). For Turkey's main trading partners, the mechanism described above is also valid (see Figure D.15) and the demand for Turkish agricultural exports increases. However the increase in export prices is not certain, as the export prices of agricultural commodities decline under the AGRI scenario. That is, for some of the Turkish tradable, the increase in demand is not high enough to increase the price to compensate for the decline due to tariff elimination under the AGRI scenario. The decline in the export price index is mostly due to the huge declines in some export prices to the main trading partners. Hence Turkey becomes less competitive in the international markets under the AGRI scenario, since the intermediate input use of non-agricultural sectors does not increase when the trade in non-agricultural sectors is not liberalized. Under the FULL scenario, prices of Turkish exports increase due to increasing demand from the firms of the other regions, except for other crops, vegetable oils and food.

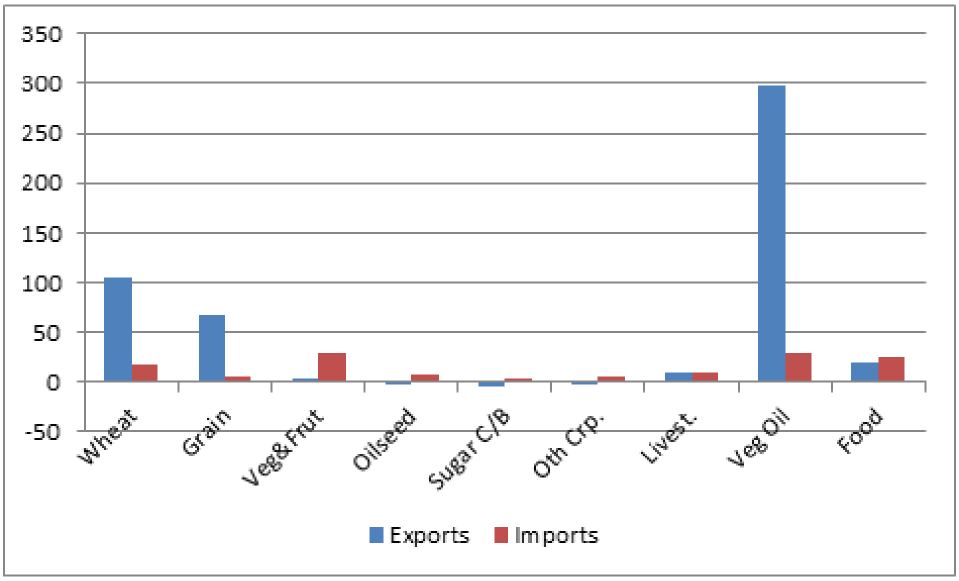


Source: Model Results

Figure 4.12: Average change in Turkish export price index under trade liberalization scenarios (percentage change)

The volume of trade of agricultural commodities changes significantly under all scenarios. Exports in agricultural commodities increase in line with the change in export prices under the EU scenario (Figure 4.13). The most important increase in exports is observed in wheat, grains and vegetable oils. Exports of vegetable oil triple under the EU scenario and the increase for wheat and grains is also quite significant with increases reaching 105 percent and 68 percent respectively. The increase is mostly due to increasing trade with the EU. Vegetable oil exports from Turkey to the EU27 countries are heavily protected. Food exports also increases around 20 percent. On the other hand, exports in non-agrifood sectors decline by around two percent. The most important increase is observed for vegetables & fruits, wheat, vegetable oils and processed food with increases ranging from 20 percent to 30 percent.

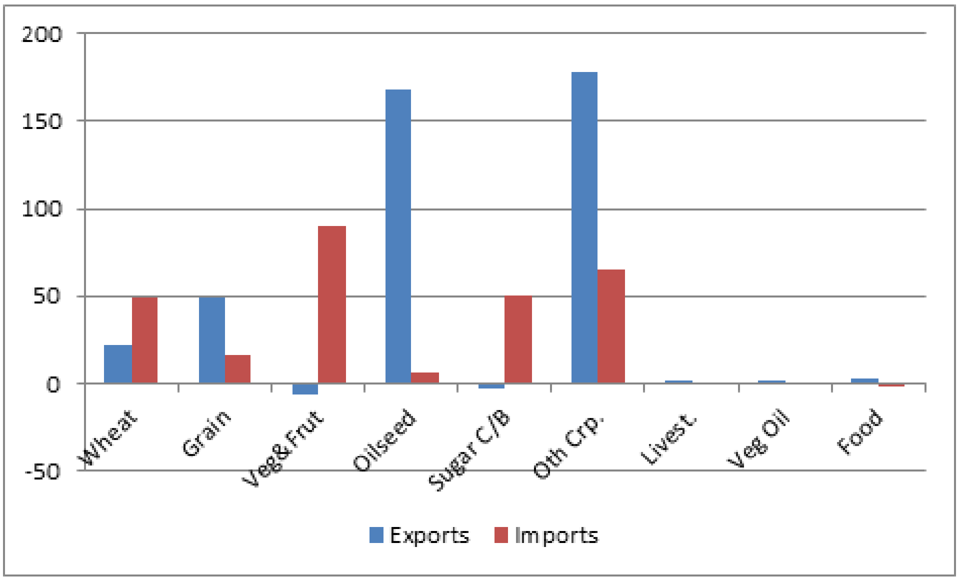
Agricultural imports are mostly used as intermediate inputs. Hence, the change in agricultural imports is mainly driven by the increasing intermediate input demand. However it is important to note that the increase in imports under the EU scenarios is significant only for the commodities that become cheaper than their domestic counterparts. Wheat, vegetable & fruits, vegetable oils and food are the most important among these commodities. The increase in these commodities is mainly driven by the boosting of production of grains, livestock products and vegetable oils.



Source: Model Results

Figure 4.13: Change in Turkish imports and exports under the EU scenario

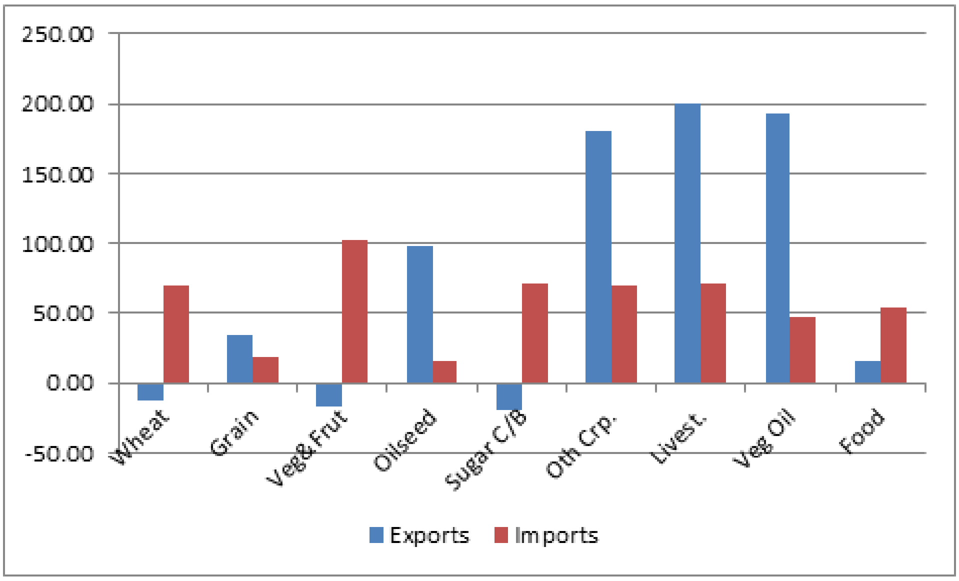
Exports of wheat, grains, oilseeds and other crops increase significantly under the AGRI scenario (Figure 4.14). However, this increase is accompanied by a decline in export prices, implying that Turkey is non-competitive in these commodities on the global scale. Declining domestic prices in most regions (see Appendix Figure D.20) forces Turkey to export at lower prices. Turkey is able to increase exports even with decreasing prices. Note that exports of vegetables and fruits decline due to small changes in domestic prices. Trade in livestock, vegetable oil and food sectors do not change significantly as domestic and imported commodities are not substitutable due to the low trade levels reflected in the baseline. Imports of agricultural commodities also increase significantly, this time as substitutes for domestic production. This is caused by declining domestic prices, which inevitably cause production to decline.



Source: Model Results

Figure 4.14: Change in Turkish imports and exports under AGRI scenario

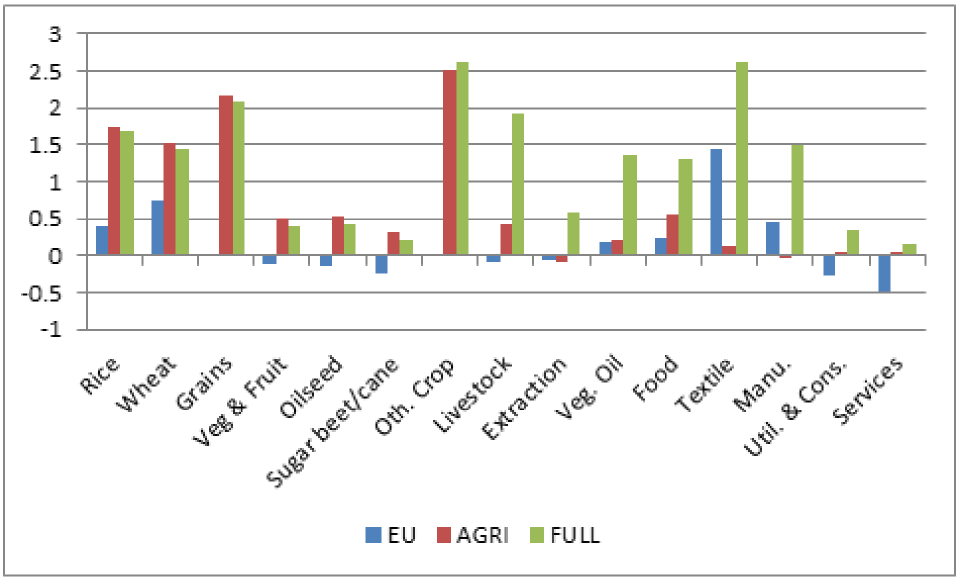
The effects of full global trade liberalization are quite significant (Figure 4.15). Under the FULL scenario, exports of livestock, vegetable oil and food increase by almost 200 percent. This causes a significant increase in the domestic production of these commodities, which in turn causes an increase in imports needed as intermediate inputs. The increase in imports is higher in vegetable & fruits than the rest, mostly due to the increase in intermediate input use from the food sector. Wheat, sugar and other crop imports also increase since the livestock and food processing sectors use them extensively. The ‘Trade opening’ effect is also observed under the FULL scenario in the sense that, declining domestic prices and increasing export prices makes exporting more appealing for the producers.



Source: Model Results

Figure 4.15: Change in Turkish imports and exports under FULL scenario

The change in consumption is relatively modest compared to the change in trade (Figure 4.16). This is not surprising considering the fact that trade is mostly driven by intermediate input use. Change in consumption of agricultural commodities is insignificant under the EU scenario. The consumption of agricultural commodities increases significantly under the AGRI and the FULL scenarios. The increase in the consumption of food, livestock commodities and vegetable oils as well as non-agrifood commodities are very high under the FULL scenario compared to the changes in consumption of these commodities under AGRI scenario. This is mainly due to the increase in imports of these commodities and underlies higher welfare gains. Note that without the trade liberalization in the textiles and manufacturing sectors, the consumption of these commodities does not increase at all. This suggests that cheaper intermediate inputs are not enough to make these sectors competitive in the international markets, but the elimination of tariffs has an important role in sustaining the competitiveness of these sectors.



Source: Model Results

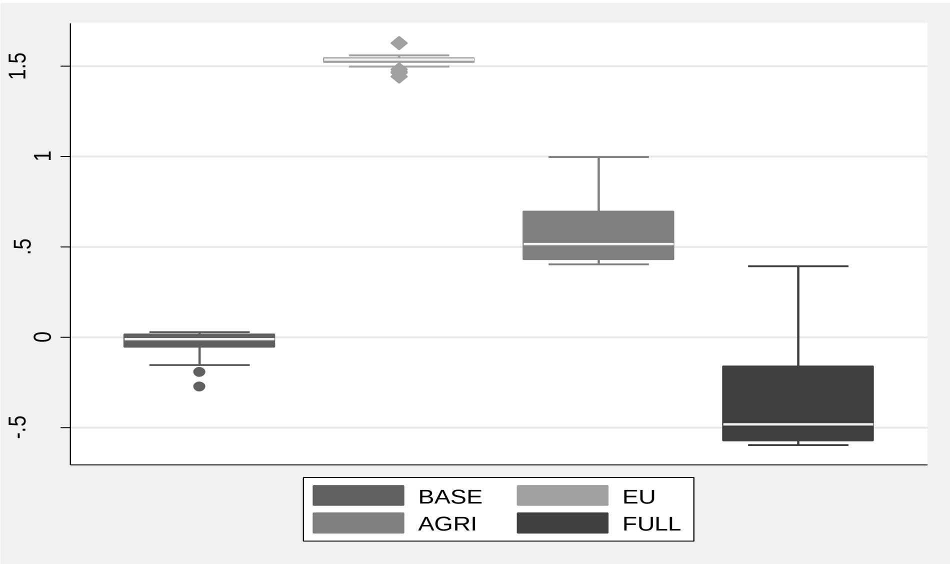
Figure 4.16: Average change in consumption for Turkey (percentage change)

An increase in consumption and a decrease in food prices can be considered as a sign of an improvement in food security. However, note that the increase is driven mainly by imports with relatively small changes in production. Exports also increase significantly under the EU and the FULL scenarios. Hence it may be misleading to conclude that food security is improved under trade liberalization by only looking at the consumption level.

A simple food security indicator that is based only on the availability of food is calculated from the simulation results:

$$\eta = \frac{C}{Q + I - X} \tag{4.1}$$

where η is the indicator, C is consumption, Q is quantity of food commodities available for private consumption from production, I is imports and X is exports. The indicator actually shows the ratio of food demand to available food. The change in the indicator for the different climate scenarios is given in Figure 4.17. The change in the index for the different climate change scenarios is relatively small. Although food production declines significantly, consumption and imports do not change much. The decline in production is compensated for by a decline in exports leaving domestic consumption relatively intact. That is to say, the substitution mechanisms in the economy allow smoothing of the impacts on food consumption. On the other hand, removing distortions from international trade has significant effects. Food security improves under the EU and the AGRI for all climate scenarios while it is always worse under the FULL trade. In this case, the main driver of change for the indicator is food exports. As food tariffs are eliminated under the FULL scenario, an increase in exports reduces the availability of food.



Source: Model Results

Figure 4.17: Food Security indicators (percentage change)

4.4 Conclusion

The results suggest that the impact of climate change on the global economy spans a wide range of probabilities. Effects can be either positive or negative depending on the size and characteristics of the physical effects, although the probability of observing negative effects is higher. The final effect is determined by a complex set of interactions among different regions of the world and sectors within these regions. This increases the level of uncertainty making the climate risk vital when evaluating possible impacts of different adaptation measures.

Economic impacts of climate change differ significantly among regions. Sub-Saharan Africa and South Asia are the only benefiting regions in terms of economic welfare while Europe, Middle East and North Africa are affected adversely. On the other hand for East Asia and Europe, the variation in the results for the different climate scenarios is very high. Hence for Europe, the effects of climate change are likely to hamper the welfare significantly.

The variation in the effects of climate change over different climate scenarios is not fully reflected in the macroeconomic variables. For most regions the changes in GDP are scattered around zero. The disperse distribution of GDP shows the contribution of economic interactions to the climate risk. The most affected regions are small economies that are in the vulnerable regions such as Turkey, Morocco, Middle East, and North African countries.

The most important conclusion of the simulation results is that the negative welfare effects of climate change can be alleviated by trade liberalization for most parts of the world. The increase in welfare under a full trade liberalization scenario is higher than the loss under the climate change scenarios. However, regional trade liberalization such as tariff elimination between Turkey and EU does not alleviate the effects of climate change.

Turkey can alleviate the negative welfare effects of climate change through the implementation of global trade liberalization policies. Furthermore, the Turkish

GDP increases after trade liberalization implying a relatively higher increase in exports compared to imports. Actually, the change in the GDP under trade liberalization is driven mainly by imports and exports. The effects of trade liberalization on Turkey are mainly through the imported intermediate input use. Although effects on sectors may differ, Turkish imports generally increase to accommodate the increased demand of intermediate inputs by exporting sectors, thus in turn resulting in an increase in exports. Imports of agricultural commodities increase to supply the intermediate input demand by food, manufacturing, livestock and vegetable oil sectors thus boosting production and in turn exports.

The effect of trade liberalization on food security is sensitive to the climatic conditions, although the variation in sectoral results across climate scenarios is generally low. The worse the effect of climate change is, the more the food security is improved by trade liberalization. This is mainly due to the increase in imports and decline in exports under severe climate conditions since domestic production declines significantly under more pessimistic climate scenarios.

The availability of food is generally determined by the export demand for Turkish food commodities. As domestic prices decline due to tariff elimination, Turkish exports increase putting pressure on the availability of food supply for domestic consumption. On the other hand, increasing food imports decreases this pressure by increasing the amount of available food. Food security improves the most after the liberalization of trade between Turkey and the EU as export pressure on domestic food availability is decreased. Under full global trade liberalization the increase in production and imports is not sufficient to compensate for the effect of increasing food exports.

CHAPTER 5

CONCLUDING REMARKS

Climate change is likely to be one of the most vital issues in the following decades. The urge for adaptation is obvious. However, it is not costless and involves various trade-offs between generations, regions, countries and social groups. This thesis is an attempt to shed some light on the potential costs and trade-offs. In addition, an overall picture of the interaction of the economy with climate change through the agricultural sector is presented. The study considered the interactions among economic agents at the regional and national level for Turkey as well as the global dynamics that Turkey can face through-out the next century. An integrated approach that uses a crop-water requirement model together with three CGE models at regional, national and global levels was adopted to achieve this purpose.

The findings suggest that the effect of climate change on agricultural production is likely to increase over time. The results show that the effects of the climate change are likely to vary depending on the period. The first period lasts until 2030s, and Turkish agriculture is likely to benefit from the climate change with increasing average yields and declining irrigation requirements in this period. The second period starts after the first period and extends until 2060s. The frequency of negative climatic extremes increases significantly, although the average yield and irrigation requirements deteriorate only slightly over this period. The last period starts in 2060s and lasts until the end of the time-scope for the analysis, 2099. The frequency of extreme negative climatic events continues to increase and the average conditions deteriorate significantly. Consequently, last period witness a drastic fall in agricultural yields and increase in irrigation requirements.

Effects on Turkish regions are quite diverse. Eastern parts of the country are affected less while the western and southern coastal regions are hit the most.

Western parts of the country are relatively better off in the first period, and relatively worse of in the following periods. This is mostly due to the relatively higher importance of irrigation in these regions. In the absence of the adequate water supply, the increasing price of irrigation water causes production to decline drastically in these regions. On the other hand, eastern and southern regions are affected less from the increasing irrigation water prices since the share of irrigated activities is relatively lower.

Similar trends are observed at the national level. In the first period change in GDP is between -0.1 and 0.7 with mostly positive GDP growth. GDP change remains between -0.5 and 0.5 with more frequent negative changes in the second period. In the last period, GDP growth is always negative between -0.5 and -3.5 percent. Changes in EV vary between -3.3 percent and +1.3 percent of the household consumption under climate change. Imports are reduced substantially while there is a boost in exports, mainly due to manufacturing sector. Liberalization of agricultural trade with EU is likely to have a limited overall effect to alleviate the adverse effects of climate change. Welfare gains are positive but not significant enough to change the sign of the overall effects. On the production side, the total value added does not change much from the climate change scenario implying a limited feedback effect. The main drivers of change on the GDP are imports and consumption. The positive effect of declining imports on the GDP is reduced by the declining domestic demand under trade liberalization.

Introducing the global dynamics does not change the effects of trade liberalization policies for Turkey. Effects of EU trade liberalization are still weak and far from alleviating climate change effect. However, global trade liberalization can alleviate the adverse effects for Turkey. The effects of global trade liberalization on Turkey are mainly through the imported intermediate input use. Although effects on sectors may differ, Turkish imports generally increase to accommodate the increased demand for intermediate inputs by exporting sectors, thus resulting in an increase in exports. Imports of agricultural commodities increase to supply the intermediate input demand by food, manufacturing, livestock and vegetable oil sectors thus boosting production and in turn exports.

The effect of trade liberalization on food security is sensitive to the climatic conditions, although the variation in sectoral results across climate scenarios is generally low. The worse the effect of climate change is, the more the food security is improved by trade liberalization. This is mainly due to the increase in imports and decline in exports under severe climate conditions since domestic production declines significantly under more pessimistic climate scenarios.

Turkey still has time to take necessary adaptation measures. Prioritizing the irrigation projects by taking into account the extent of regional impact of climate change, investing in R&D activities to develop drought resistant crops, rationalizing the irrigation water use by farmers, improving the integration of farmers to the markets, enhancing the linkages between food and agricultural sectors, enriching the links between agricultural markets in different regions can be considered as policies to increase the resilience of the economy to the effects of climate change. However, our analysis shows that any policy should be elaborated carefully for costs and benefits. For example, trade liberalization can alleviate the negative effects of the climate change only if implemented at the global scale. However, regional trade liberalization can still contribute to adaptation efforts by relaxing the constraints on consumption and on the supply of intermediate inputs.

The tools presented in this thesis can also be used to analyze many other adaptation policy options by introducing relevant data into the model. For example, irrigation policies can be introduced to the model in more detail to simulate the effects of different water management strategies as an adaptation measure. Likewise, different subsidy schemes can be simulated to see their effectiveness in climate change adaptation and mitigation. Similarly, R&D investments can also be included in the model to test if the technological development can create opportunities for adaptation.

The analysis presented in the chapters of this thesis also paves the way for further methodological improvements. For example, the modeling approach in second and third chapters can be combined to analyze the effects of climate change at regional level in a dynamic setting. Another possible improvement can be including more household types in the model to extend the analysis to cover the distributional effects of the climate change. Further, the model used in the last chapter can be improved by including GHG emissions to see how adaptation through the trade liberalization can affect the mitigation efforts to decreases GHG emission.

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APPENDICES

APPENDIX A

Structure and Results of Crop Water Requirement Model

Modeling Framework

The methodology presented in Allen et al. (1998) is used to translate the physical effects of climate change to economic impacts. This methodology allowed calculating the monthly reference evapotranspiration for each of the 81 NUTS-3 regions from January 2001 until December 2099. Temperature and precipitation data required for the calculations are taken from Dalfes et al. (2011). The soil and crop specific parameters are obtained from FAO (Food and Agriculture Organization, 2011). The approach used in Allen et al. (1998) depends on calculating a reference crop evapotranspiration[14] (ET_0) and crop evapotranspiration under standard conditions (ET_C) and under water stress (ET_s). ET_0 is evapotranspiration from a standardized vegetated surface and shows the evaporation power of the atmosphere. ET_0 is a parameter that can be calculated by using merely weather data such as radiation, air temperature, humidity and wind speed.

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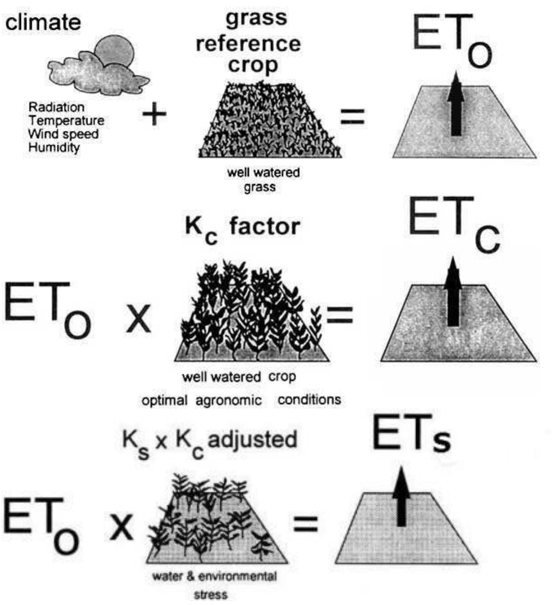
[14] Evapotranspiration is the simultaneous occurring of evaporation and transpiration. Evaporation is the process where liquid water is converted into water vapor followed by the removal of this water vapor from the evaporation surface. The degree of evaporation is determined by the amount of water available in the soil and the degree of shading received from the crop canopy. Evaporation is mainly determined by the soil type and meteorological conditions such as precipitation level and frequency, temperature. Transpiration is the vaporization of liquid water from the plant tissues and removal of vapor from the plant leaf. Transpiration depends on the type of crop, radiation, air temperature, air humidity and wind (Allen et al., 1998).

ET_C is the amount of evaporation in a specific crop type under optimum management of water and environmental conditions to achieve maximum yield under the given climatic conditions. Hence, the difference between ET_0 and ET_C is determined by crop specific factors such as "differences in resistance to transpiration, crop height, crop roughness, reflection, ground cover and crop rooting characteristics" (Allen et al., 1998). This difference is generally reflected to a parameter, namely crop coefficient K_c, which is calculated using different plant characteristics (Allen et al., 1998).



Source: Allen et al. (1998).

Figure A.1: Crop water requirement modelling approach

ET_s is the evapotranspiration under water stress, caused by the low water content of soil due to lack of precipitation or irrigation (Allen et al., 1998). The difference between ET_C and ET_s is expressed as the water stress coefficient K_s, which can be calculated by using water availability, soil characteristics, precipitation and crop characteristics.

ET_C and related K_c values are generally measured by field experiments by using "lysimeters where the crop grows in isolated tanks filled with either disturbed or undisturbed soil" (Allen et al., 1998) . However, ET is generally computed using weather data since lysimeters are expensive and hard to maintain. The FAO Penman-Monteith method is the most commonly used method for the computation of ET_0. ET from crop surfaces under standard conditions is determined by K_c. Then K_s is used to find ET_s (Allen et al., 1998).

Reference Evapotranspiration

The Penman-Monteith method depends on the equation developed by Penman (1948) which combined energy balance with the mass transfer method. The equation was further developed by several researchers and extended to cropped surfaces by introducing resistance factors, resulting in Penman-Monteith form of the combination equation:

$$\lambda ET = \frac{\Delta \times (R_n - G) + \rho_a \times c_p \times \dfrac{(e_s - e_r)}{r_a}}{\Delta + \gamma \times \left(1 + \dfrac{r_s}{r_a}\right)} \tag{A.1}$$

where R_n is the net radiation, G is the soil heat flux, $(e_s - e_a)$ represents the vapor pressure deficit of the air, ρ_a is the mean air density at constant pressure, c_p is the specific heat of the air, Δ represents the slope of the saturation vapor pressure temperature relationship, g is the psychrometric constant, and r_s and r_a are the surface and aerodynamic resistances (Allen et al., 1998).

In equation(A.1), r_a is the Aerodynamic resistance? It determines the transfer of heat and vapor from surface to air above the crop canopy and is calculated by the following formula:

$$r_a = \frac{\ln\left(\frac{z_m - d}{z_{om}}\right) \times \ln\left(\frac{z_h - d}{z_{oh}}\right)}{k^2 \times U_z} \tag{A.2}$$

where r_a is the aerodynamic resistance [s m^{-1}][15], z_m is the height of wind measurements [m], z_h is the height of humidity measurements [m], d is the zero plane displacement height [m], z_{om} is the roughness length governing momentum transfer [m], z_{oh} is the roughness length governing transfer of heat and vapor [m], k is the von Karman's constant which is around 0.41 and u_z is the wind speed at height z [m s^{-1}] (Allen et al., 1998).

In equation(A.1), r_s shows the surface resistance of vapor flow through crop and soil surface. r_s is dependent on a complicated relationship between the density and the water status of vegetation, but the following formula has been shown to give a good approximation:

$$r_s = \frac{r_l}{LAI_a} \tag{A.3}$$

where r_l is the stomatal resistance of a well-illuminated leaf, which is generally assumed to be 100 s m^{-1}, and LAI_a is the active leaf area index [m^2 m^{-2}, leaf area per for soil surface] and is assumed to be half of the LAI which is the leaf area index and is generally approximated by the formula:

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[15] Units for the variables used in calculations are given in square brackets throughout the text. Accordingly *m* is meter, *mm* is millimeters, *s* is seconds, *kPa* is kilopascal, *°C* is centigrade degrees, *MJ* is mega joule and *Kg* is kilogram, *rad* is radian.

$$LAI = 24 \times h \tag{A.4}$$

where h is the height of the plant [m] (Allen et al., 1998).

Allen et al. (1998) combine the equations (A.1) and (A.4) to obtain the FAO Penman-Monteith equation as follows:

$$ET_0 = \frac{0.408 \times \Delta \times (R_n - G) + \gamma \times \dfrac{900}{T + 273} \times u_2 (e_s - e_a)}{\Delta + \gamma \times (1 + 0.34 u_2)} \tag{A.5}$$

where R_n is the net radiation at the crop surface [MJ m^{-2} day^{-1}], G is the soil heat flux density [MJ m^{-2} day^{-1}], T is the mean daily air temperature at 2 m height [°C], u_2 is wind speed at 2 m height [m s^{-1}], e_s is the saturation vapour pressure [kPa], e_a is the actual vapour pressure [kPa], $e_a - e_s$ is the saturation vapour pressure deficit [kPa], Δ is the slope of the vapour pressure curve [kPa °C^{-1}], γ is a psychrometric constant [kPa °C^{-1}] (Allen et al., 1998).

Soil heat flux, G_{sc}, is calculated by:

$$G = 0.14 \times (T_i - T_{i-1}) \tag{A.6}$$

where T_i is the mean temperature at month i.

Psychrometric constant, γ, is calculated according to the following formula

$$\gamma = \frac{c_p \times P}{\varepsilon \times \lambda} = \frac{1.013}{0.622x2.45} \times 10^{-3} \times P = 0.665 \times 10^{-3} \times P \tag{A.7}$$

where P is the atmospheric pressure [kPa], λ is the latent heat of vaporization and is approximately 2.45 MJ kg^{-1}, c_p is the specific heat at a constant pressure and is approximately 1.013x10^{-4} MJ kg^{-1} °C^{-1}, and ε is the ratio of the molecular weight of water vapour/dry air and is approximately 0.622 (Allen et al., 1998).

From the simplification of ideal gas law, atmospheric pressure, P, is calculated by

$$P = 101.3 \times \left(\frac{293 - 0.0065z}{293} \right)^{5.26} \tag{A.8}$$

where z is the elevation above sea level [m]. Hence psychrometric constant equals

$$\gamma = 0.665 \times 10^{-3} \times 101.3 \times \left(\frac{293 - 0.0065 \times z}{293} \right)^{5.26} \tag{A.9}$$

The mean daily air temperature, T, is calculated from the average of maximum and minimum temperatures reported by the meteorological sources (Allen et al., 1998). We take this data directly from Dalfes et al. (2011).

The slope of the saturation vapor pressure curve, Δ, is calculated according to the following formula

$$\Delta = \frac{4098 \times \left(0.61 \times \exp\left(\frac{17.27 \times T}{T + 237.3} \right) \right)}{(T + 237.3)^2} \tag{A.10}$$

To calculate e_a and e_s, one needs to know the saturation vapour pressure at the air temperature, T. This is calculated by

$$e^0(T) = 0.6108 \times \exp\left(\frac{17.27 \times T}{T + 237.3} \right) \tag{A.11}$$

Then, e_s can be calculated as:

$$e_s = \frac{e^0\left(T_{\max}\right) + e^0\left(T_{\min}\right)}{2} \tag{A.12}$$

where $T_{\max}$ is maximum temperature [°C], and $T_{\min}$ is the minimum temperature [°C]. Since Dalfes et al. (2011) do not report the minimum and maximum temperatures, we extrapolated the mean temperature by using daily minimum and maximum temperature data for each of the NUTS-3 regions reported by Allen et al. (1998) according to the following formula:

$$T_{\max} = T_{mean} \times \left(1 + \frac{1}{2}\theta\right) \qquad T_{\min} = T_{mean} \times \left(1 - \frac{1}{2}\theta\right) - 2 \tag{A.13}$$

where θ is an extrapolation factor that is corrected for the sign of the mean temperature as shown below and is not allowed to be greater than μ, which is assumed to be 5 for this study. θ is calculated as

$$\theta = \frac{abs\left(T_{mean}\right)}{T_{mean}} \times \frac{abs\left(T_{mean}^{FAO}\right)}{T_{mean}^{FAO}} \times \max\left(\mu, \mathrm{abs}\left(\frac{T_{\max}^{FAO} - T_{\min}^{FAO}}{T_{\mathrm{mean}}^{FAO}}\right)\right) \tag{A.14}$$

where $T_{mean}^{FAO}, T_{\max}^{FAO}, T_{\min}^{FAO}$ show the average, maximum and minimum daily temperature values reported by Allen et al. (1998) for Turkey. Note that we also make the minimum temperature adjustment for the arid regions suggested by Allen et al. (1998).

Since dew point temperature is not reported in Dalfes et al. (2011), we used an approximation formula suggested by Allen et al. (1998) to calculate e_a:

$$e_a = e_0\left(T_{\min}\right) \tag{A.15}$$

Net radiation, R_n is calculated as the difference between incoming and outgoing radiation of both short and long wave lengths and calculated by

$$R_n = R_{ns} - R_{nl} \tag{A.16}$$

where R_{ns} is net shortwave radiation [MJm^{-2}] and R_{nl} is net longwave radiation [MJm^{-2}]. Net long wave radiation R_{nl} is calculated as follows:

$$R_{nl} = \alpha \times \left(\frac{\left(T_{\max} + 273\right)^4 + \left(T_{\min} + 273\right)^4}{2} \right) \times \left(0.34 - 0.14 \times \sqrt{e_a}\right) \times \left(1.35 \times \frac{R_s}{R_{so}} - 0.35\right) \tag{A.17}$$

where α is Stephan-Boltzmann constant and is approximately equal to 4.0903×10^{-9} [MJm^{-2} day^{-1}], R_s is the calculated solar radiation [MJm^{-2} day^{-1}], R_{so} is the calculated clear sky solar radiation [MJm^{-2} day^{-1}]. R_s is calculated as

$$R_s = \left(\frac{1}{4} + \frac{n}{2N} \right) \times R_a \tag{A.18}$$

where n is the actual duration of sunshine [hours], N is the maximum possible duration of sunshine [hours] and R_a is the extraterrestrial radiation. n is obtained from the data reported by Allen et al. (1998) for Turkey at NUTS-3 level while N is calculated by

$$N = \frac{24}{\pi} \times \omega_s \tag{A.19}$$

The extraterrestrial radiation, R_a, for each day of the year and for the different locations is estimated by the formula:

$$R_a = \frac{24 \times 60}{\pi} G_{sc} \times d_r \left[\omega_s \times \sin\left(\varphi\right) \times \sin\left(\delta\right) + \cos\left(\varphi\right) \times \cos\left(\delta\right) \times \sin\left(w_s\right) \right] \tag{A.20}$$

where G_{sc} is the solar constant and is approximately 0.0820 MJm^{-2}min^{-1}, d_r is the inverse relative distance between earth and sun, ω_s is sunset hour angle [rad], δ solar decimation [rad], and φ is the latitude [rad] (Allen et al., 1998).

In equation (A.20), the inverse relative distance, d_r, and the solar declination, δ, are calculated as follows:

$$d_r = 1 + 0.033 \times \cos\left(\frac{2\pi}{365} \times J\right) \tag{A.21}$$

$$\delta = 0.409 \times \sin\left(\frac{2\pi}{365} \times J - 1.39\right) \tag{A.22}$$

where J is the number of days in the year between 1 (January 1st) and 365 (December 31st).

The sunset hour angle, ω_s, is calculated as follows:

$$\omega_s = \arccos\left(-\tan(\varphi) \times \tan(\delta)\right) \tag{A.23}$$

Clear sky solar radiation, R_{so}, is calculated with the following data

$$R_{so} = \left(0.75 + 2 \times 10^{-5} \times z\right) \times R_a \tag{A.24}$$

Then the net shortwave solar radiation, R_{ns}, is calculated as follows:

$$R_{ns} = (1 - \phi) \times R_s \tag{A.25}$$

where ϕ is the net solar canopy reflection coefficient and is assumed to be 0.23 for the hypothetical grass reference crop (Allen et al., 1998).

Crop Evapotranspiration

Crop Evapotranspiration, ET_c, is calculated as

$$ET_c = K_c ET_0 \tag{A.26}$$

where K_c is the crop coefficient that takes different values at different stages of crop growth depending on the climate and soil evaporation. To calculate K_c for different stages of crop growth we use the crop growth periods and planting dates that are supplied by Allen et al. (1998) for semi-arid regions. The crop growth is separated into 4 periods: Initial, development, mid and late growth periods. The K_c values for the initial period, $K_{c,ini}$, is directly taken from the tables reported by Allen et al. (1998) without any adjustments. However, crop coefficients for mid and end period, $K_{c,\mathrm{mid}}$ and $K_{c,\mathrm{end}}$, are adjusted according to the weather conditions as follows

$$K_{c,\mathrm{mid}} = K_{c,\mathrm{mid}}^{table} + \left(0.04\times\left(u_2 - 2\right) - 0.004\times\left(RH_{\mathrm{min}} - 45\right)\right)\left(\frac{h}{3}\right)^{0.3} \tag{A.27}$$

where $K_{c,\mathrm{mid}}^{table}$ is $K_{c,mid}$ value reported by Allen et al. (1998), RH_{min} is the average minimum relative humidity during the mid-season growth stage [percent], and h is the average crop height during the mid-season growth stage (Allen et al., 1998). The average minimum relative humidity during mid-season growth stage, RH_{min} is calculated as follows:

$$RH_{\min} = \frac{\sum_i \frac{e^o\left(T_{\min,i}\right)}{e^o\left(T_{\max,i}\right)}}{\sum_i 1} \tag{A.28}$$

where i is time index, showing each month in the mid-season period.

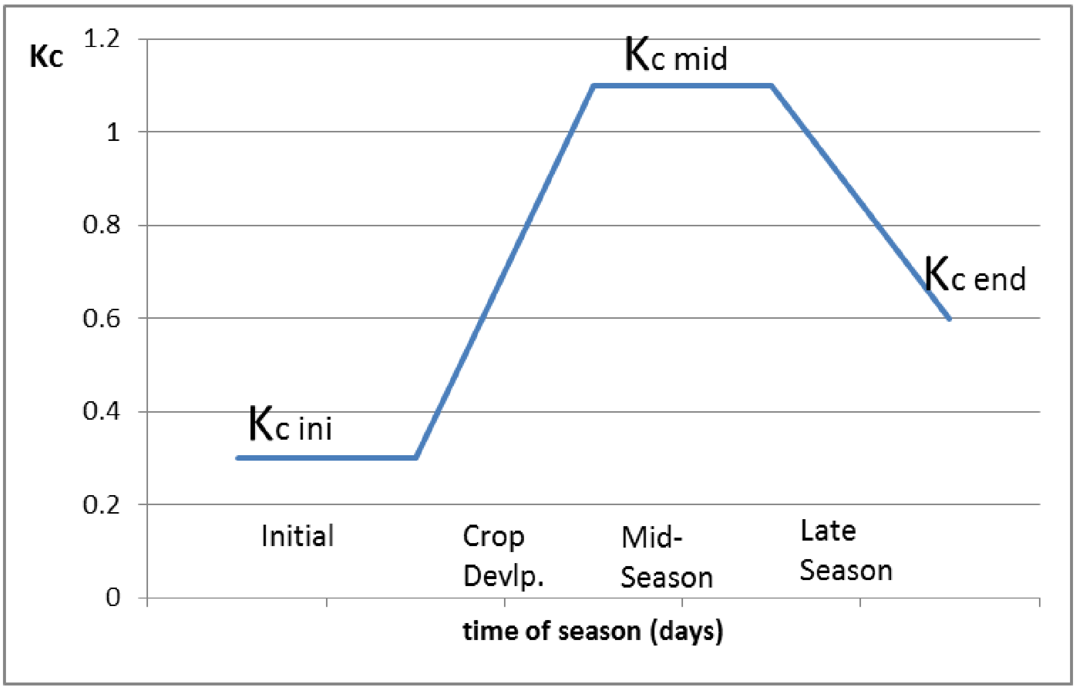
The end period crop coefficient, $K_{c,end}$ is calculated in the same way:

$$K_{c,\mathrm{end}} = K_{c,\mathrm{end}}^{table} + \left(0.04\times\left(u_2-2\right)-0.004\times\left(RH_{\min}-45\right)\right)\left(\frac{h}{3}\right)^{0.3} \tag{A.29}$$

During the initial and mid-season stages K_c is constant, but it increases and declines linearly during the development and late seasons, respectively (see Figure A.2) (Allen et al., 1998). To find K_c for any given time, i, we use the following formula:

$$K_{c.i} = K_{c,prev} + \left(\frac{i-\sum L_{prev}}{L_{stage}}\right)\left(K_{c,next}-K_{c,prev}\right) \tag{A.30}$$

where $K_{c,prev}$ is the crop coefficient of the previous period (initial for the development period and mid-season for the late period), $K_{c,\mathrm{next}}$ is the crop coefficient for the next period (mid-season for the development period and end value for the late period), L_{stage} is the length of the stage in days, $\sum L_{prev}$ is the sum of the lengths of all previous periods.

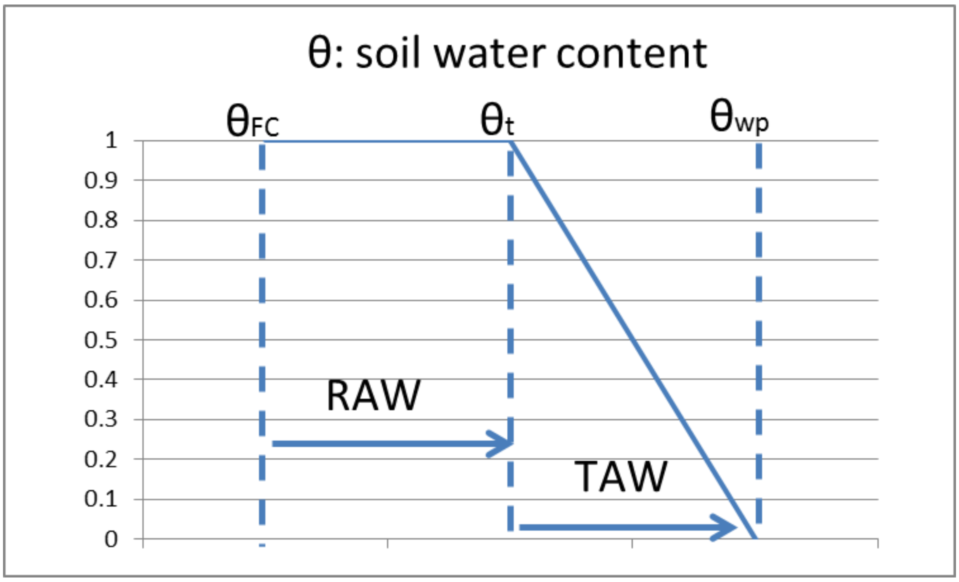


Source: Allen et al. (1998).

Figure A.2: Crop coefficient as a function of time

Crop Evapotranspiration under Water Stress

Crop ETs had to be adjusted to reflect water stress since the calculated ETs were used to calculate both the changes in yield and the irrigation water requirements under changing climate conditions. Water stress occurs when the potential energy of the soil water falls below a threshold value. The potential energy of soil water is determined by total available soil water in the root zone (TAW), readily available water in the root zone (RAW) and root zone depletion (D_r), all measured in *mm* (Allen et al., 1998). The crop does not experience water stress as long as the soil water content is more than the RAW. Once RAW is reached, crop experiences water stress until the rest of the TAW is depleted when crop ET stops.



Source: Allen et al. (1998).

Figure A.3: K_s as a function of RAW and TAW

A water stress coefficient, K_s, is calculated from these factors. Crop coefficient is reduced proportionally to reflect the effect of water stress on crop evapotranspiration (Allen et al., 1998). Hence adjusted crop evapotranspiration is calculated as follows:

$$ET_{c,adj} = K_s K_c ET_c \tag{A.31}$$

and water stress coefficient, K_s, is calculated as follows:

$$K_s = \min\left(1, \frac{TAW - D_r}{TAW - RAW}\right) \tag{A.32}$$

Total available water is calculated according to the following equation:

$$TAW = 1000\left(\theta_{FC} - \theta_{WP}\right) Z_r \tag{A.33}$$

where θ_{FC} is the water content at field capacity [m^{3}m^{-3}], θ_{WP} is the water content at the wilting point [m^{3}m^{-3}] and Z_r is the rooting depth [m] (Allen et al., 1998). θ_{FC}, θ_{WP} and Z_r follows from the tables supplied by Allen et al. (1998) for semi-arid countries. However, the table values for Z_r are the rooting depth at the middle of crop growth periods so we calculate the $Z_{r,i}$ at a given time, i, as follows:

$$Z_{r,i} = Z_{r,prev} + \frac{i - \sum L_{prev}}{L_{stage}} \times \left(Z_{r,next} - Z_{r,\mathrm{prev}} \right) \tag{A.34}$$

Readily available water is calculated as follows:

$$RAW = p \times TAW \tag{A.35}$$

where p is the average fraction of TAW that can be depleted from the root zone before water stress. The initial values for p is also taken from Allen et al. (1998) and are adjusted according to the following formula:

$$p = \max\left(1, p_{tab} + 0.04\left(5 - ET_C\right)\right) \tag{A.36}$$

D_r is the average of daily root zone depletions. For the initial period it is calculated as follows

$$D_{r,i} = \min\left(TAW, 1000\left(\theta_{FC} - \frac{\theta_{WP}}{2} \right) \times Z_r - Pn_{eff} + ET_C \right) \tag{A.37}$$

where Pn_{eff} is the effective precipitation. Allen et al. (1998) also includes a capillary rise[16] and a deep percolation[17] factor in the formula for root depletion but since we work with monthly data, we ignore these factors.

Effective precipitation, Pn_{eff}, is calculated as follows:

$$Pn_{eff} = \begin{cases} Pn \times \frac{(125 - 0.2 \times Pn)}{125} & if \quad Pn < 250 \\ 125 + 0.1 \times Pn & if \quad Pn > 250 \end{cases} \tag{A.38}$$

where Pn is the reported precipitation.

For the following periods $D_{r,i}$ is calculated as follows:

$$D_{r,i} = \min\left(TAW, D_{r,i-1} - Pn_{eff} - ET_C\right) \tag{A.39}$$

Yield Change and Irrigation Water Requirement

Monthly ET_C and ET_S are used to estimate two model parameters: The yield change and irrigation water requirement. Yield change is calculated from the yield loss with respect to the maximum yield according to the following formula:

$$Y_{loss} = 1 - \frac{Y_a}{Y_M} = \psi_c \left(1 - \frac{ET_s}{ET_c}\right) \tag{A.40}$$

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[16] "The amount of water transported upwards from the water table to the root zone" (Allen et al., 1998).

[17] Depletion becomes zero after heavy rain or irrigation (Allen et al., 1998).

where Y_{loss} is yield loss, Y_a is actual yield, Y_M is maximum yield, ψ_c is crop specific yield response coefficient, ET_s is the crop evapotranspiration with water stress and ET_c is crop evapotranspiration without water stress. Accordingly the change in yields is given by

$$\Delta Y = 100\left(\frac{Y_a}{Y_M} - 1\right) = -100\psi_c\left(1 - \frac{ET_s}{ET_c}\right) \quad \text{(A.41)}$$

Monthly irrigation requirements for each crop in each region and year are calculated as the deficiency between effective precipitation and ET_s .

$$IRQ_s = ET_s - Pn_{eff} \quad \text{(A.42)}$$

Annual irrigation requirement is obtained by summing the monthly irrigation requirements within a year.

Data and Results

The necessary climate data are obtained from the results of the “Climate Change Scenarios for Turkey” project carried out by the Istanbul Technical University and the General Directorate of State Meteorological Services (Dalfes et al., 2011). In this project, the results of the ECHAM5 model (Roeckner, 2003) are downscaled using the RegCM3 regional climate model (Pal et al., 2007) in order to obtain the monthly projections for key environmental variables starting from 2001 until 2099 (Dalfes et al., 2011). Önol et al. (2009) report the details of the models used in Dalfes et al. (2011).

Yield and irrigation water requirements are based on IPCC-B1 scenario which describes a relatively integrated world with rapid economic growth. IPCC-B1 scenario assumes that global population will increase to 9 billion in 2050 and decline from then on. Economic development is primarily focused on services and communication sectors and sustainability is important in economic decisions under IPCC-B1 scenario (Nakicenovic et al., 2000).

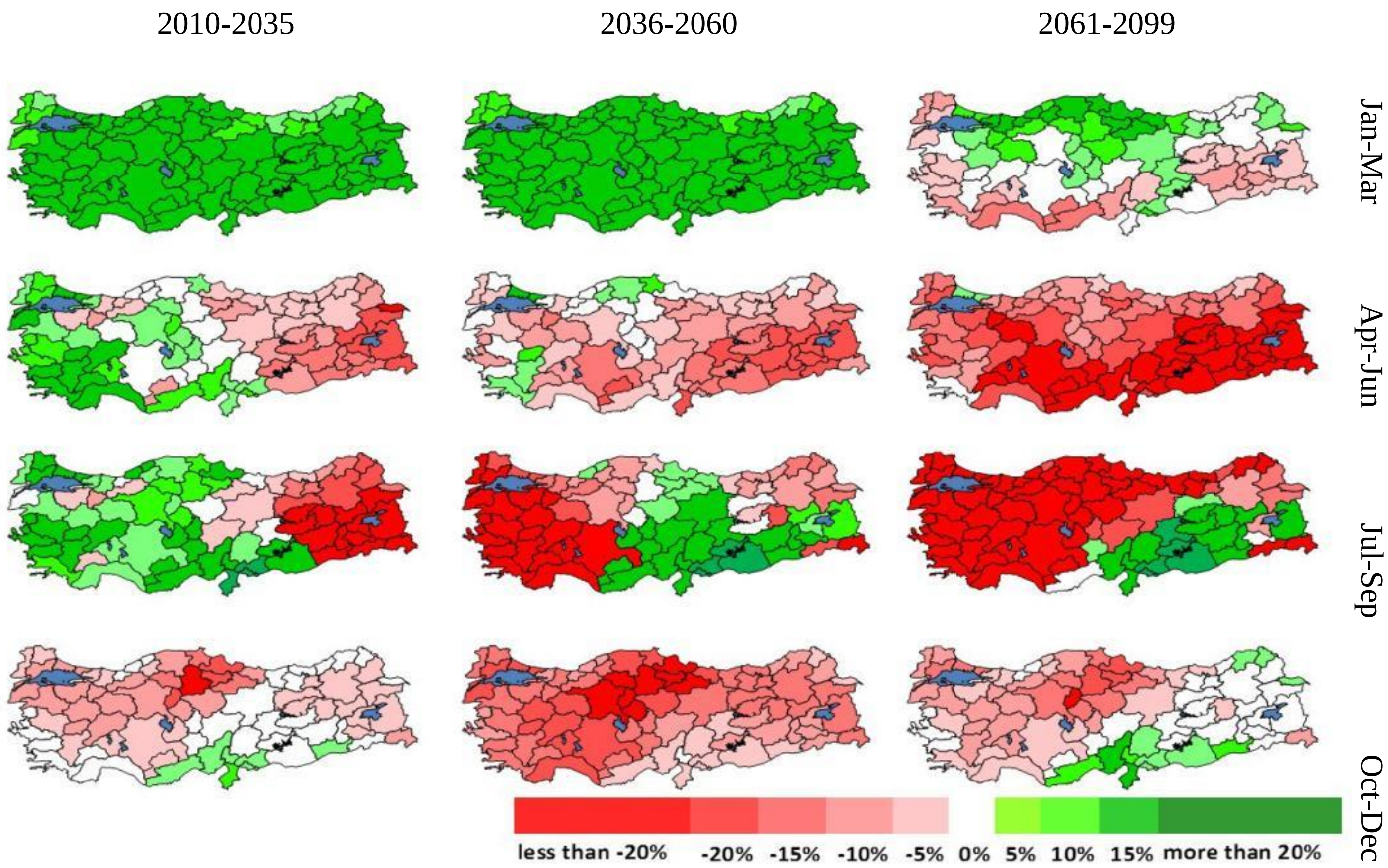
Estimations of westerly and southerly wind speed, precipitation and mean temperatures that are provided by Dalfes et al., (2011) are used to calculate the reference evapotranspiration and increase in water stress for different crops in each province (i.e. at NUTS-3 level) until 2100. The spread of minimum and maximum temperature, critical depletion, crop height, initial K_c values, crop planting date, length of crop development stages, rooting depth, yield response coefficients and soil parameters are taken from Allen et al. (1998) (see appendix A).

Figure A.4 shows the mean precipitation changes for the periods 2010-2035, 2036-2060 and 2061-2099, throughout the year. Precipitation generally increases up to 20 percent in the first period, especially in the western regions. The most significant increase is observed during the January-March season. In other seasons, precipitation declines in the eastern regions but remains high in the west. However precipitation declines all over the country, except in the Çukurova basin during October-December season.

In the second period, the pattern remains same for the January-March period, but it changes drastically for the rest of the year. While the south eastern regions enjoy increased precipitation between April and September, the rest of the country experiences significantly drier spring and summer. The mean precipitation between October and December falls all over the country. Decline in precipitation becomes severe for central, western and south western regions for all seasons in the last period. However, there is an increase in precipitation in the northern regions between January and March and south eastern regions between July and December.

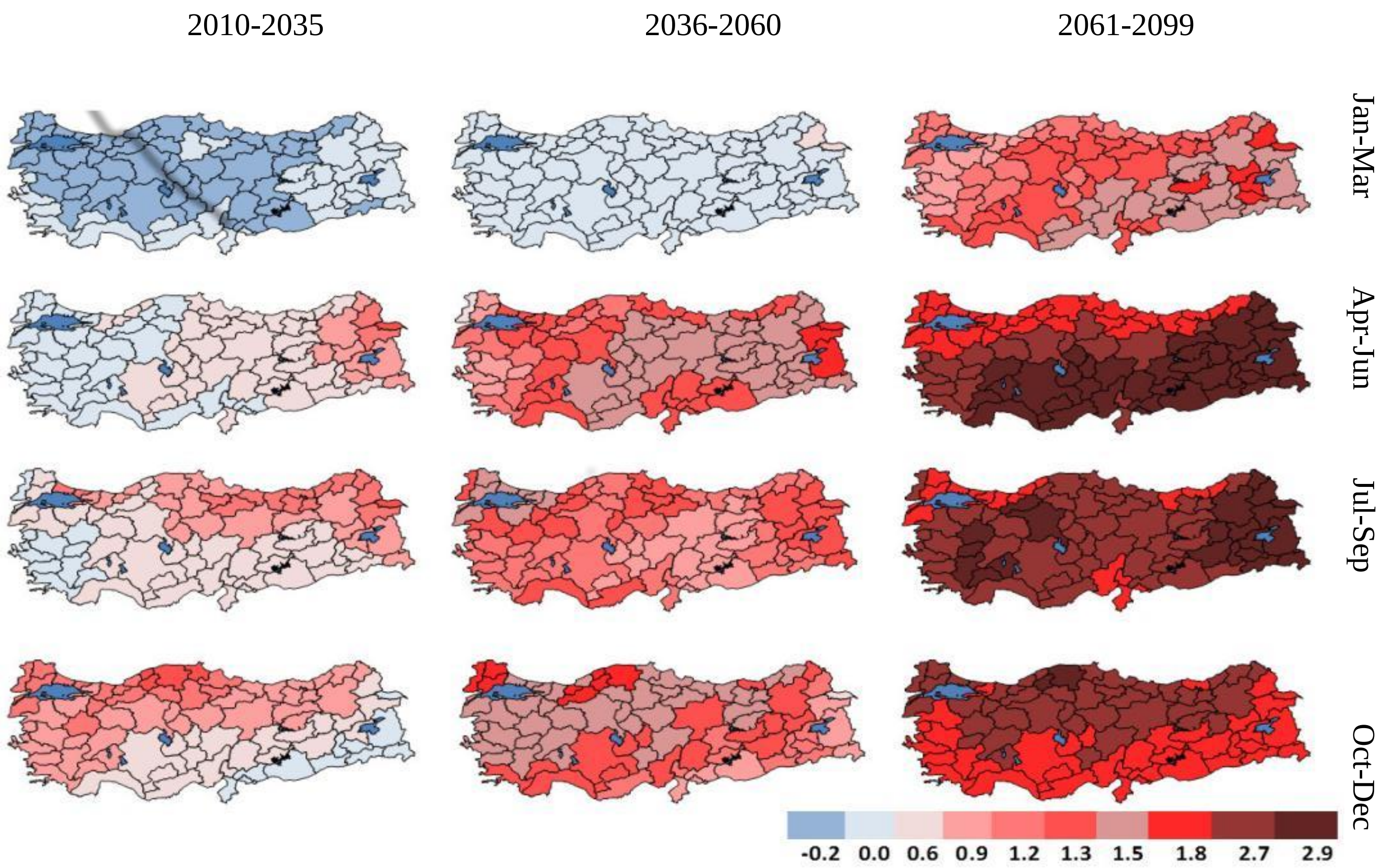
These findings reflect a significant change in precipitation patterns over time and space, especially after 2030s. Precipitation will increase in the Northwest regions between January and March in all periods while it generally declines in the other seasons. The western regions are either not affected significantly or benefit from the change in precipitation until 2035, while they suffer from declining precipitation after 2035. In the southeastern regions, precipitation declines in all seasons in the first period but increases after 2035, especially in the summer. However, note that the mean precipitation is quite low in the summer for the eastern and south eastern regions and hence high changes in percentage terms do not imply very high levels of precipitation. The central regions follow a similar pattern as the western regions; however the increases in precipitation are lower while the declines are higher.

Changes in temperature display a similar pattern. Higher precipitation in a region is generally accompanied by lower temperatures and vice versa. The only exception is the southeastern regions where higher precipitation is accompanied with quite high temperature changes. The results suggest that the average temperature change throughout the year in the western and central regions are between -0.2 and 1 °C until 2035. The temperature change is slightly higher in the northern and eastern regions during this period. In the second period, the increase is between 0 and 1.5 °C, all over the country. However, the western and central regions experience the highest changes during the last quarter of the year while the eastern and northern regions experience it in April-June season. Temperature increase becomes quite significant after 2060. All regions suffer from higher temperatures in all seasons. The mean temperature increases reach as high as 3 °C in eastern and southern regions and 2.7 °C in the other regions. The western and central regions are affected from temperature increase throughout the year except January-March season while effects are higher in eastern and southern regions during April-September season.



Source: Author's calculations from Dalfes et al. (2011)

Figure A.4: Change in precipitation (percentage difference with 2001-2010 average)



Source: Author's calculations from Dalfes et al. (2011)

Figure A.5: Change in mean temperatures (°C difference with 2001-2010 average)

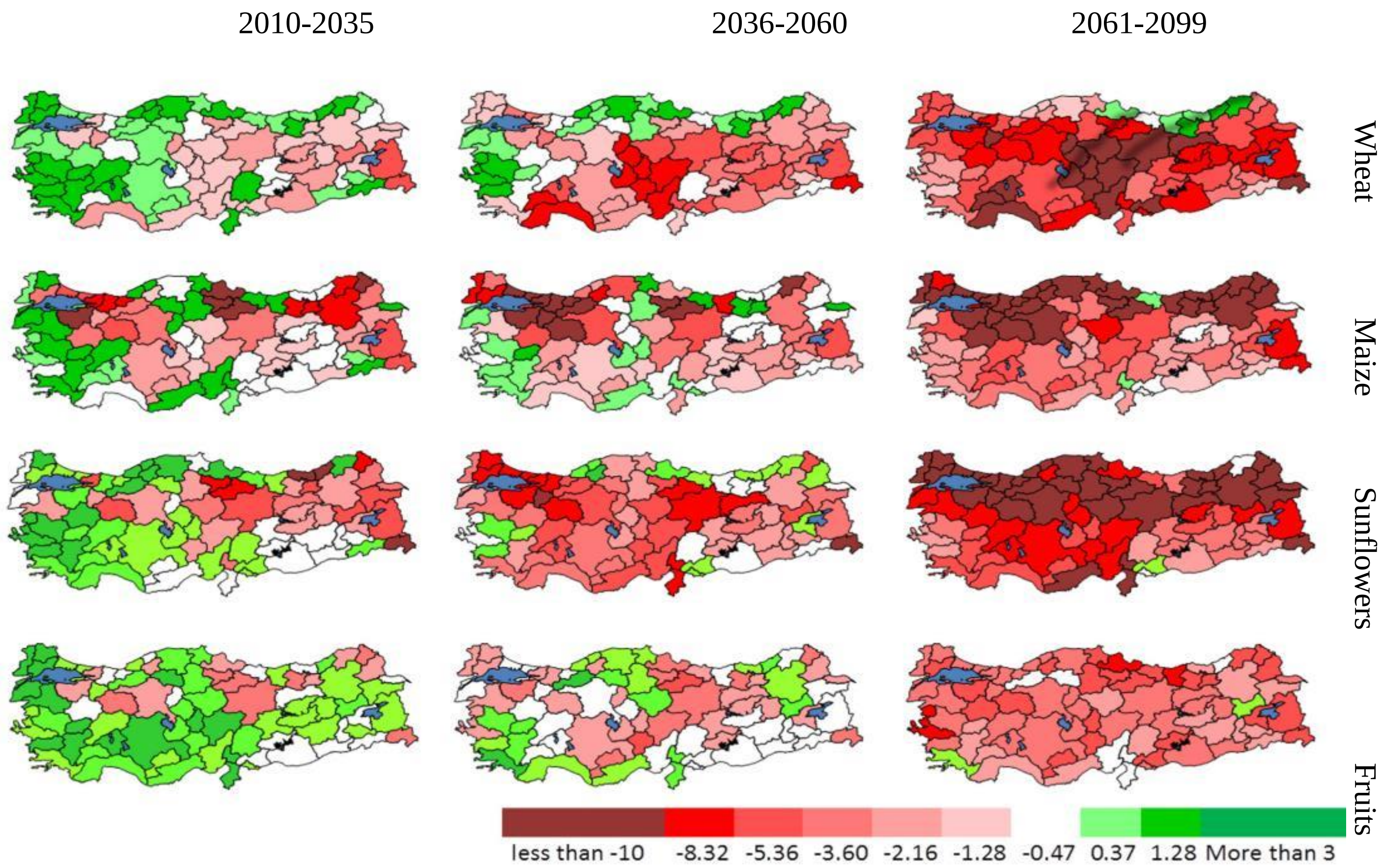
Impact of the change in precipitation and temperature depends both on crop type and location. The results are given in Figure A.6. In the first period, yield changes are generally non-negative indicating better conditions for the agricultural production. However, in the second and especially in the last period the yields decline and irrigation requirements increase significantly with some minor exceptions. Yield gains are higher and yield losses are lower generally in the western regions in all periods. On the other hand, the eastern regions generally suffer yield losses in all periods for all crops.

Wheat yields increase in almost all western and central west Anatolia, together with the Black Sea coast. Slight decline in the yields is observed in the Mediterranean coast. The eastern and south eastern regions generally suffer a loss in wheat yields, with the exception of Çukurova basin and GAP regions. The pattern changes drastically in the second and third period. Although yield gains are sustained in the Aegean and Black Sea coastal regions in the second period, yields decline significantly in the rest of the country during the second period. In the last period, yield losses are prevalent in almost all the country with the exception of the eastern Black Sea. Yield losses are especially severe in east central Anatolia and the western Mediterranean coast.

Maize yields respond less positively to the changes in climate conditions in general. The yield gains are generally low and limited to the Aegean coast, the Çukurova basin and the west Black Sea coast. Most of the regions on the Aegean coast cannot sustain the gains in the second period, while the Thrace and Marmara regions suffer significant losses in maize yields. In the last period, maize yields decline in almost all regions with quite significant losses in the Black Sea region, the Thrace and western Central Anatolia. Changes in sunflower yields are generally non-negative in the major producing regions in the first period. However, the negative impact of changing climatic conditions becomes significant in the second and last period. The Thrace and Aegean coastal regions are among the most affected. In the last period, the yield losses are quite high throughout the country, and they exceed 10 percent for most of the Northern regions.

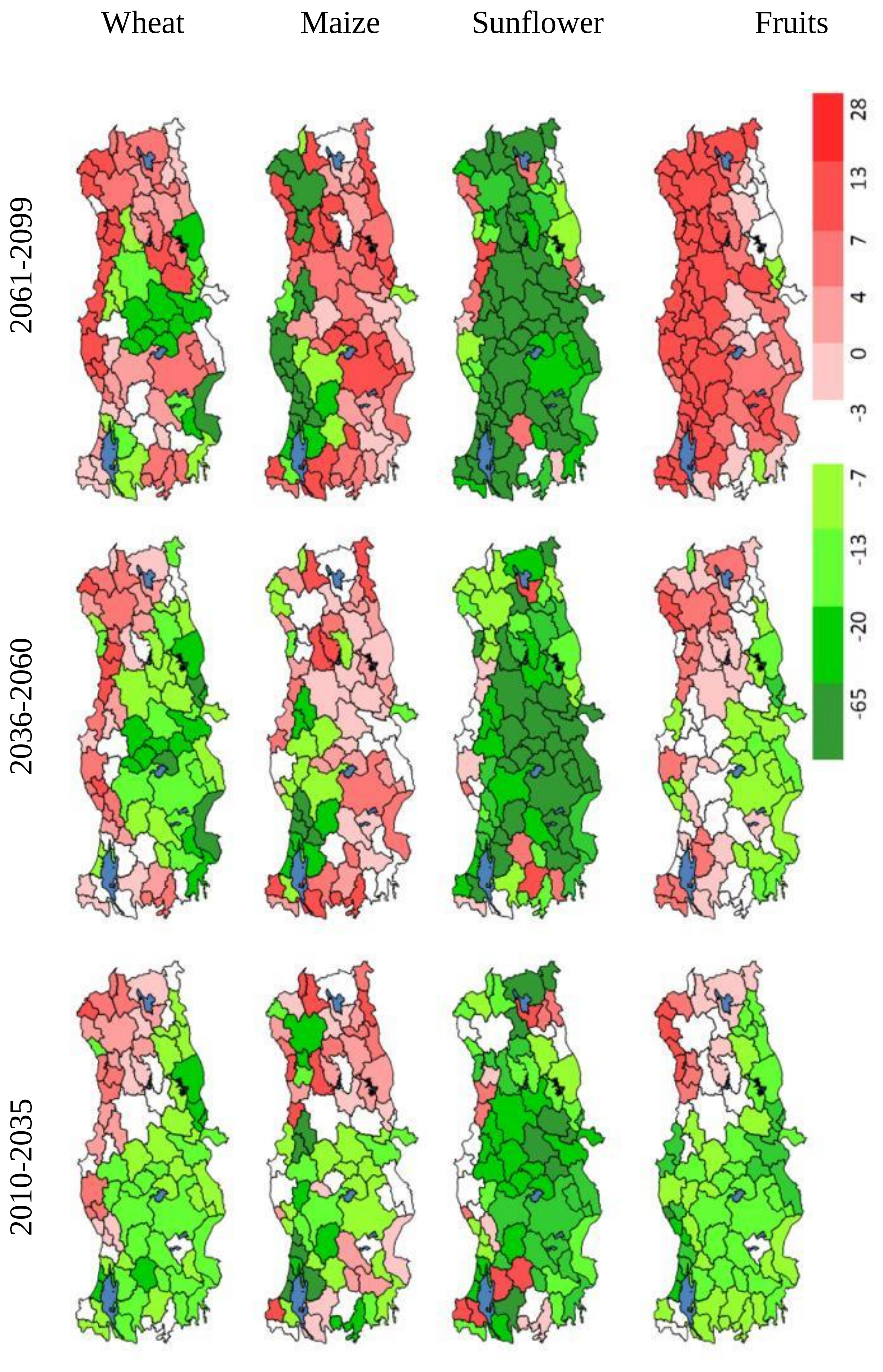
Fruit yields are generally better in the first period. The declines are observed only in a few regions in central and north central Anatolia as well as the north east regions. In the second period yield changes are nonnegative in the western coastal regions and southeast Anatolia. In the last period, fruit yields declines all over the country with a few exceptions.

The crop pattern crucially depends on the availability of irrigation water in these regions together with the changes in yields. Changes in irrigation requirements are less drastic compared to the change in yields. Irrigation requirements are lower than the base period in the eastern central regions in all periods. In the first and second period the irrigation requirements increase only for the northern and north-eastern regions (Figure A.7).



Source: Model results

Figure A.6: Change in yields of selected crops (percentage difference with 2001-2010 average)



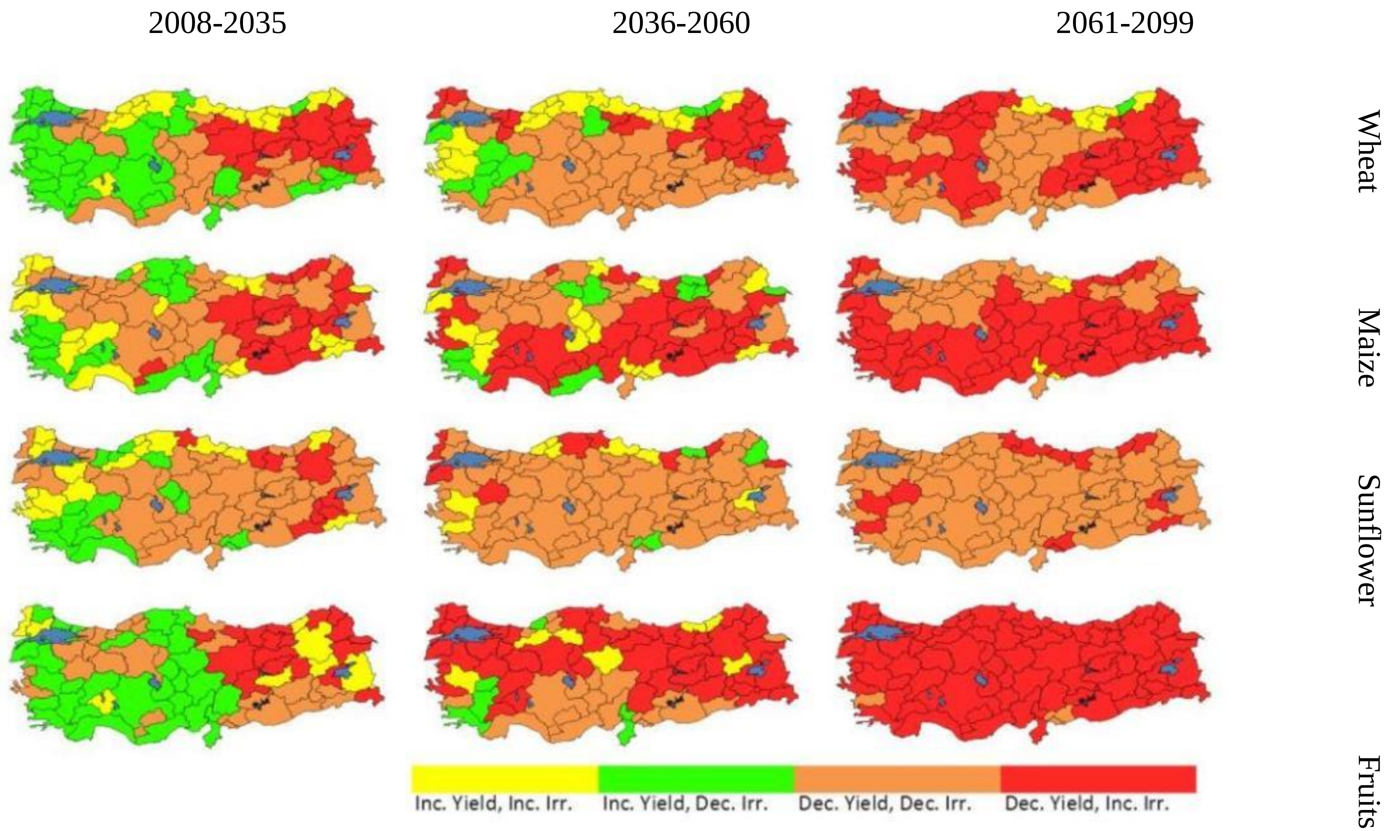
Source: Model results

Figure A.7: Change in irrigation requirements (percent difference from 2001-2010 average)

Figure A.8 shows the changes in yields and irrigation requirements for each region. The technical conditions for production of each crop in each region can be classified under four groups. The first group is the crops for which both irrigation requirement and yield increases (shown with yellow). Crops in this group require higher irrigation to get higher yields. Hence these regions can have an advantage in producing the crops in this group with appropriate investments in the irrigation infrastructure. This is generally observed in the first period. The most important examples are wheat production in the Black sea coast; sunflower production in the northern Aegean regions, Thrace and western black sea regions; fruit production in some eastern regions such as Erzincan, Erzurum, Tunceli and Van. This case is observed less frequently in the second and last period. Only significant example is wheat production in Black sea coast line.

The second category consists of the crops for which yields increase while irrigation requirements decline. Hence crops in this group can dominate agricultural production and constitute a good alternative to the conventionally produced crops. These crops generally require irrigation in the months when precipitation is relatively higher. Wheat and fruit production in the western regions and the Thrace, fruit production in central Anatolia, and sunflower production in the south-western regions are the most important examples in the first period. Cases for which increase in yields are accompanied by decreasing irrigation requirements are quite exceptional in the second and third period. Wheat production in the central Aegean regions is the most significant example.

The third category is the most commonly observed scenario where yields and irrigation requirements declines simultaneously. This scenario is observed in the second period in almost all of the regions for wheat and sunflower; and in the third period it is observed throughout the country for sunflower production, in east-central Anatolia for wheat production, and for maize production in the black sea and the north-central Anatolia regions.



Source: Model results

Figure A.8: Change in yields and irrigation requirements

The last category consists of the crops for which yields are declining while irrigation requirements are increasing. The technical conditions for production of these crops are likely to deteriorate significantly. This case is generally observed in the second and last periods. Maize production in the southern regions and fruit production in northern and eastern regions are the most significant examples in the second period. In the last period irrigation requirements increase while yields decline for wheat production in central Anatolia and eastern regions, for maize production throughout the country except northern regions and for fruit production throughout the country.

Considering these facts and scenarios we can conclude that wheat production is likely to increase in western regions and decline in the eastern regions in the first period. In the second period, only the Aegean and black sea coast lines are likely to benefit from the changes in climatic conditions depending on the availability of irrigation. In the last period, wheat production is likely to increase in eastern central Anatolia and the northern Aegean regions.

Maize production is likely to spread to the western and southern coastline in the first period. However in the second and last periods, the technical conditions for maize production will deteriorate throughout the country. Marmara and the western black sea regions will have relatively better conditions with simultaneously declining yields and irrigation requirements.

In the first period, fruit production improves significantly in the western regions while it deteriorates in southern Marmara, central Anatolia and in almost all eastern regions. Meanwhile, in the second and third periods yields decline all over the country either with declining or increasing irrigation requirements. In these periods, there are few exceptions where fruit yields increase such as Aydın, Muğla, Isparta, Kırşehir, and Bingöl. In the last period, declining yields are generally accompanied by increasing irrigation requirements.

Conclusion

The results of the crop water requirement model are consistent with the past findings in the literature. Technical conditions of agricultural production in Turkey are likely to deteriorate on average. Significant adverse effects are also likely to be observed after 2060s.

Our study also reveals that the effects of climate change are not homogenous throughout the country. They also display high seasonal variability. Precipitation generally will increase up to 20 percent in the first period (i.e. 2010-2035), especially in the western regions. The most significant increase will be observed during winter (i.e. January-March). In other seasons, precipitation will decline in the eastern regions but will remain high in west. In the second period (i.e. 2036-2060), the pattern will remain the same during the winter but it will change drastically for the rest of the year. Precipitation will decline throughout the country during the spring (i.e. April-June) and the fall (October-December). In the summer (i.e. July-September), precipitation will increase significantly for the east central regions, central south and south eastern Anatolia. In the last period (i.e. 2061-2099) higher precipitation will be sustained in the northern regions during the winter but precipitation will decline in the rest of the country. The decline in precipitation will be quite significant during the spring throughout the country. In the summer, precipitation will increase only in southeastern Anatolia. The decline will be milder in the fall and the change in precipitation will be non-negative in the south-eastern regions. Temperature changes will follow a similar trend. Higher precipitation in a region will generally be accompanied by lower temperatures and vice versa.

The impact of the change in precipitation and temperature on the technical conditions for agriculture will depend both on the crop type and the location. The technical conditions for production of each crop in each region can be grouped under four scenarios. The first group is the scenario where yields and irrigation requirements will increase simultaneously. This scenario will generally be observed in the first period and they are quite rare in the second and third period. Crops in this group will require higher irrigation for higher yields and hence, with appropriate investments in the irrigation infrastructure, the regions can have an advantage in producing these crops. Wheat production in Black sea coast and sunflower production in northern Aegean regions, Thrace and western black sea regions are the most important examples. Hence, improving the irrigation infrastructure in these regions will be crucial in helping these regions to adjust more easily to changes in the agricultural production conditions.

The second category considers crops whose yields will increase with a decline in irrigation requirements. Hence crops that fit in this category can dominate agricultural production and can constitute a good alternative to the conventionally produced crops. Such a scenario is generally observed in the first period. Important examples of this would be wheat and fruit production in the western regions and the Thrace, fruit production in central Anatolia, and sunflower production in the south-western regions. This scenario is observed only on an exception basis in the second and third periods. The most significant example here would be wheat production in the central Aegean regions.

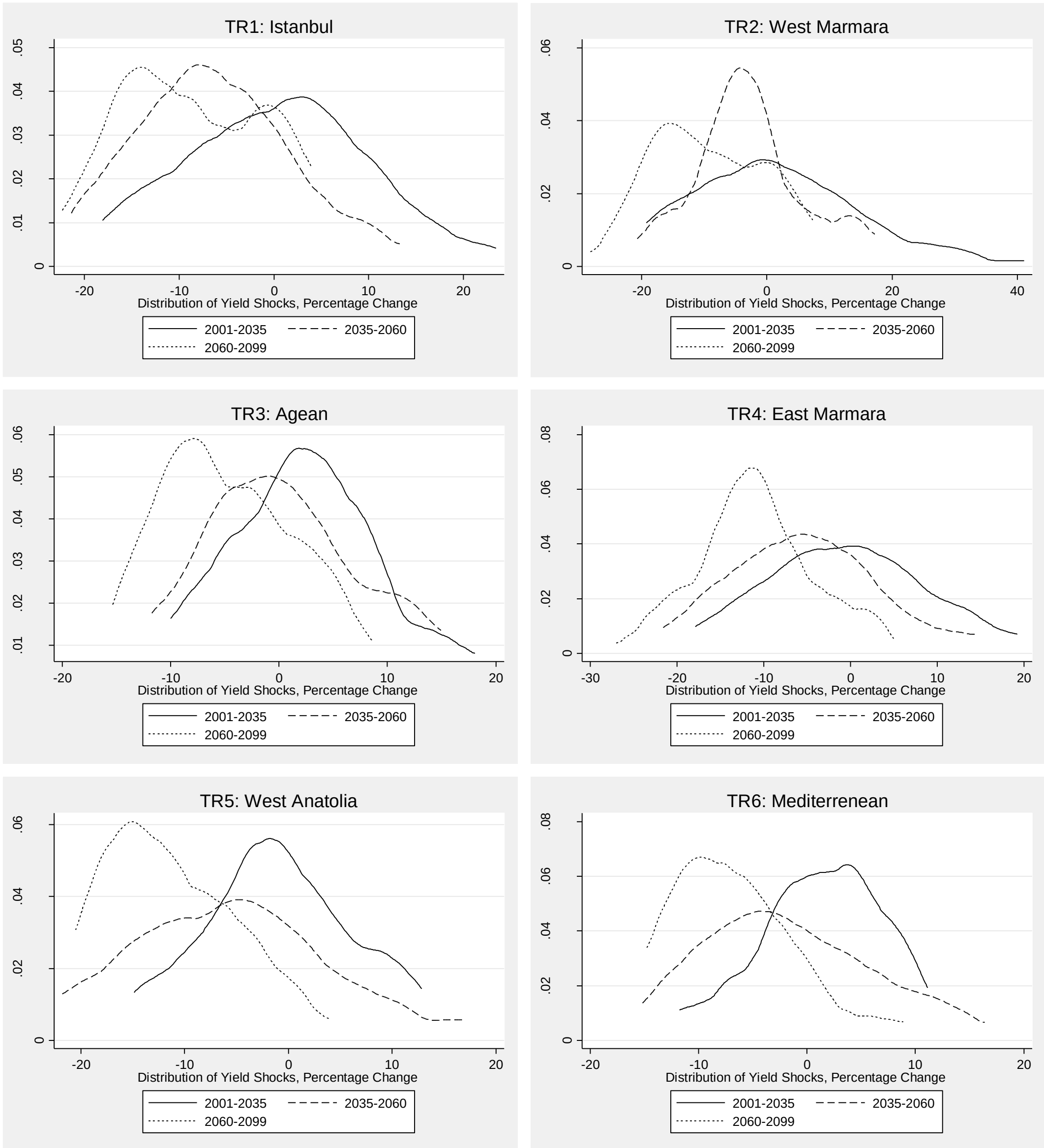
The third category is the scenario where yields and irrigation requirements decline simultaneously. This is the most commonly observed scenario and is observed for wheat and sunflower production in the second period, in almost all regions.

The last category consists of the crops whose yields decline with increased irrigation requirements. The technical conditions for production of crops that fall in this category are likely to deteriorate significantly. This scenario is generally observed in the second and last periods. Maize production in the southern regions and fruit production in the northern and eastern regions are the most significant examples.

In Conclusion, the results suggest that agricultural production of most crops will benefit from climate change until 2030s. However after 2030s and especially after 2060s the conditions will deteriorate significantly throughout the country and for almost all crops. The conventional crops such as cereals will be hit the hard by the changes in climatic conditions. Fruit production will also be affected quite significantly, especially in the last period. The results also suggest that Turkey needs to take into account the heterogonous effect of changes in climatic conditions when prioritizing its irrigation infrastructure development activities. Sustaining higher levels of yields is crucially dependent on the availability of irrigation, for most regions and crops, especially in the first and second period. In the long-run, more drought resistant crops seem to be only solution indicating the importance of supporting R&D activities that focus on developing such seeds.

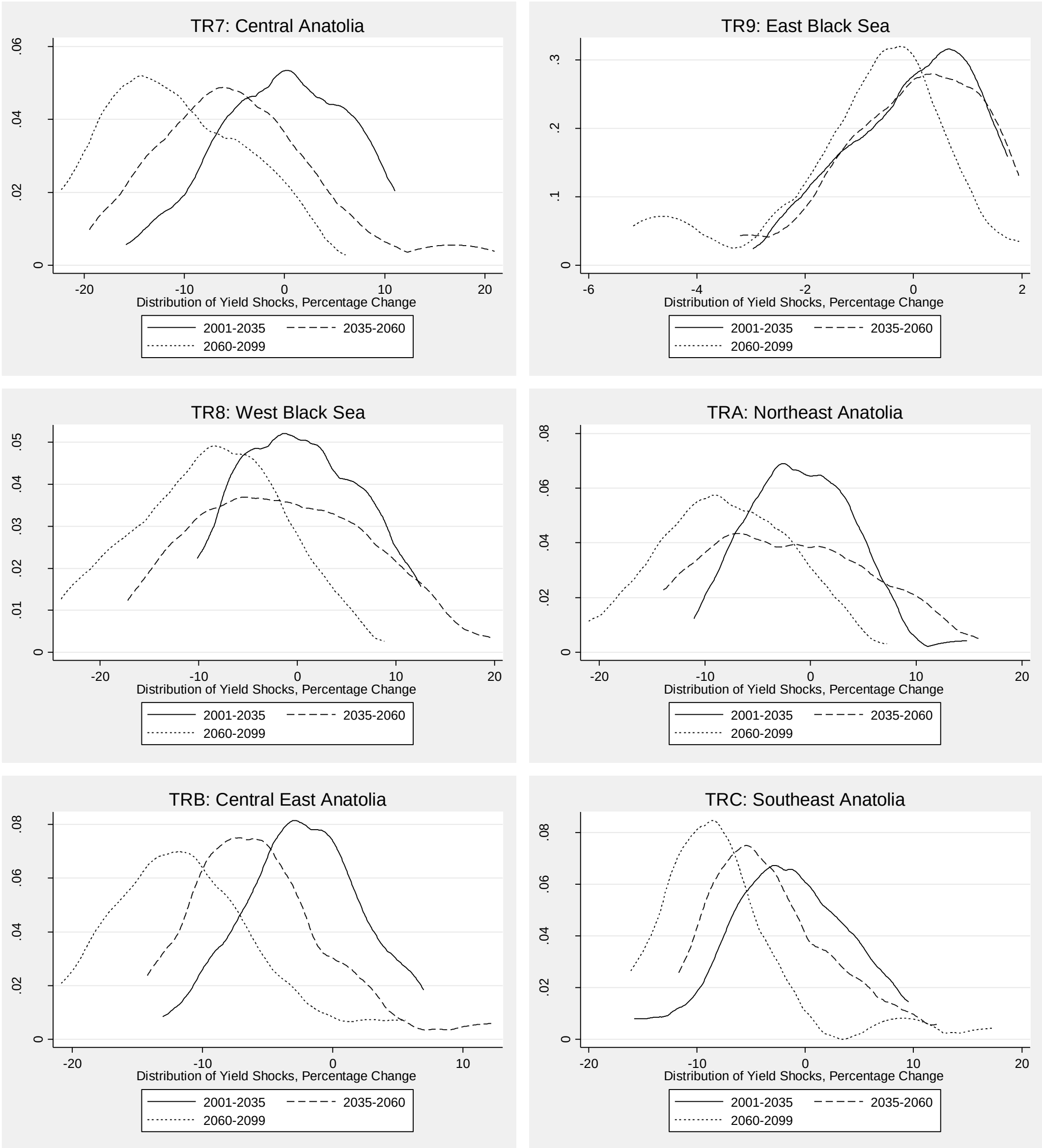
APPENDIX B

Supplementary Tables and Figures for Chapter 2



Source: Author's calculation

Figure B.1: Kernel distribution of yield change for each region



Source: Author’s calculation

Figure B.1: Kernel distribution of yield change for each region (continued)

Table B.1: Effects on selected aggregate variables of other sectors

			BASE	2010-2035	2035-2060	2060-2100
Manufacturing	Mark.	**Prod.**	142,478	0.01	-0.95	-2.62
		Cons.	103,317	0.08	-1.52	-4.26
		Prices	1.00	0.01	-0.60	-1.65
	Empl.	**Labor**	3,179	-0.01	-0.39	-1.06
		Capital	73,739	0.05	-1.45	-4.01
		Water	1,079	-0.02	0.32	0.90
	Wage	**Labor**	21.29	0.06	-1.42	-3.93
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.15	-2.27	-6.38
	Trade	**Import**	229,988	0.09	-2.14	-5.82
		Export	135,216	-0.07	-1.46	-3.77
		Deficit	-94,772	0.31	-3.10	-8.74
Textile	Mark.	**Prod.**	35,046	0.04	-1.14	-3.14
		Cons.	46,251	0.03	-0.53	-1.50
		Prices	1.00	-0.01	-0.44	-1.19
	Empl.	**Labor**	1,657	0.03	-0.43	-1.17
		Capital	22,141	0.06	-1.53	-4.24
		Water	186.857	-0.01	0.21	0.64
	Wage	**Labor**	7.68	0.03	-1.48	-4.11
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.14	-2.25	-6.35
	Trade	**Import**	11,830	0.04	-0.90	-2.44
		Export	32,308	0.06	-2.23	-6.03
		Deficit	20,478	0.07	-3.00	-8.11
Energy	Mark.	**Prod.**	14,031	0.06	-0.94	-2.68
		Cons.	12,786	0.05	-0.75	-2.13
		Prices	1.00	0.02	-0.37	-1.01
	Empl.	**Labor**	161	-0.05	-0.46	-1.26
		Capital	10,800	0.08	-1.10	-3.13
		Water	7.167	-0.01	0.40	1.12
	Wage	**Labor**	20.09	0.16	-0.88	-2.58
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.18	-1.91	-5.51
	Trade	**Import**	18.956	0.04	-1.17	-3.16
		Export	101	0.00	-2.13	-5.68
		Deficit	82	0.00	-2.35	-6.26

Table B.1: Effects on selected aggregate variables of other sectors (continued)

			BASE	2010-2035	2035-2060	2060-2100
Private Services	Mark.	Prod.	429,450	0.09	-1.61	-4.51
		Cons.	326,497	0.09	-1.85	-5.14
		Prices	1.00	0.01	-0.45	-1.22
	Empl.	Labor	10,012	0.03	-0.77	-2.22
		Capital	308,817	0.12	-1.91	-5.36
		Water	1,928	0.01	-0.15	-0.42
	Wage	Labor	11.86	0.09	-1.55	-4.26
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.17	-2.33	-6.54
	Trade	Import	34,029	0.14	-2.14	-5.86
		Export	44,558	0.16	-2.59	-7.30
		Deficit	10,529	0.21	-4.05	-6.00
Public Services	Mark.	Prod.	84,707	0.02	-1.07	-2.96
		Cons.	19,477	0.04	-1.77	-4.85
		Prices	1.00	0.08	-0.73	-2.07
	Empl.	Labor	486	0.02	-0.94	-2.59
		Capital	13,306	0.14	-1.71	-4.84
		Water	573.957	0.01	-0.22	-0.59
	Wage	Labor	145.59	0.13	-1.08	-3.07
		Capital	1.00	0.00	0.00	0.00
		Water	1.00	0.18	-1.97	-5.63

Note: Production and Consumption figures and quantity of water are quantities in terms of value added units, i.e. units that make base prices 1. Labor is in thousand person. Rest of the base values are in million TL

Source: Author’s calculation

APPENDIX C

Supplementary Tables and Figures for Chapter 3

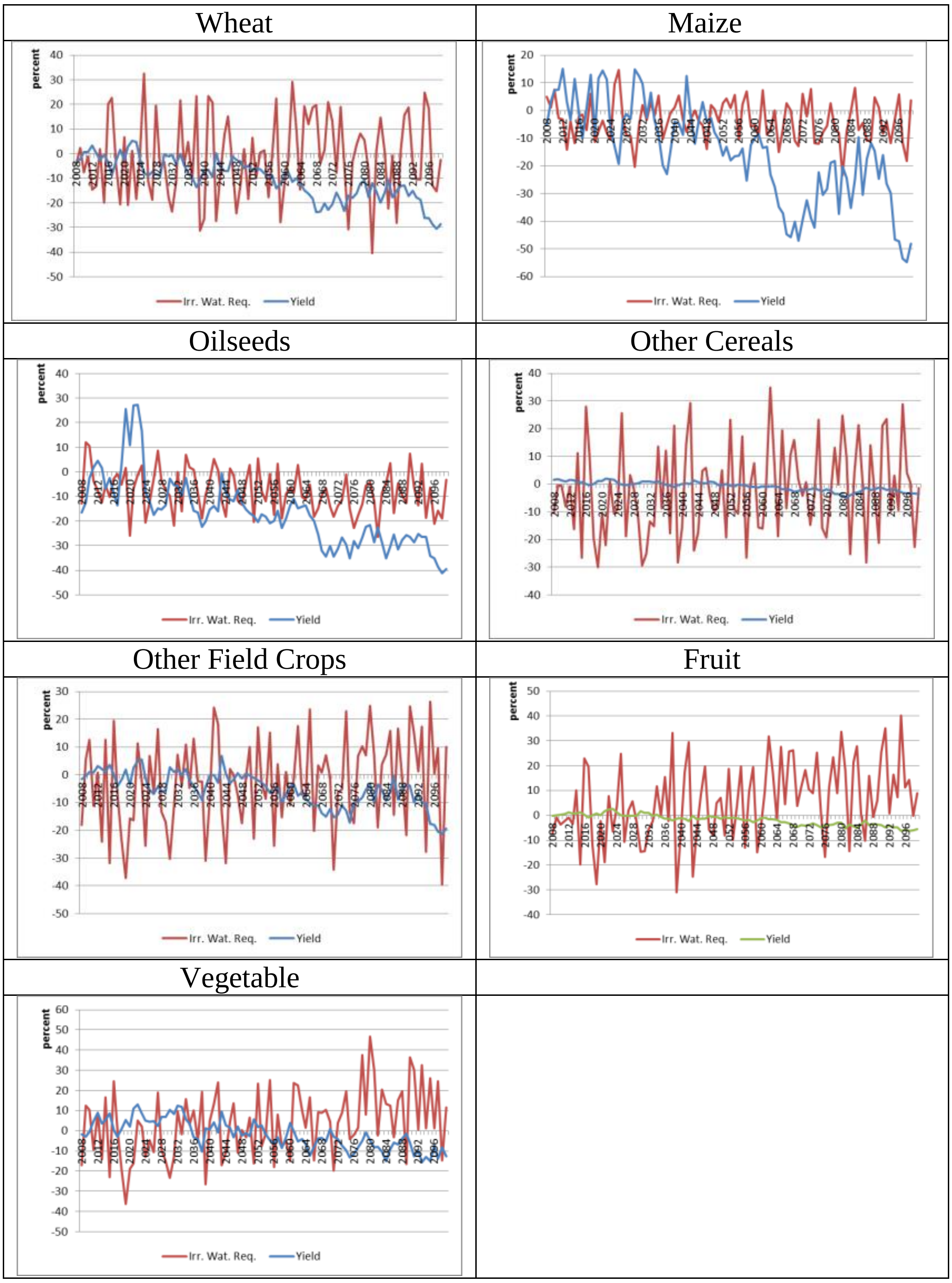
Table C.1: Statistics about yield and irrigation requirement changes

Crop	Variable	Statistics	Period 1	Period 2	Period 3
Wheat	**Irrigation Water Req.**	Minimum	-23.46	-31.28	-40.54
		Mean	-3.30	-3.92	1.06
		Maximum	32.62	23.38	29.15
		Standard Dev.	15.41	16.98	16.03
	Yield	Minimum	-9.14	-14.08	-30.51
		Mean	-2.15	-7.13	-17.55
		Maximum	5.23	0.23	-7.53
		Standard Dev.	4.16	3.51	5.68
Maize	**Irrigation Water Req.**	Minimum	-20.33	-13.83	-23.28
		Mean	-3.30	-1.52	-5.02
		Maximum	14.58	6.90	8.31
		Standard Dev.	7.79	5.50	7.47
	Yield	Minimum	-19.32	-25.39	-54.83
		Mean	2.45	-9.88	-29.73
		Maximum	15.07	12.57	-8.62
		Standard Dev.	9.40	8.46	13.15
Oilseeds	**Irrigation Water Req.**	Minimum	-26.01	-20.52	-26.49
		Mean	-5.46	-6.62	-10.27
		Maximum	12.06	5.42	7.33
		Standard Dev.	9.52	8.38	7.59
	Yield	Minimum	-17.48	-22.71	-41.21
		Mean	-1.94	-15.44	-27.28
		Maximum	27.26	-0.64	-11.00
		Standard Dev.	13.20	5.15	7.37
Other Cereals	**Irrigation Water Req.**	Minimum	-29.96	-28.24	-28.29
		Mean	-6.92	-3.01	1.33
		Maximum	27.93	29.20	34.80
		Standard Dev.	15.44	16.36	16.05
	Yield	Minimum	-0.47	-1.14	-4.94
		Mean	0.82	-0.14	-2.32
		Maximum	1.93	1.32	-0.70
		Standard Dev.	0.70	0.65	1.00

Table C.1: Statistics about yield and irrigation requirement (continued)

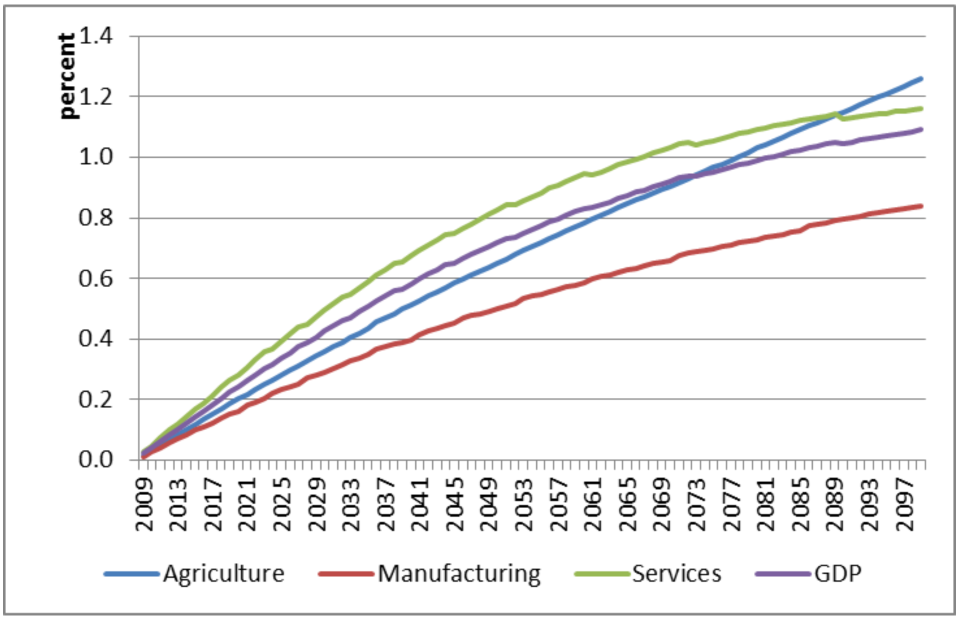
Crop	Variable	Statistics	Period 1	Period 2	Period 3
Fruit	**Irrigation Water Req.**	Minimum	-27.79	-30.95	-16.74
		Mean	-1.76	2.98	12.54
		Maximum	24.80	33.26	40.26
		Standard Dev.	12.65	16.28	13.53
	Yield	Minimum	-0.77	-2.77	-6.35
		Mean	0.62	-1.32	-3.84
		Maximum	2.58	-0.22	-0.87
		Standard Dev.	0.84	0.62	1.35
Vegetable	**Irrigation Water Req.**	Minimum	-36.37	-26.47	-19.87
		Mean	-4.44	1.09	10.41
		Maximum	24.47	25.18	46.80
		Standard Dev.	15.39	14.03	15.93
	Yield	Minimum	-2.86	-10.32	-15.61
		Mean	5.35	-0.77	-7.33
		Maximum	12.96	9.48	3.77
		Standard Dev.	4.57	4.46	4.64
Other Field Crops	**Irrigation Water Req.**	Minimum	-37.27	-31.86	-39.67
		Mean	-7.10	-3.61	0.73
		Maximum	19.48	24.30	26.35
		Standard Dev.	16.16	15.19	16.55
	Yield	Minimum	-6.88	-10.03	-21.35
		Mean	-0.25	-2.83	-10.02
		Maximum	5.48	6.86	-0.55
		Standard Dev.	3.45	3.59	5.22

Source: Crop water requirement model results



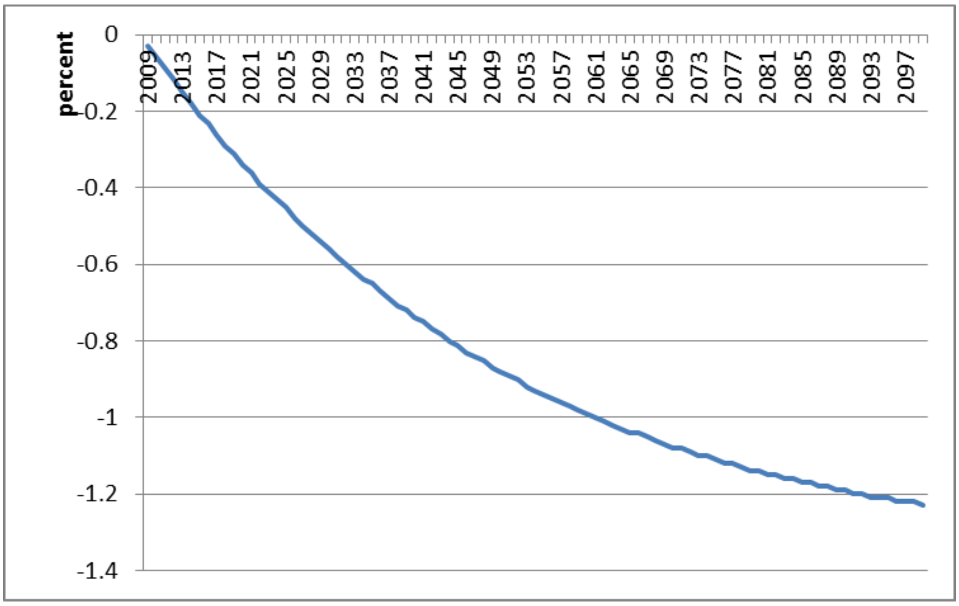
Source: Model Results

Figure C.1: Change in yield and irrigation water requirement of selected crops (percentage change from the base year)



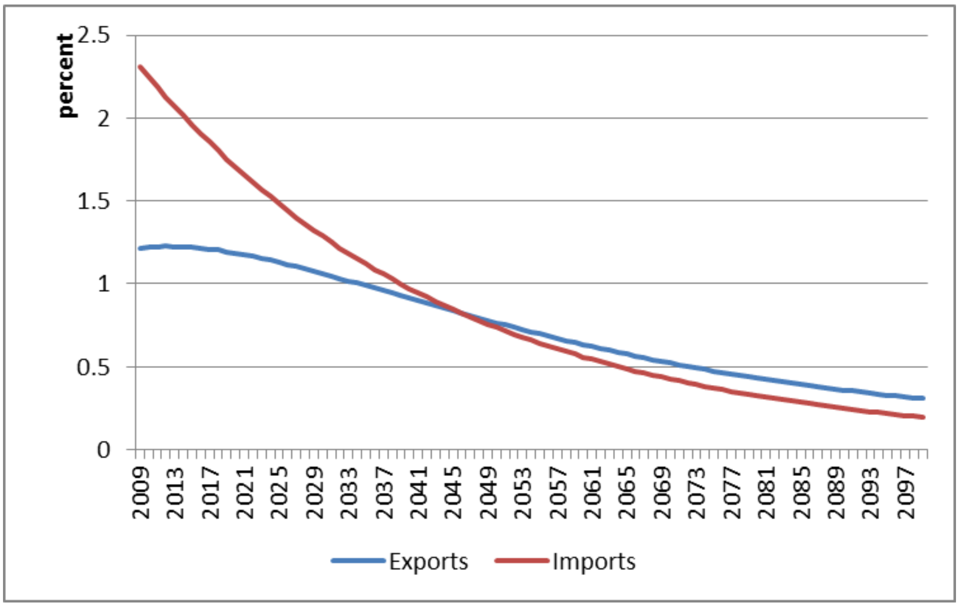
Source: Model Results

Figure C.2: Sectoral value added and GDP growth under baseline (percentage deviation from the base year)



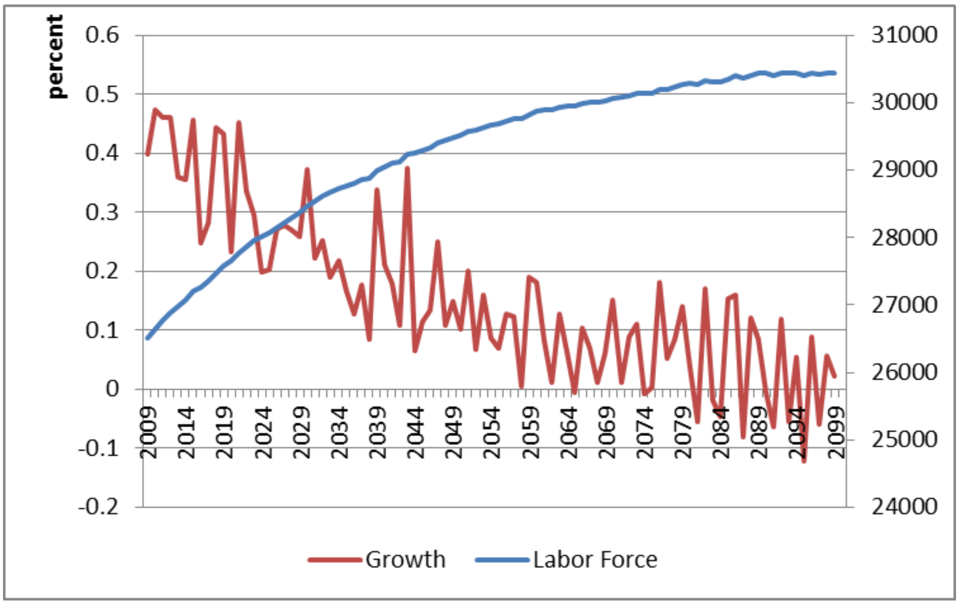
Source: Model Results

Figure C.3: Change in CPI under baseline (percentage deviation from the base year)



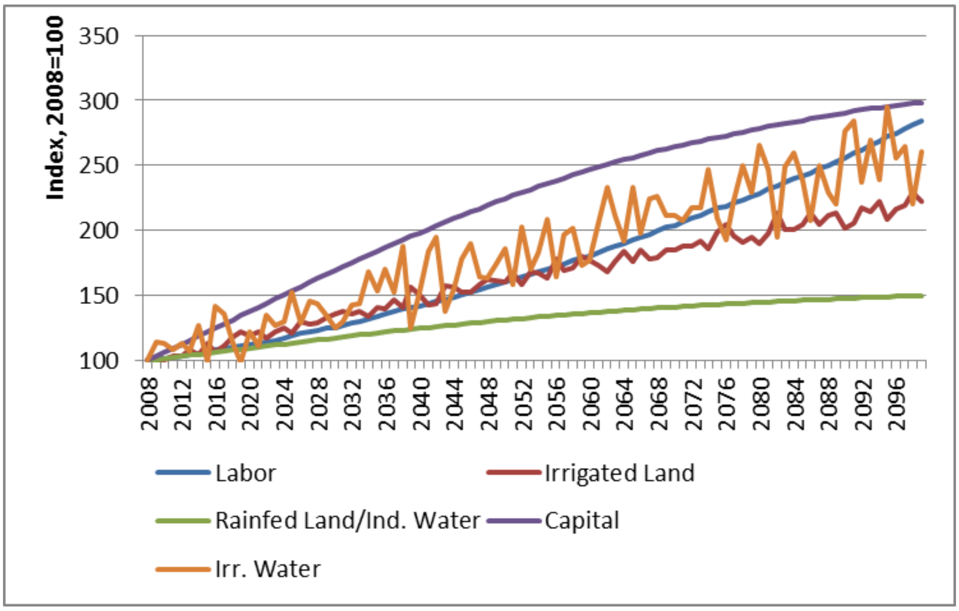
Source: Model Results

Figure C.4: Change in Imports and exports under the baseline (percentage deviation from the base year)



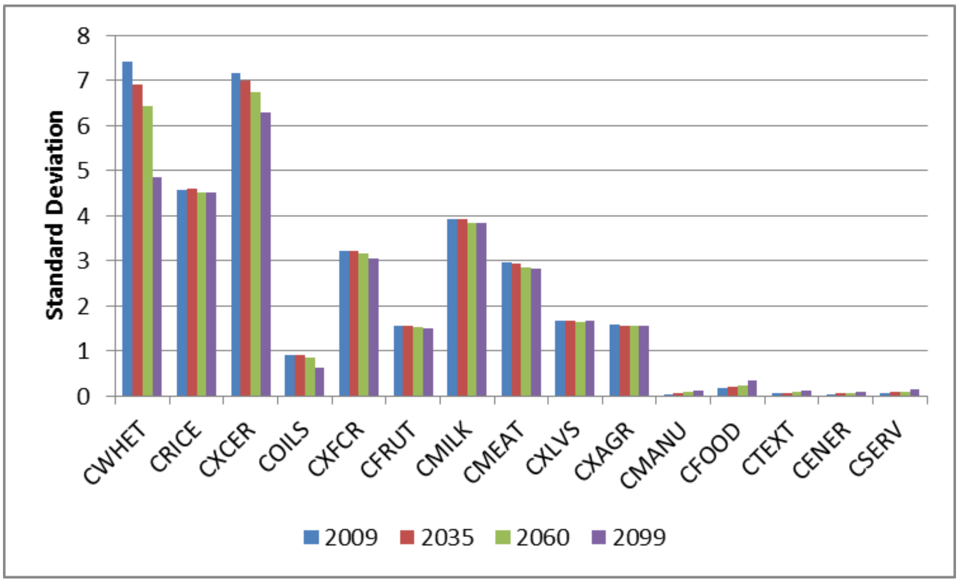
Source: Model Results

Figure C.5: Labor Force growth in the baseline scenario.



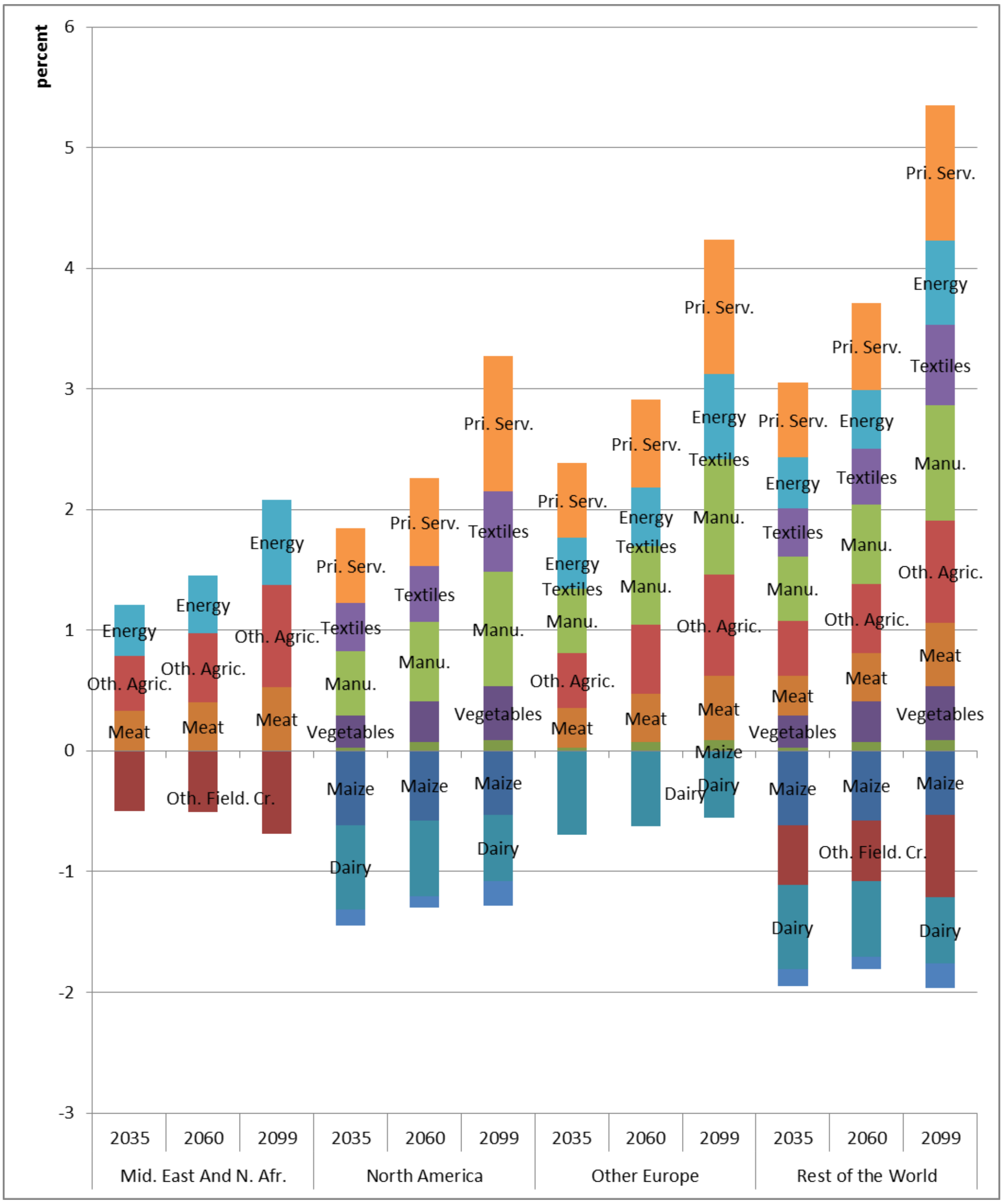
Source: Model Results

Figure C.6: Growth path of factor supplies in the baseline scenario



Source: Model Results

Figure C.7: Standard deviation of change in imports to EU

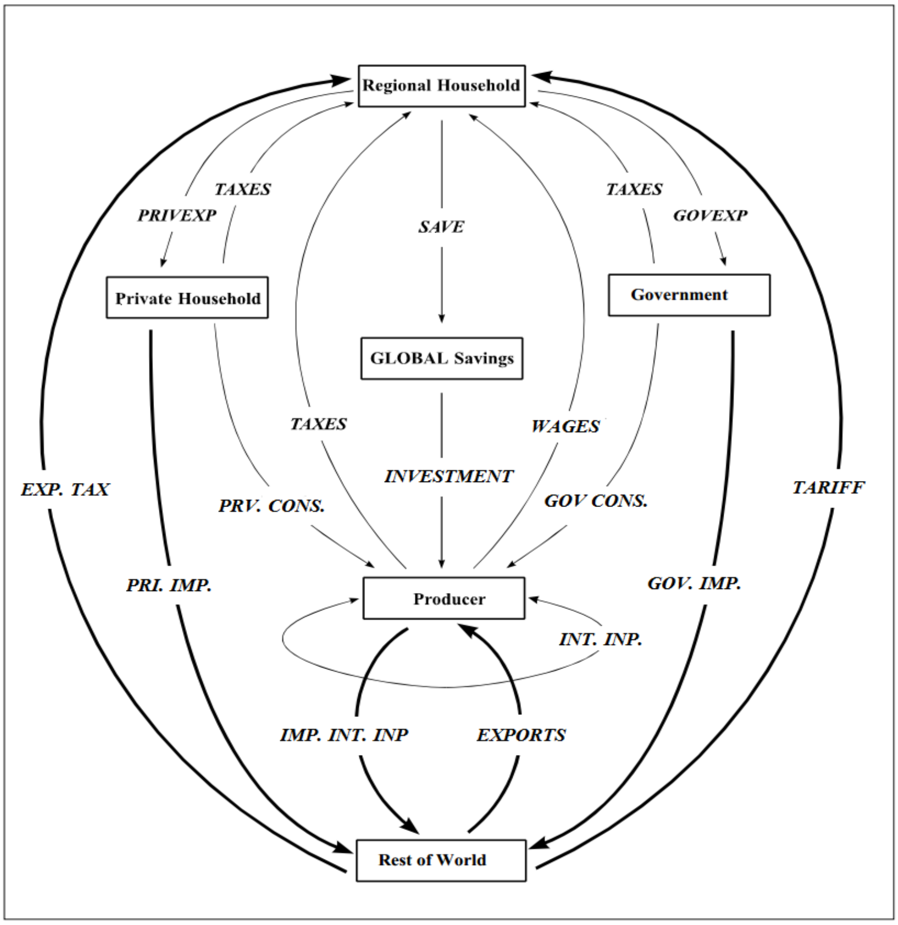


Source: Model Results

Figure C.8: Change in imports to the other trading partners for the rest of the sectors (percentage deviation from the baseline)

APPENDIX D

Supplementary Tables and Figures for Chapter 4



Source: Author's adaptation from Brockmeier (1996)

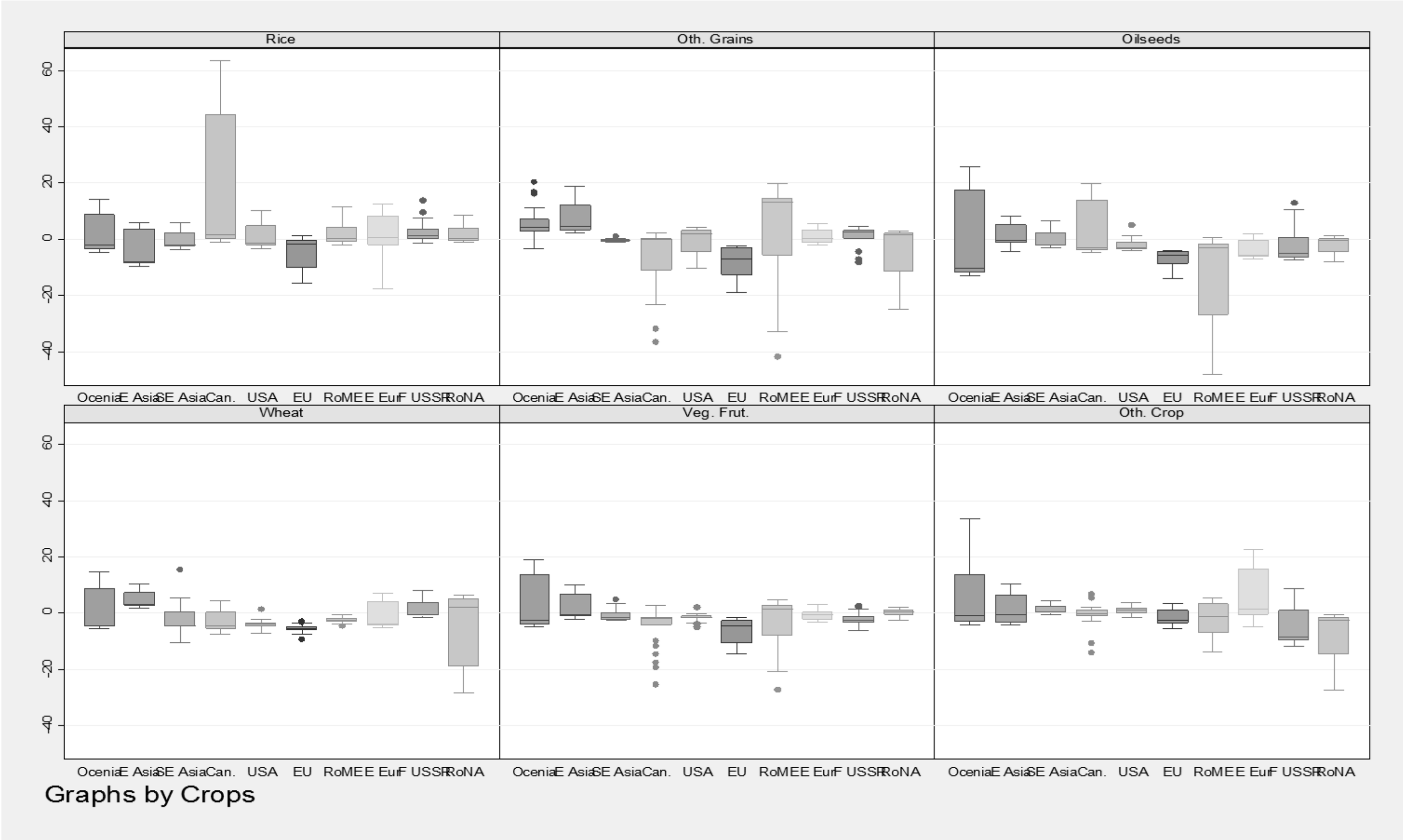
Figure D.1: Detailed structure of GTAP model

Table D.1: Yield Shocks for selected regions and crops (percentage change)

Imposed on Turkey	Oceania	E Asia	S E Asia	S Asia	Canada	USA	L Amer	Brazil	EU27	Mid East	E Europe	F USSR	Turkey	N Africa	Morocco	S-Sah Afr.
Paddy rice	0	0	0	0	0	7.51	19.92	0	52.03	0	11.77	12.77	0	0	0	0
Wheat	0	0	0	0	0	2.85	0	0	9.18	2.98	16.67	1.62	0	0	0	0.52
Coarse grains	0	2.72	0	0	0	0.11	0	0	19.79	23.15	4.35	0.56	0	5.18	0	3.23
Vegetables, fruits, and nuts	2.55	7.61	7.83	14.24	0.04	1.97	17.8	8.22	1.19	4.73	12.37	8.85	0	23.01	31.65	3.96
Oilseeds	0	0	0	41.17	0	0.89	3.65	4.53	0.12	17.14	3.64	17.56	0	6.05	21.41	7.8
Sugar cane, Suger beet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other crops nes	0.04	5.45	33.71	6.56	0.29	31.35	16.16	10.48	0.35	5.58	4.86	4.4	0	7.65	17.24	8.88
Meat, livestock, raw milk	0	4.95	1.02	8.42	0.95	0.56	0.96	0	1.56	60.85	13.96	7.6	0	14.48	0.92	3.08
Forest, fish,	1.37	2.38	2.14	10.44	0.05	0	9.84	4.77	0	6.33	0.49	3.59	0	12.2	16.14	4.11
Vegetable oils and fats	0.37	4.34	7.34	21.03	1.08	2.61	13.8	10.45	32.95	9.8	16.3	7.88	0	2.5	34.21	17.45
Other processed food	3.18	9.34	8.48	17.49	6.17	5.99	12.72	12.12	6.68	11.19	15.89	13.75	0	19	29.22	15.11
Textile and apparel	11.36	7.82	12.06	12.53	12.28	9.44	15.71	14.71	0.14	10.83	4.73	13.15	0	15.61	26.21	19.43
Manufactures	3.53	4.08	6.51	14.7	0.73	0.79	10.13	12.18	0.04	5.79	3.87	9.02	0	14.58	19.6	13.75

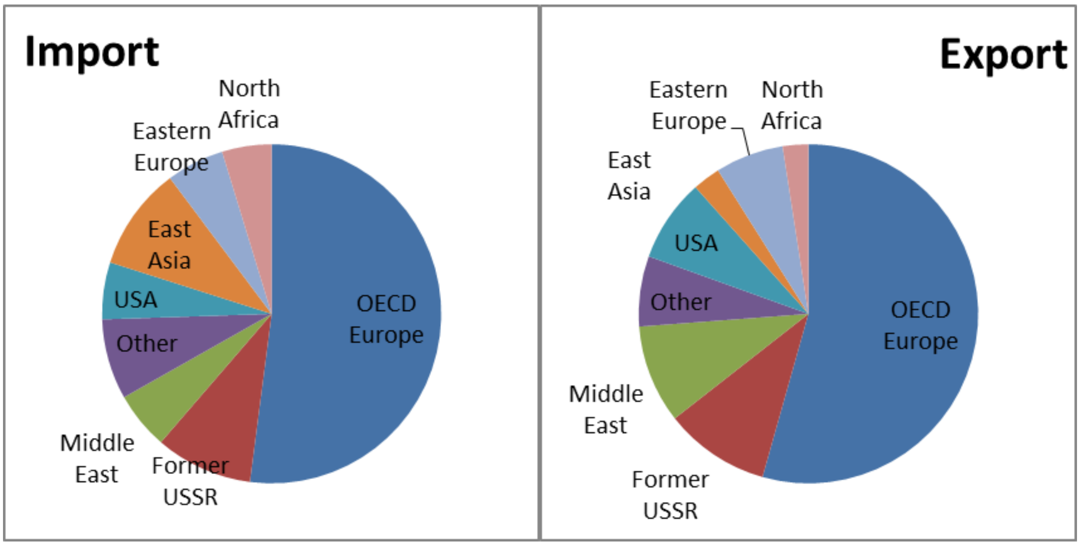
Imposed by Turkey	Oceania	E Asia	S E Asia	S Asia	Canada	USA	L Amer	Brazil	EU27	Mid East	E Europe	F USSR	Turkey	N Africa	Morocco	S-Sah Afr.
Paddy rice	0	0	0	0	0	24.38	0	0	20.09	0	0	23.98	0	26.47	0	0
Wheat	11.76	0	10.37	0	11.76	11.76	11.6	11.76	12	12.64	11.64	11.77	0	0	0	0
Coarse grains	0.95	16.54	1.54	12.58	13.89	16.28	16.12	0	23.96	29.84	15.92	28.5	0	0	0	2.4
Vegetables, fruits, and nuts	31.91	14.33	23.18	17.48	14.58	29.26	54.33	31.27	28.29	28.94	29.78	22.65	0	20.15	9.01	20.09
Oilseeds	5.46	20.63	8.36	12.2	1.39	0.38	0.13	0	5.47	8.91	7.12	7.07	0	20.1	0	11.4
Sugar cane, Suger beet	0	0	0	0	0	0	0	0	0	0	0	16.46	0	0	0	0
Other crops nes	9.71	19.83	25.63	58.03	19.8	0.48	9.12	16.62	5.29	2.8	17.68	1.37	0	2.09	21.12	3.89
Meat, livestock, raw milk	1.1	5.63	4.88	46.83	13.45	20.93	15.99	43.65	4.65	1.71	3.92	1.56	0	0	0	0.53
Forest, fish,	0.27	0.14	5.5	1.43	0.14	0.27	0	0.97	0.34	0	0.55	0.02	0	0.45	0	0.25
Vegetable oils and fats	2.05	15.27	8.64	11.85	0	13.45	8.84	11.31	18.97	10.14	14.78	11.42	0	22.28	0	21.1
Other processed food	5.63	25.61	18.31	53.97	8.92	18.51	9.17	16.99	12.19	27.32	18.6	14.14	0	27.57	22.21	13.59
Textile and apparel	0.89	6.74	6.2	5.67	7.08	6.1	3.59	5.02	0.02	4.5	0.35	5.04	0	6.43	10.05	5.51
Manufactures	0.81	3.58	3.11	3.99	1.55	2.04	0.83	3.93	0	1.41	0.28	5.63	0	2.02	3.04	0.81

Source: GTAP database



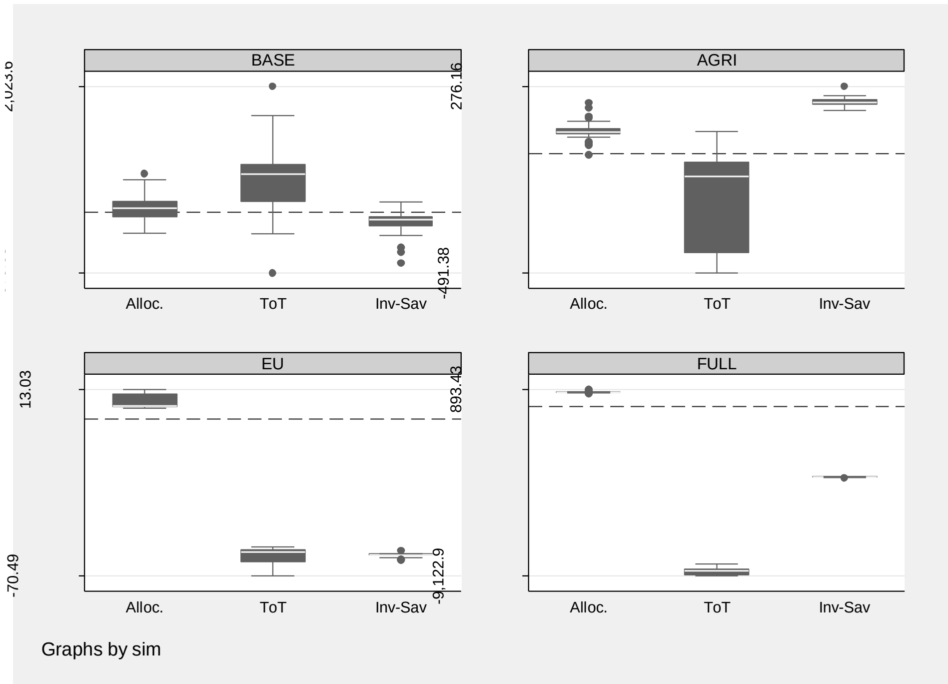
Source: Authors' Calculation from IMAGE and IFPRI Databases

Figure D.2: Yield Shocks for selected regions and crops (percentage change)



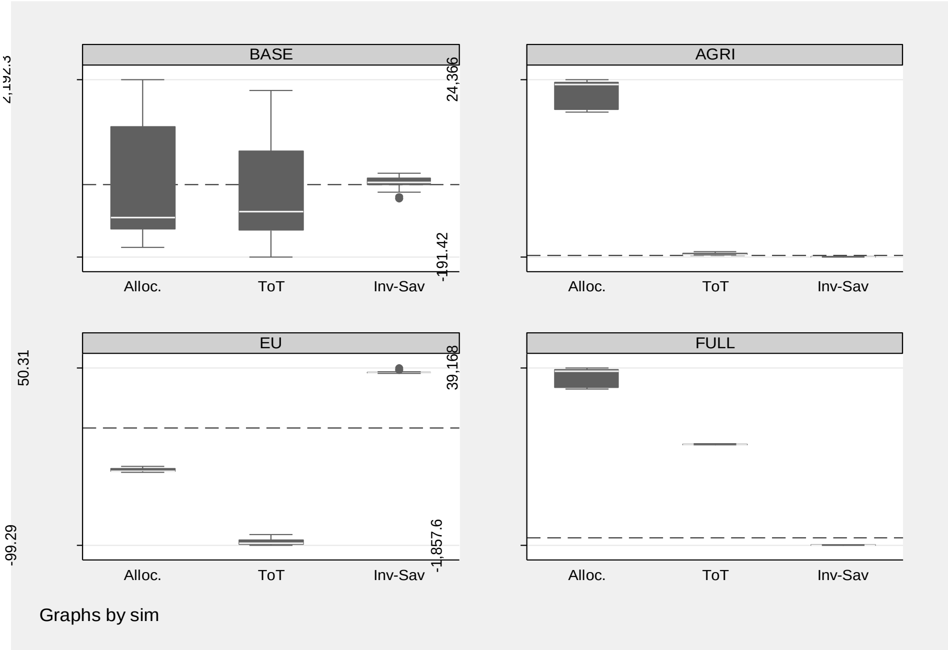
Source: Author's adaptation from Brockmeier (1996)

Figure D.3: Most important trading partners of Turkey



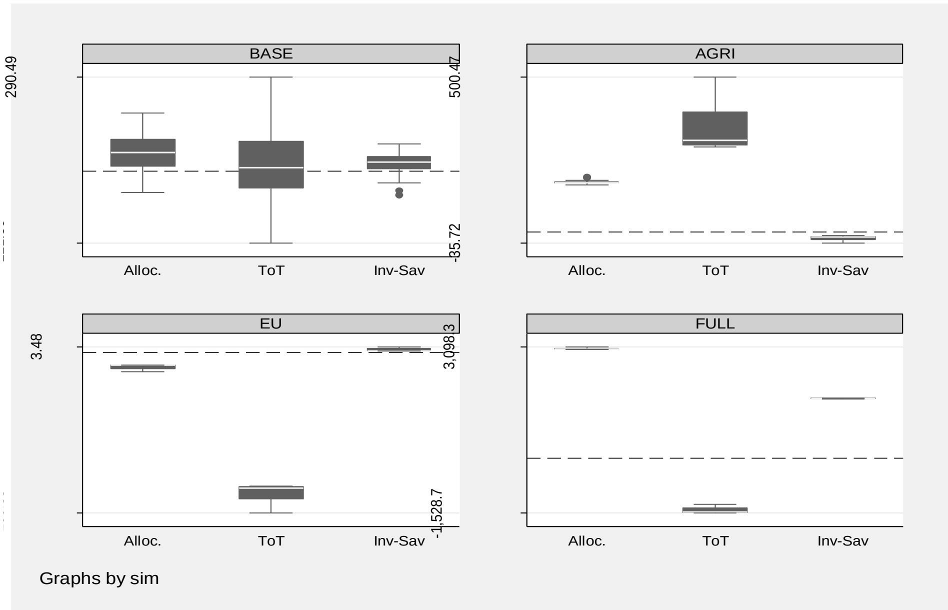
Source: Model Results

Figure D.4: Distribution of decomposition of EV for USA



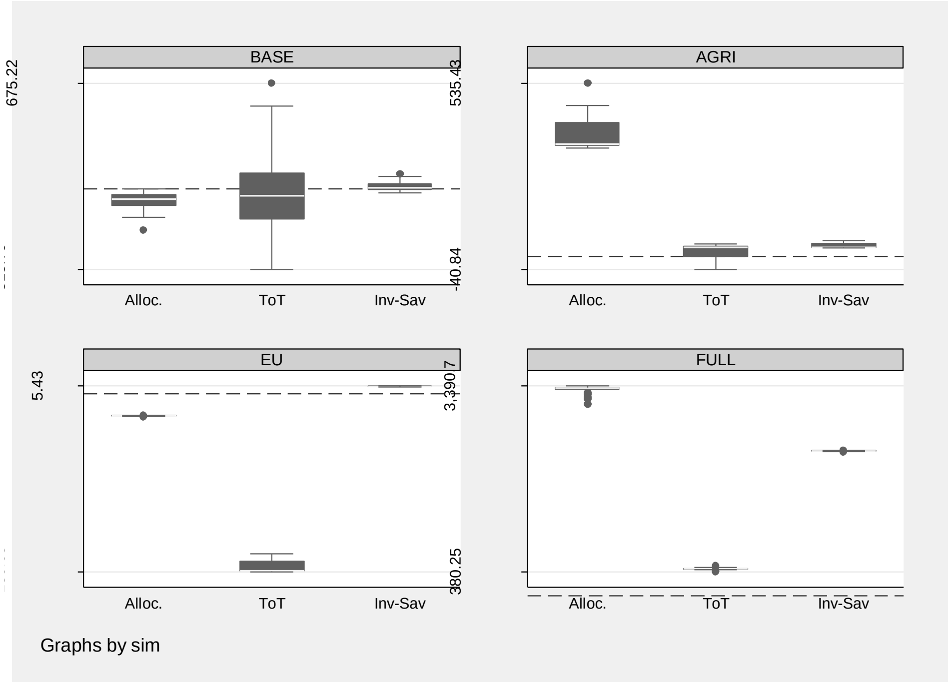
Source: Model Results

Figure D.5: Distribution of decomposition of EV for East Asia



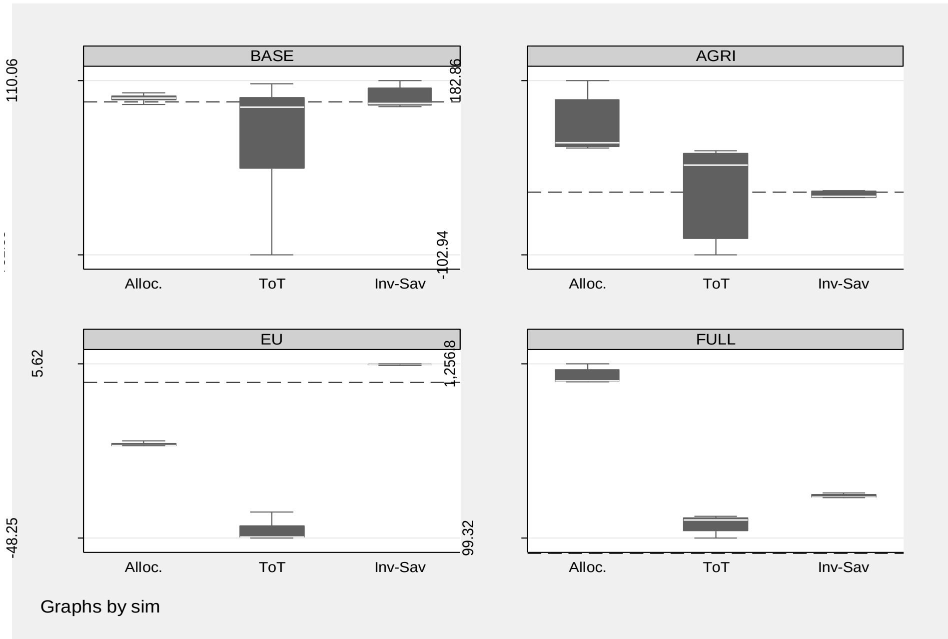
Source: Model Results

Figure D.6: Distribution of decomposition of EV for Former USSR Region



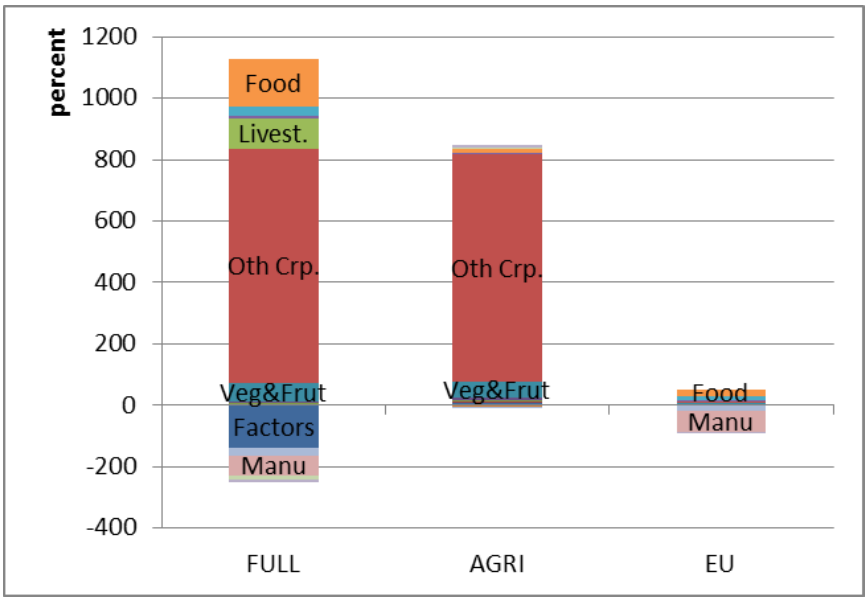
Source: Model Results

Figure D.7: Distribution of decomposition of EV for Middle East



Source: Model Results

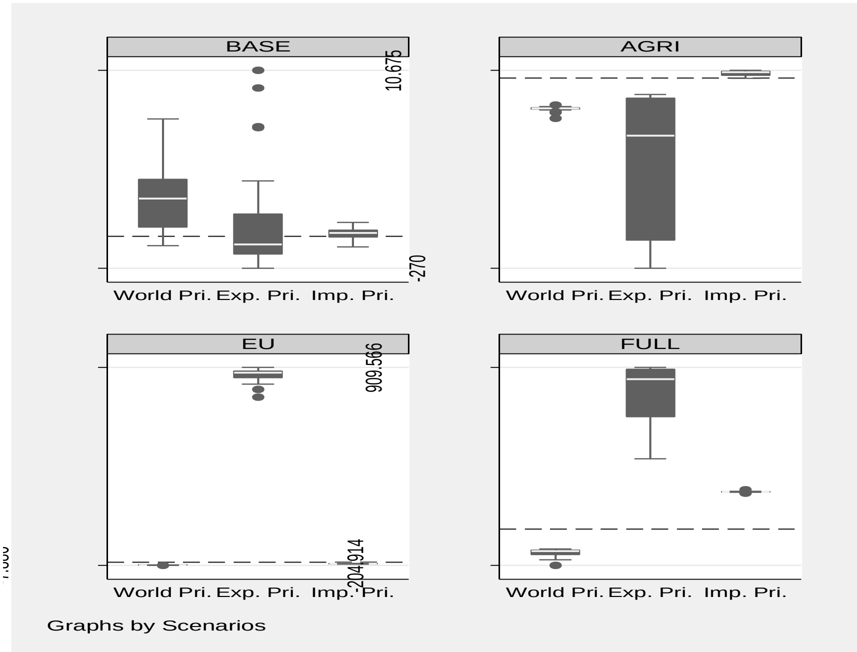
Figure D.8: Distribution of decomposition of EV for East Asia



Source: Model Results

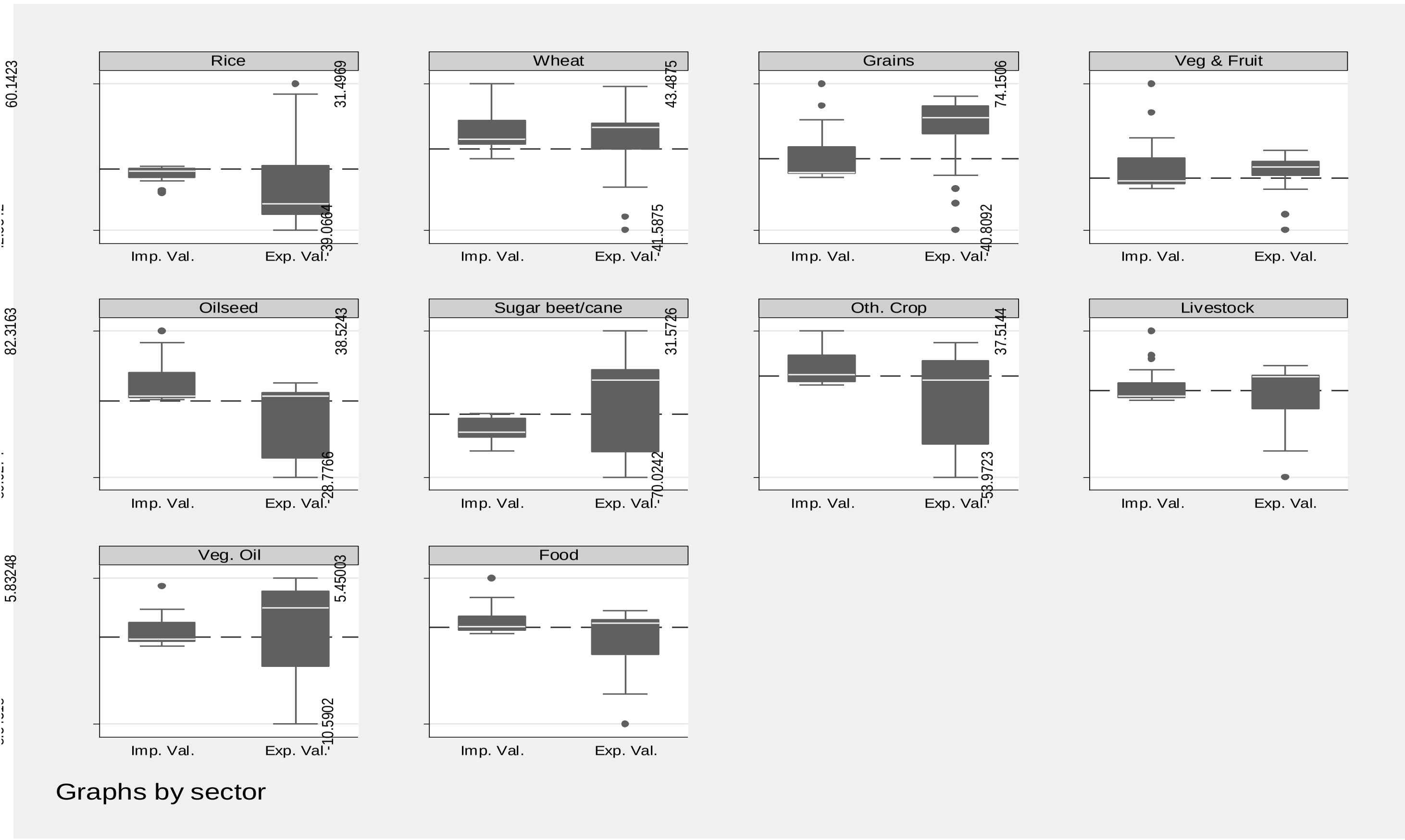
Note: We present the average over all climate scenarios since variation is not significant

Figure D.9: Distribution allocative efficiency effects according to sectors for Turkey (million USD)



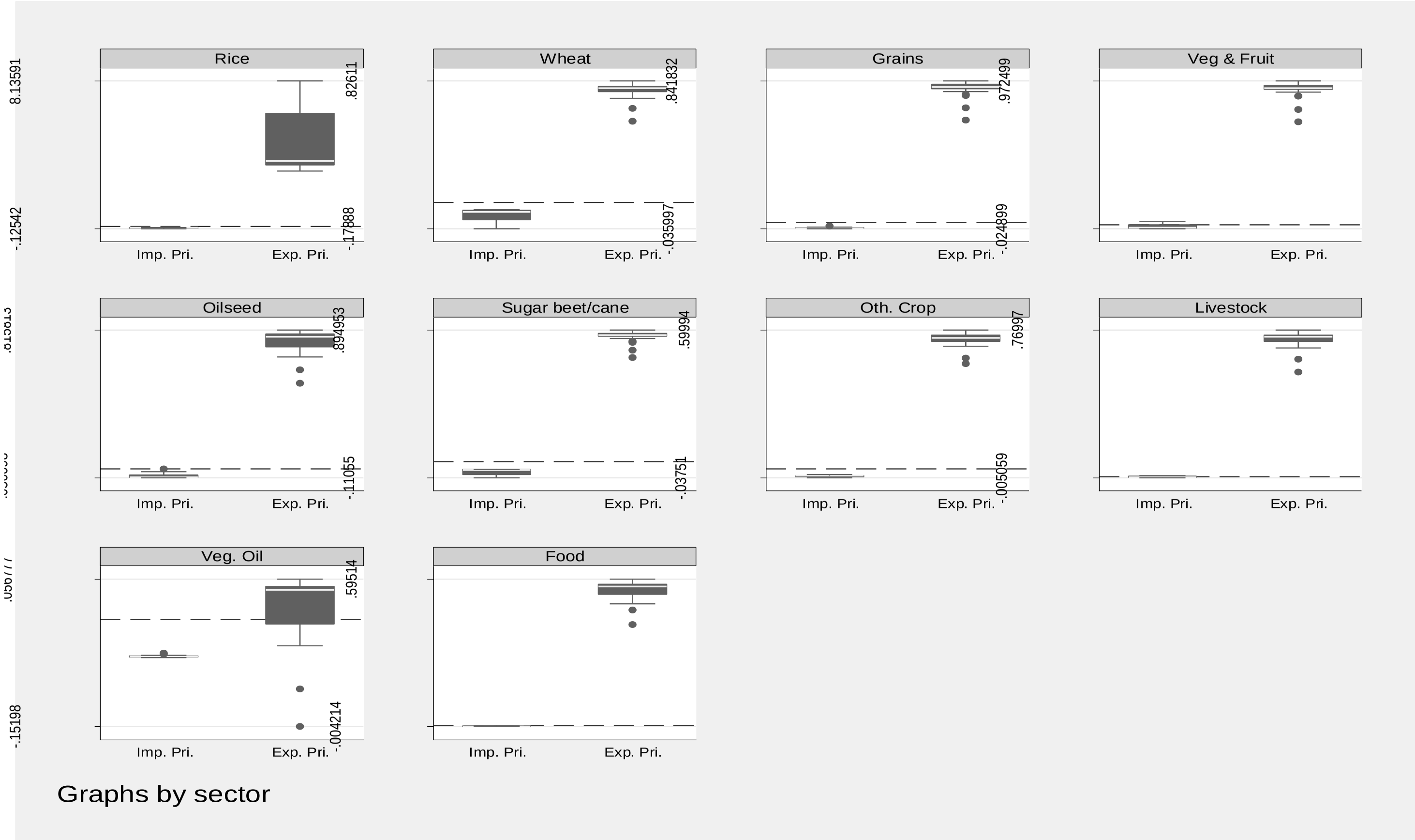
Source: Model Results

Figure D.10: Distribution decomposition of terms of trade component of EV (million USD)



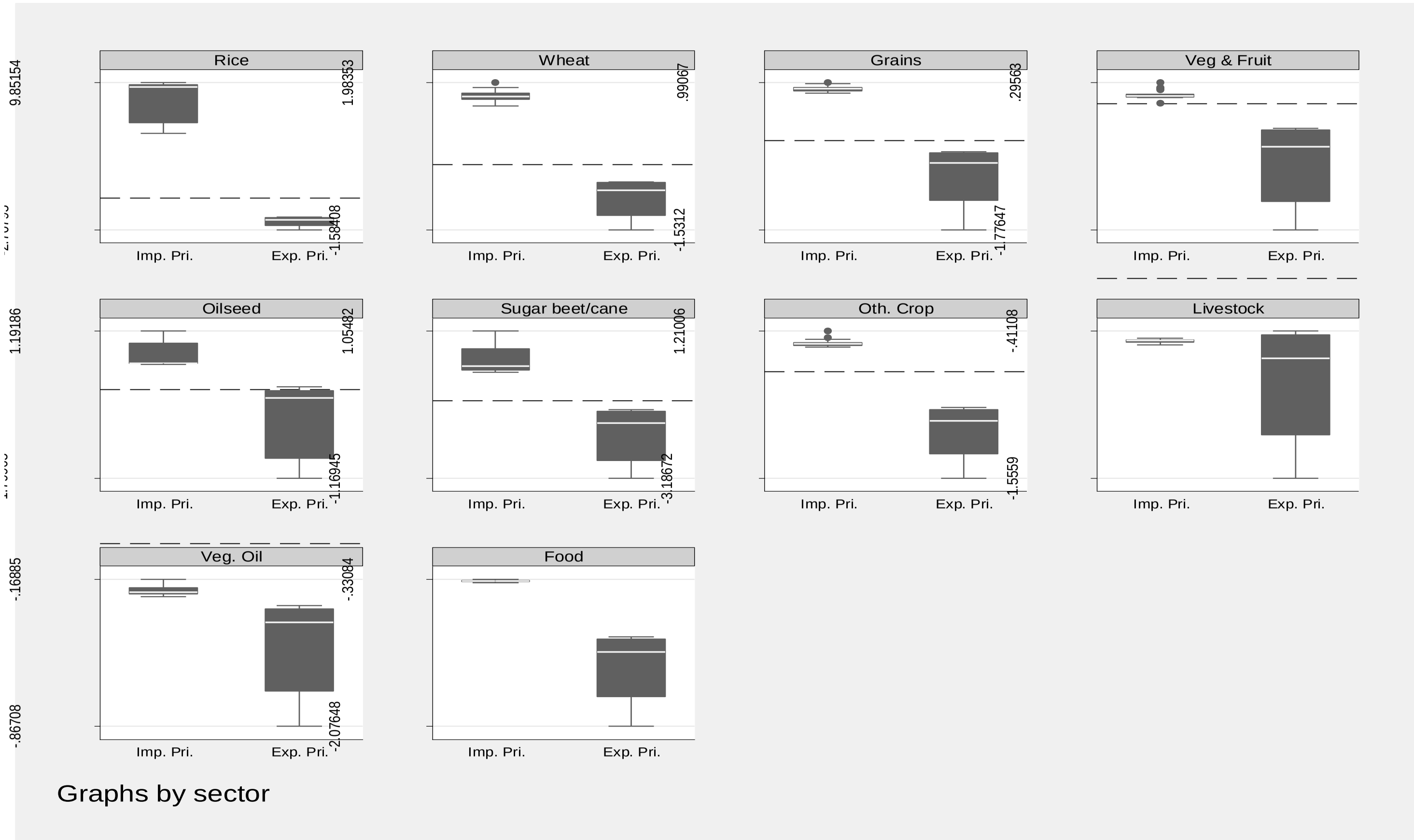
Source: Model Results

Figure D.11: Change in import and export values of agri-food sectors in Turkey under baseline (percentage change)



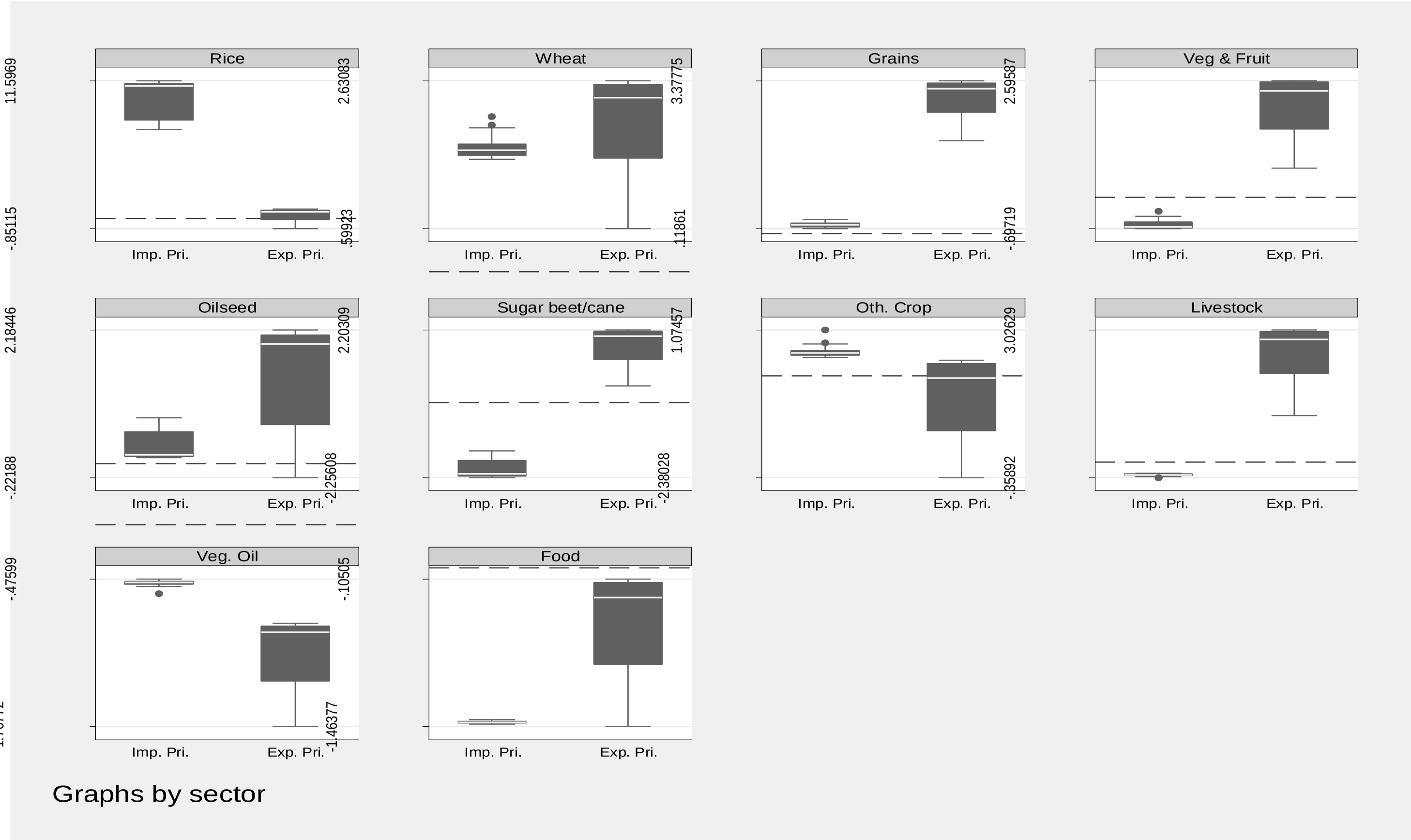
Source: Model Results

Figure D.12: Distribution of change in import and export price of agri-food commodities in Turkey under EU scenario (percentage Change)



Source: Model Results

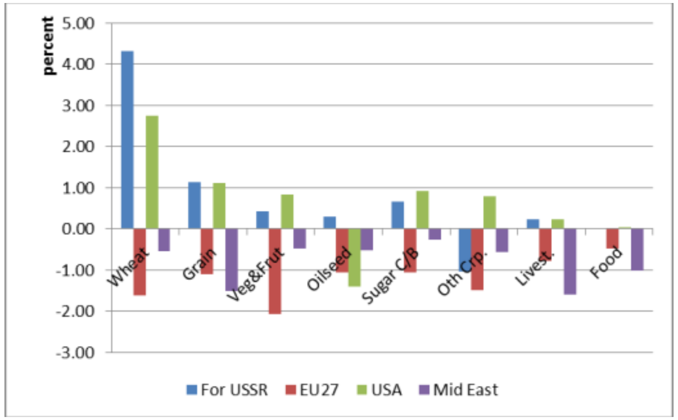
Figure D.13: Distribution of change in import and export price of agri-food commodities in Turkey under AGRI scenario (percentage Change)



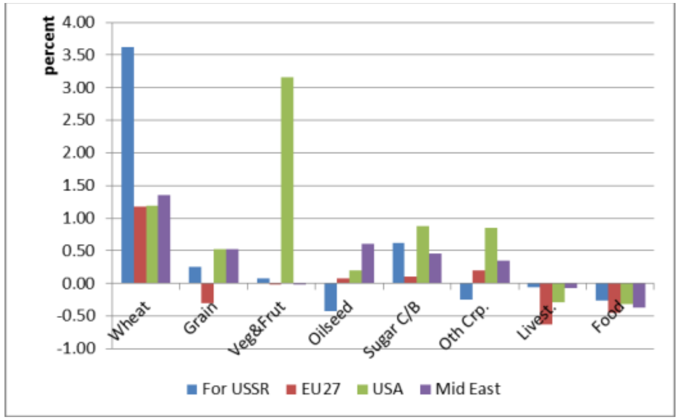
Source: Model Results

Figure D.14: Distribution of change in import and export price of agri-food commodities in Turkey under FULL scenario (percentage change)

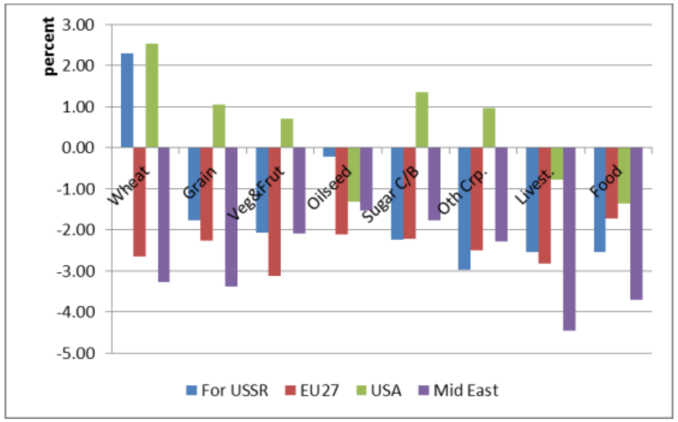
Export Prices under AGRI



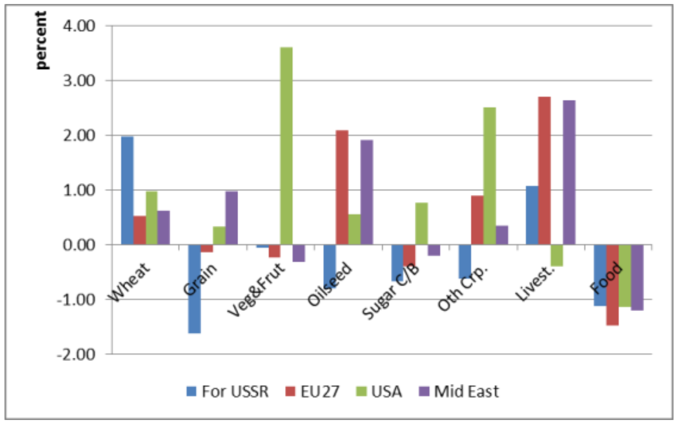
Import Prices under AGRI



Export Prices under FULL scenario



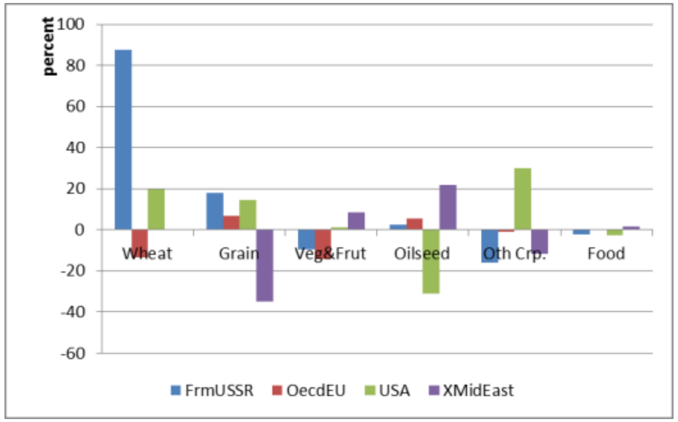
Import Prices under FULL scenario



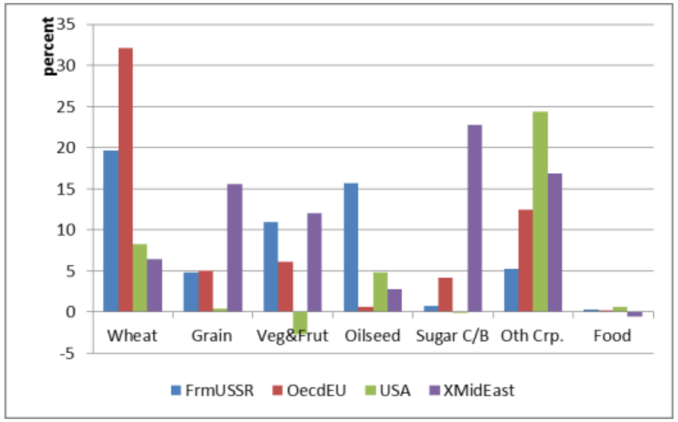
Source: Model Results

Figure D.15: Import and export prices under trade liberalization scenarios (percentage change)

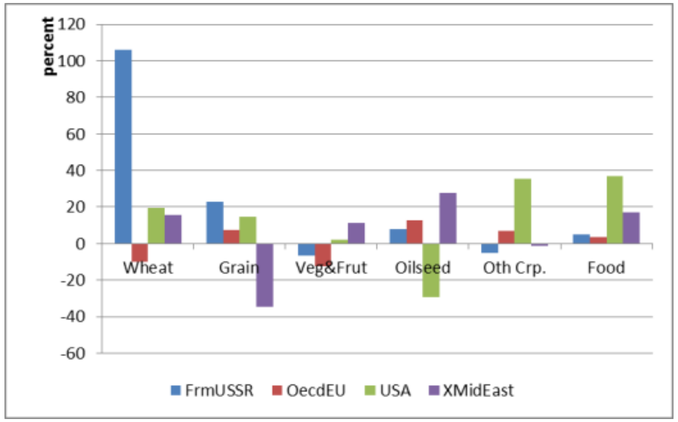
Export Quantity under AGRI



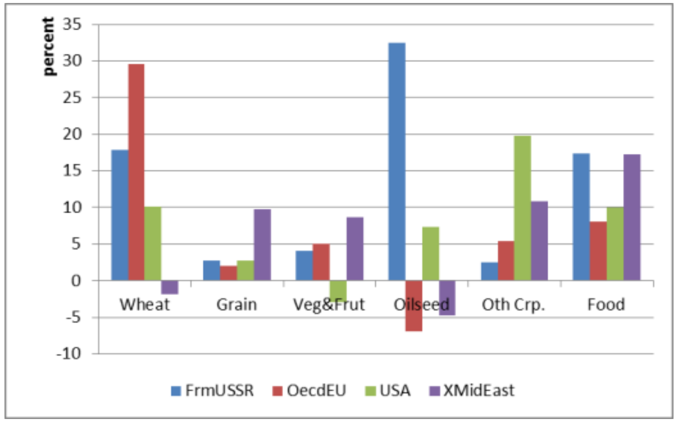
Import Quantity under AGRI



Export Quantity under FULL scenario

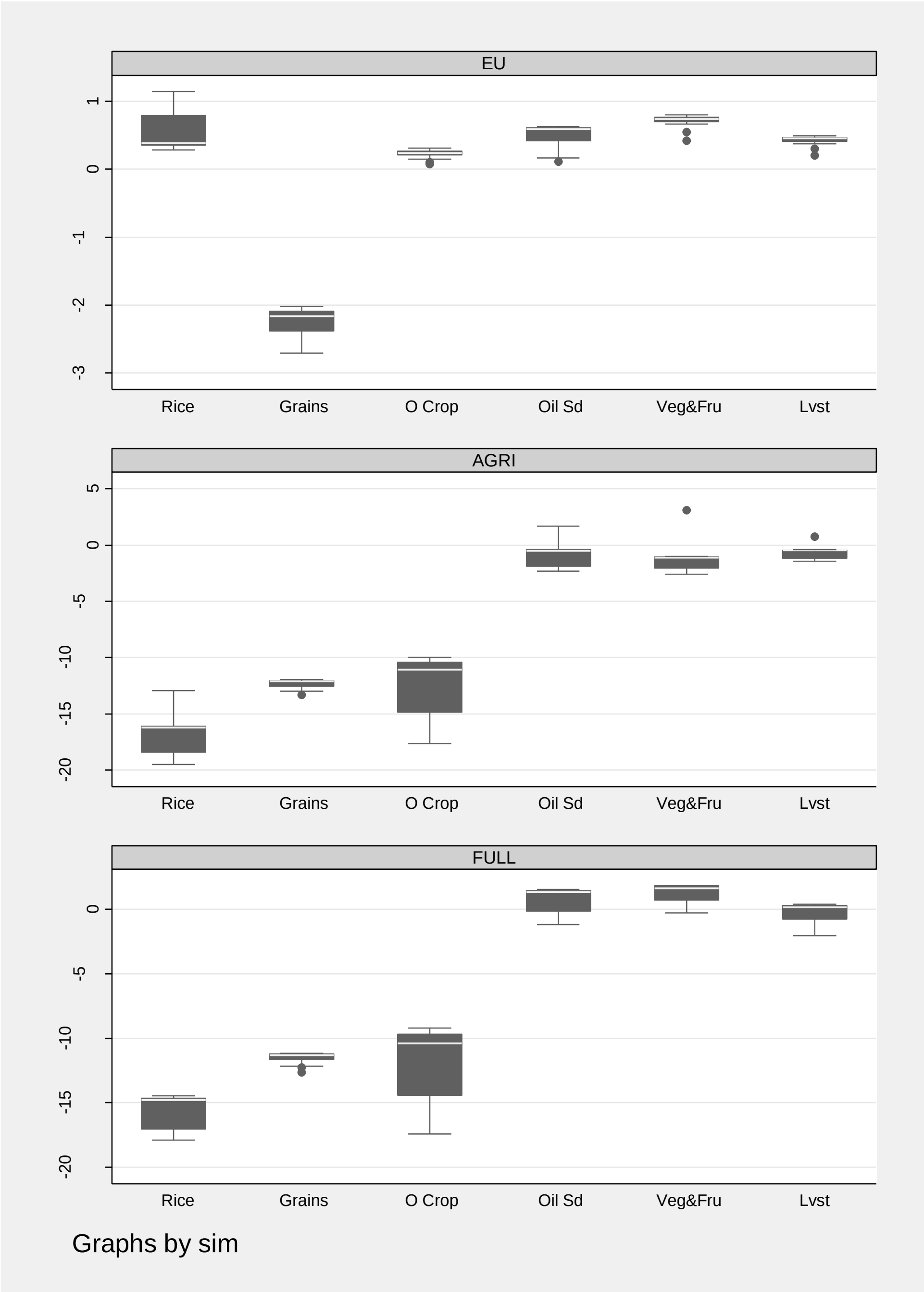


Import Quantity under FULL scenario



Source: Model Results

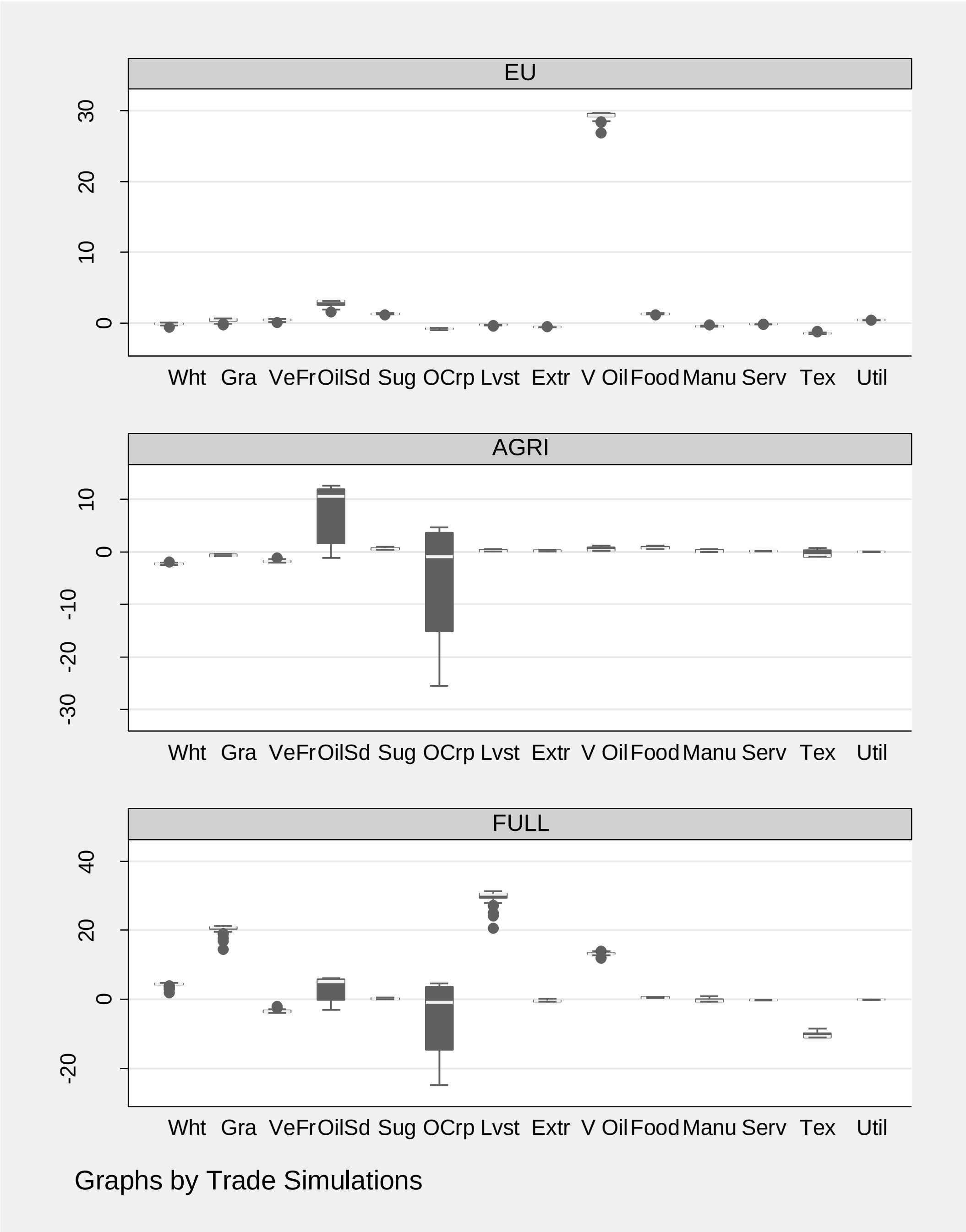
Figure D.16: Import and export quantities under trade liberalization scenarios (percentage change)



Source: Model Results

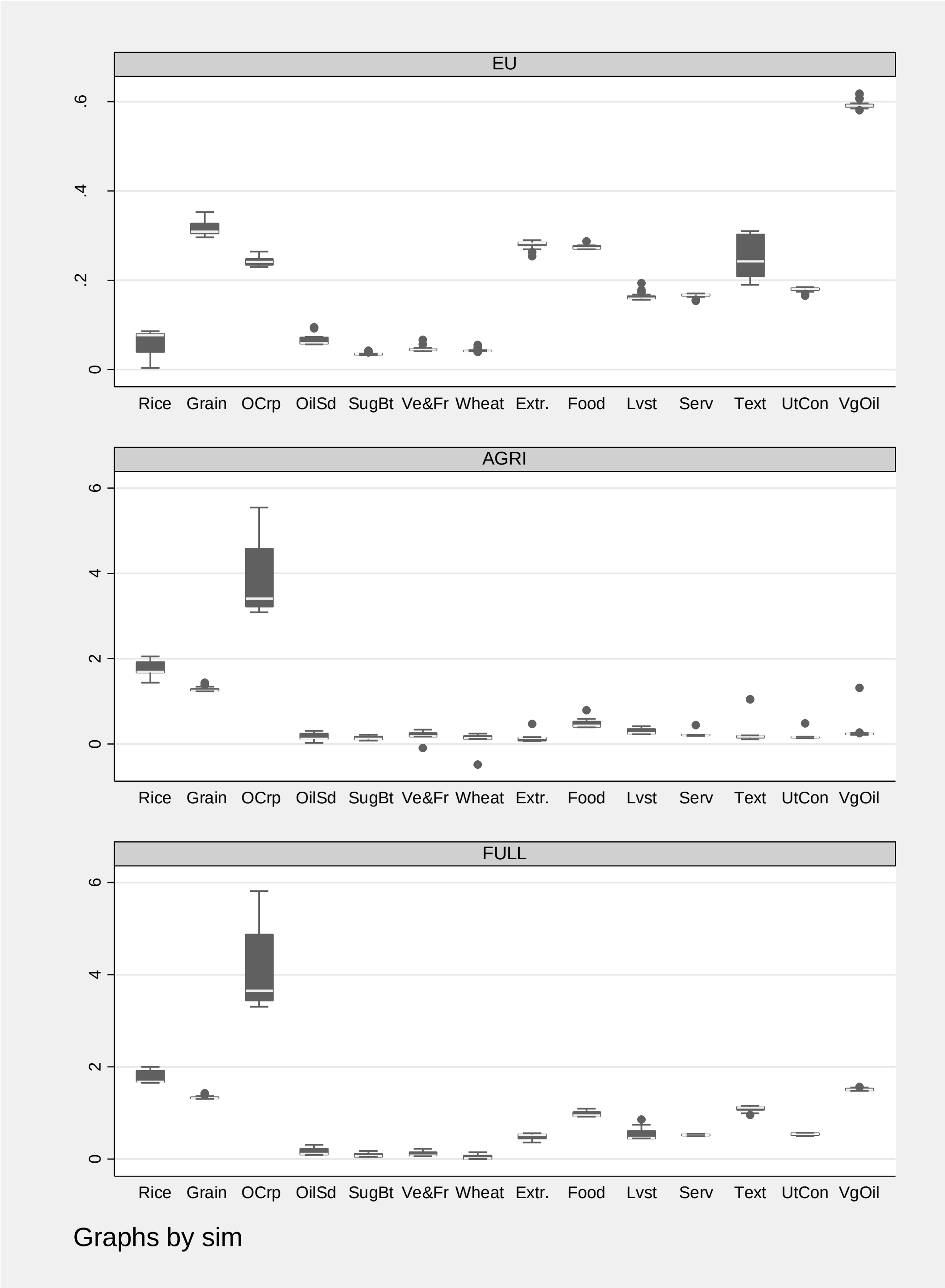
Note: Figure includes only the sectors with high variation across Climate change scenarios

Figure D.17: Distribution of change in domestic prices of selected agri-food commodities in Turkey



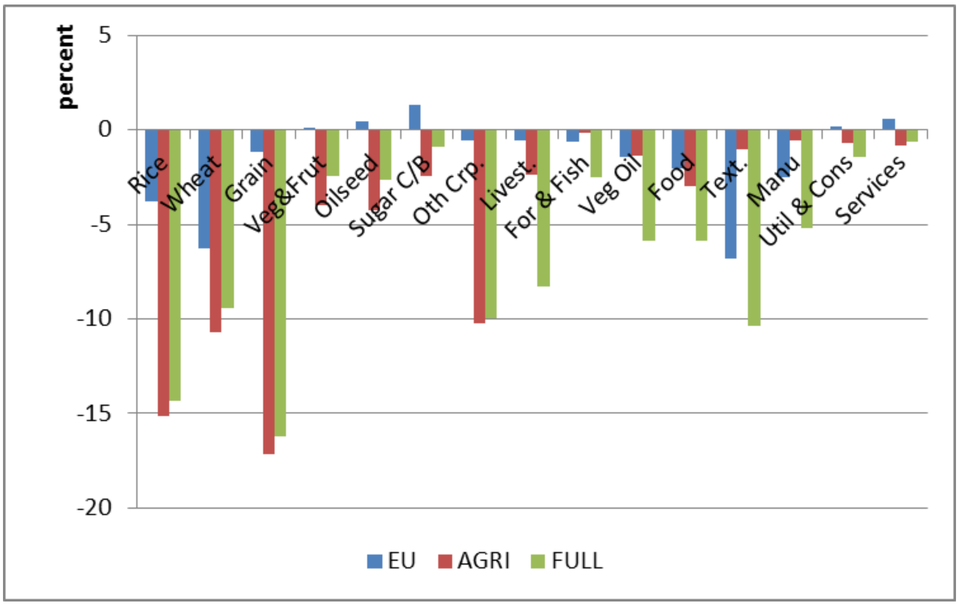
Source: Model Results

Figure D.18: Distribution of change in production of agri-food commodities in Turkey



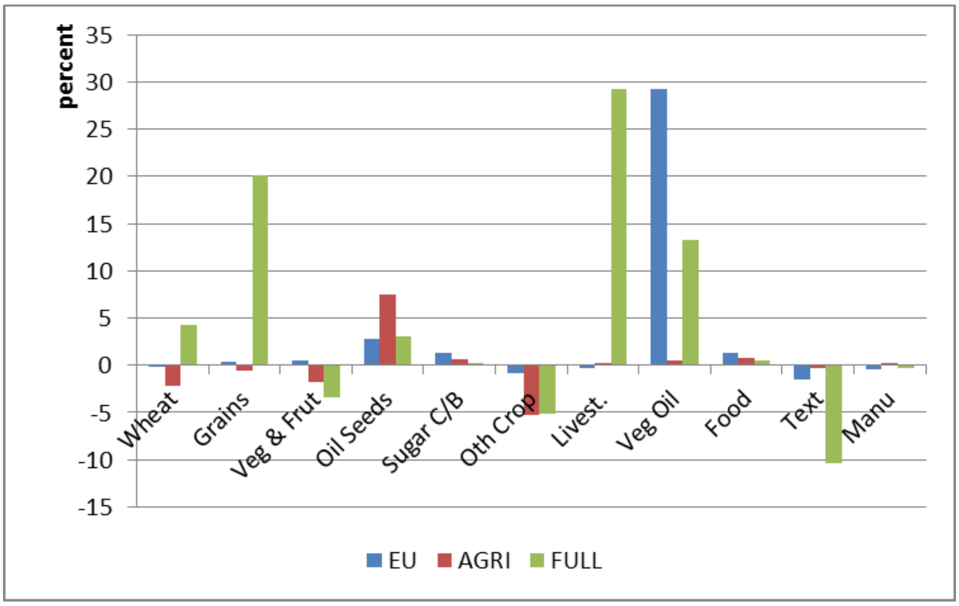
Source: Model Results

Figure D.19: Distribution of change in consumption of agri-food commodities in Turkey



Source: Model Results

Figure D.20: Average change in domestic prices under trade liberalization scenarios



Source: Model Results

Figure D.21: Average change in production of agri-food commodities

APPENDIX E

TURKISH SUMMARY

Bölüm 1: Giriş

İklim değişikliği insanlığın, dünya üzerinde var olduğu günden bu yana, baş etmek zorunda kaldığı en önemli sorunlardan birisi olmuştur. İnsan evriminin gerçekleştiği 2 milyon yıl boyunca iklim koşullarında meydana gelen döngüsel değişiklikler önümüzdeki yüzyılda karşılaşmayı beklediğimiz değişikliklerden çok daha şiddetliydi. Ancak türümüz, Afrika'da 500 bin yıl önce başlayıp, modern insanın ortaya çıkmasına kadar devam eden büyük iklim dalgalanmalarına adapte olmak konusunda oldukça başarılı oldu. Bugün de değişen iklim şartlarına adaptasyon insanlığın kolektif olarak çözmek zorunda olduğu en büyük sorunlardan birisi olarak uluslararası kamuoyunun gündemindedir.

İklim değişikliğine adaptasyon genel özellikleri itibariyle iktisadi bir problemdir. Atalarımızın insan evriminin erken aşamalarında değişik iklimlere adaptasyon konusunda geliştirdikleri en önemli yöntem "ekonomik" olmaktır. Homo sapiens türü doğal kaynakları kullanmak konusunda en verimli organizmalardan birisi olma özelliğine sahiptir. Sağlıklı bir insan vücudu biyosfer tarafından sağlanan hiç bir şeyi israf etmez. Hayatta kalmak için bitkileri, hayvanları, madenleri ve hatta toprak ve kayaları sonuna kadar kullanırız. Ne var ki bu hayatta kalma stratejisi tamamen çevresinde var olanlara bağımlı bir tür ortaya çıkarmıştır. İnsanlık tarihi boyunca türümüzün verdiği en temel mücadale hayatta kalmamızı sağlayacak kaynakları güvence altına alma çabasıdır. Ancak bu çaba o kadar yoğun bir hale gelmiştir ki, çabanın kendisi biyosferi değiştirerek –en azından iklim değişikliğini hızlandırarak- esenliğimizi tehdit etmeye başlamıştır. Dolayısıyla insanlığın varlığını sürdürmek konusunda başladığı noktaya döndüğü düşünülebilir. Yok olmak tehlikesini atlatabilmek için "ekonomik olmanın" yeni yollarını bularak biyosferle etkileşim stratejilerimizi geliştirmemiz gerekmektedir.

Bu tezin ana amacı iklim değişikliğini ve iklim değişikliğinin iktisadi faaliyetlerle olan etkileşimini anlama çabasına katkıda bulunmakdır. Bu amaçla, tezi oluşturan üç bölüm birbirlerinden bağımsız olarak tasarlanmakla birlikte, bir arada değerlendirildiklerinde iklim değişikliği, tarım ve ticaret politkası arasındaki bağlantıların bütüncül bir portresini çizmektedirler. Çalışmanın odağında Türkiye olsa da, elde edilen sonuçlar çoğu gelişmekte olan ülke ve/veya bölgeyi kapsayacak şekilde genelleştirilebilir. Çalışmamızda güncel teori ve verilere dayanan analitik bir yaklaşım izlenmiştir. Statik yansıtımlar yerine, mümkün olan bütün gelecek tasarımlarını betimlemeye çalışan stokastik bir yaklaşım takip edilmiştir. Yani, iklim değişikliğinin fiziksel etkilerini değerlendirirken, sorunun özü itibariyle var olan belirsizlikler de dikkate alınmıştır.

Bölüm 2: İklim Değişikliğinin Türkiye üzerindeki Etkilerinin Bütüncül bir Yaklaşımla İncelenmesi

Hali hazırda su kaynakları önemli bir baskı altında olan Türkiye'de iklim değişikliğinin etkilerinin belirgin olması kaçınılmazdır. Tezin ikinci bölümünün amacı iklim değişikliklerinin ekonominin tamamı üzerindeki etkilerinin nicel yöntemlerle ortaya konulmasıdır. Bu amaçla, 2008-2099 dönemi için hesaplanabilir genel denge modeli ve bitki su gereksinimi modeli içeren bütünleşik bir yaklaşım takip edilmiştir. İklim değişikliğinin etkileri en fazla tarım sektörünü etkileyeceği için, olası etkilerin incelenmesinde tarımın ileri ve geri sektörel bağlantılarının dikkate alınması gerekmektedir. Tezin ikinci bölümünde kullanılan hesaplanabilir genel denge modeli tarım sektörü ve diğer sektörler arasındaki bağlantıları birinci iktisadi bölge birimleri sınıflaması (İBBS-I) seviyesinde modellemektedir. Diğer taraftan, 2010-2099 yılları arasında aylık olarak 81 ildeki 35 ürün için iklim değişikliği kaynaklı verim ve sulama suyu gereksinimlerindeki değişimler bir bitki su gereksinimi modeli ile hesaplanmıştır. Bitki su gereksinimi modelinin sonuçları daha sonra hesaplanabilir genel denge modeline iklim şoku olarak sı-okulmuştur.

Bitki Su Gereksinimi Modeli ve Kullanılan Veri Seti

İklim değişikliğinin tarımsal üretimin teknik koşulları üzerindeki etkisi bitki-su modelleri ile incelenebilir. Bu modeller yağış, sıcaklık ve rüzgâr hızı gibi ana iklim değişkenleri ile ilgili tahminleri küresel dolaşım modellerinden alarak verim değişikliklerini tahmin etmektedirler. Çalışmamızda iklim değişikliğinin bitkisel üretim üzerindeki etkilerini ölçümlendirmek için Allen ve ark. (1998) tarafından geliştirilen yöntemler takip edilmiştir. Bu yaklaşıma göre 81 ilde Aralık 2001 – Aralık 2099 dönemi için aylık referans terleme-buharlaşmalar hesaplanmıştır. Hesaplamalar için gerekli olan aylık yağış, sıcaklık ve rüzgar hızı verileri Dalfes ve ark. (2010)'dan alınmıştır. Toprak ve bitkiye özel parametreler ise FAO (2011)'den alınmıştır.

Allen ve ark. (1998)'de izlenen yöntem bitki terleme-buharlaşmasının referans şartlarda (referans terleme-buharlaşma), standart şartlar altında (standart terleme-buharlaşma) ve su stresi altında (stres altında terleme-buharlaşma) hesaplanmasına dayanmaktadır. Referans terleme-buharlaşma standartlaştırılmış bir bitki örtüsünde meydana gelen terleme-buharlaşmadır ve atmosferin buharlaştırma kapasitesini gösterir. Referans terleme-buharlaşma sadece ışınım, hava durumu verileri kullanılarak hesaplanmaktadır.

Standart terleme buharlaşma, veri iklim koşullarında belirli bir bitki türü için optimum su yönetimi ve çevresel koşullar altında en yüksek verim elde edilen terleme-buharlaşma miktarıdır. Dolayısıyla referans ve standart terleme-buharlaşmalar arasındaki fark bitkiye özgü "terleme direnci, bitki boyu, bitki sertliği, yansıtım, yüzey kaplama ve bitki kök derinliği" (Allen ve ark., 1998) gibi karakteristikler arasındaki farklar tarafından belirlenmektedir. Bu farklar değişik bitki karakteristikleri kullanılarak hesaplanan ve standart bitki katsayısı olarak ifade edilen bir parametre ile ifade edilir.

Su stresi altındaki terleme-buharlaşma, yağış veya sulama eksikliği nedeniyle topraktaki su miktarının düşük olması nedeniyle ortaya çıkan terleme-buharlaşmadır. Standart ve su stresi altındaki terleme-buharlaşma arasındaki fark erişilebilir su miktarı, toprak karakteristikleri, yağış miktarı ve bitki özellikleri ile hesaplanan su stresi katsayısı tarafından ifade edilmektir.

Çalışmamızda göreceli olarak entegre olmuş bir dünya ve hızlı ekonomik büyümeye sahip bir gelecek öngörüsünde bulunan IPCC B1 senaryosu altında bitki sulama gereksinimleri ve verimleri hesaplanmıştır. IPCC B1 senaryosu 2050 yılına kadar dünya nüfusunun 9 Milyar kişiye ulaşacağını ve ondan sonra yavaş yavaş düşeceğini varsaymaktadır. Bu senaryoda iktisadi büyüme hizmetler ve iletişim sektörlerine odaklı seyrederken, iktisadi sürdürülebilirlik önemlidir.

Referans ve su stresi altındaki terleme-buharlaşma katsayıları Dalfes ve ark. (2011) tarafından hesaplanan rüzgar hızları, yağış ve ortalama sıcaklıklar kullanılarak her ilde ve 2001-2099 yılları için aylık olarak hesaplanmıştır. En düşük ve en yüksek sıcaklıkların yayılımı, kritik boşalma, bitki boyu, başlangıç standart bitki katsayısı değerleri, bitki ekim tarihleri, bitki gelişim süreleri, kök derinliği, verim yanıt katsayıları ve toprak parametreleri Allen ve ark. (1998)'den alınmıştır.

Bitki su gereksinimi modelinin sonuçları literatürde yapılmış olan benzer çalışmaların bulgularlıyla tutarlıdır. Model sonuçlarına göre, Türkiye'de tarımsal üretimin teknik koşulları ortalamada kötüleşmektedir. İklim değişikliğinin olumsuz etkileri 2060'dan sonra belirgin bir hal almaktadır. Model sonuçları ayrıca iklim değişikliğinin etkilerinin ülke genelinde homojen olmayacağını ve mevsimler arasında önemli farklılıklar göstereceğini de ortaya koymaktadır. Sonuçlar incelendiğinde, iklim değişikliğinin tarımsal üretimin teknik koşulları üzerindeki etkilerinin özellikleri açısından önümüzdeki yüzyılın üç döneme ayrılabileceği görülmektedir. 2010-2035 yılları arasındaki birinci dönemde özellikle batı bölgelerinde, ortalama yağışlarda %20'ye varan artışlar gözlemlenmektedir. En önemli artış kış (Ocak-Mart) aylarında olacaktır. Diğer mevsimlerde, ortalama yağışlar doğu bölgelerinde azalırken batı bölgelerinde yüksek seyretmektedir. 2036-2060 yıllarını kapsayan ikinci dönemde kış aylarında yağış desenleri pek fazla değişmezken, yılın geri kalan dönemlerinde belirgin bir şekilde değişmektedir. 2061-2099 yıllarını kapsayan üçüncü dönemde ise kuzey bölgelerinde kışın gözlemlenen yüksek ortalama yağış miktarları korunurken, ülkenin geri kalanında ortalama yağışlarda ciddi azalmalar meydana gelecektir.

Yağış ve sulama gereksinimlerindeki değişikliklerin verim ve sulama gereksinimleri üzerindeki etkisi hem bölge hem de bitki türüne göre değişiklik göstermektedir. Bu etkiler verim ve sulama gereksinimlerindeki değişiklikler bakımından dört grup senaryo altında incelenebilir. Verim ve sulama gereksinimlerinin eş zamanlı olarak arttığı durumlar birinci grubu oluşturmaktadır. Bu durum genellikle birinci dönemde izlenmekte, ikinci ve üçüncü dönemlerde ise istisnai olarak ortaya çıkmaktadır. Bu guruptaki bitki üretim faaliyetleri, daha yüksek verimler için daha fazla sulama gerektireceğinden, uygun sulama yatırımları ile bu durumların gözlendiği bölgelerin söz konusu ürünlerin yetiştirilmesinde bir avantaj sahibi olması mümkündür. Verimler yükselirken, sulama gereksinimlerinin düştüğü durumlar ikinci grubu oluşturmaktadır. Dolayısıyla bu gruptaki üretim faaliyetleri, bu durumun gözlendiği bölgelerde tarımsal üretimde baskın hale gelecektir. Bu durum genellikle birinci dönemde gözlemlenmektedir. Verimlerin ve sulama gereksinimlerinin aynı anda düştüğü durumlar üçüncü grubu oluşturmaktadır. Bu durum, ülke genelinde ve bütün dönemlerde en sık olarak gözlemlenen durumdur. Verimler düşerken sulama gereksinimlerinin arttığı durumlar son grubu oluşturmaktadır. Bu guruptaki üretim faaliyetlerinin teknik koşulları önemli ölçüde kötüleşmektedir. Bu durum genellikle ikinci ve üçüncü dönemde gözlemlenmektedir.

Sonuç olarak bulgularımız 2030'lu yıllara kadar tarımsal üretimin önemli bir kısmının iklim değişikliğinin etkilerinden olumlu yönde etkileneceğini göstermektedir. Ne var ki, bunda sonra ve özellikle 2060'lı yıllardan sonra hemen hemen bütün ürünler için üretim koşulları belirgin bir şekilde kötüleşecektir. Tahıllar gibi geleneksel ürünler iklim değişikliğinden oldukça olumsuz bir şekilde etkilenecektir. Meyve üretimi üzerindeki etkiler de özellikle son dönemde oldukça olumsuzdur. Bu sonuçlara göre Türkiye'de sulama yatırımı planlaması yapılırken iklim değişikliğinin heterojen etkilerinin dikkate alınması çok önemlidir. Özellikle birinci ve ikinci dönemlerde, verimlerin düşmesinin önlenmesi önemli ölçüde sulama altyapısının geliştirilmesi ile mümkün olacaktır. Uzun vadede ise kuraklığa dayanıklı türlerin geliştirilmesi ve yaygınlaştırılması tek çözüm olarak görünmekte ve bu sebeple tarımsal Ar-Ge çalışmalarının desteklenmesinin önemini ortaya koymaktadır.

Statik HGD Modeli ve Kullanılan Veri Seti

Bu bölümde geliştirilen Walrasyan hesaplanabilir genel denge modeli, ekonomiyi 12 IBBS-1 bölgesinde 7 sektör için üretim yapan 7 üretim faaliyetine ayırmaktadır. Üretim faaliyetleri tarım, gıda üretimi, tekstil, diğer sanayi üretimi, enerji, özel hizmetler ve kamu hizmetleri sektörleridir. Ekonomideki her sektör diğer sektörlerden sağlanan ara malı girdileriyle birlikte üretim faktörü olarak işgücü, sermaye, susuz toprak, sulu toprak, tarımsal sulama suyu ve sınai su kullanarak üretim yapan bir üretim faaliyeti ile temsil edilmektedir. Üretim fonksiyonunun kademeli bir yapısı vardır. Birinci kademede sulama suyu ile sulu toprak Leontief tipi bir üretim fonksiyonuna girerek sulama suyu-sulu toprak bileşik faktörünü oluşturmaktadır. Bu şekilde bu iki faktör arasındaki tamamlayıcılık ilişkisi modele dâhil edilmektedir. Bu bileşik faktör ikinci kademede diğer üretim faktörleri ile birlikte sabit ikame esneklikli bir üretim fonksiyonuna girerek bir çeşit bileşik üretim faktörü üretmektedir. Diğer taraftan, yine ikinci kademede, ara malı girdileri Leontief tipi bir üretim fonksiyonunda bileşik girdiye dönüştürülmektedir. Üçüncü kademede ise bileşik üretim faktörü sabit ikame esneklikli bir üretim faktörüne girerek katma değer cinsinden nihai ürünü oluşturmaktadır.

Üretim sürecinde üretilen ürünler yurt içi piyasalara ara malı ve nihai mal olarak ve aynı zamanda uluslararası piyasalara ihracat ürünü olarak arz edilmektedir. Üretim faaliyetleri devlete üretim vergisi ödemekte ve devletten destek almaktadırlar.

Sermaye tarafından yaratılan katma değer gelir olarak firmalara ödenmektedir. Firmalar devletten ve yurt dışından gelir transferleri almaktadırlar. Firma gelirleri, hanehalkına sermaye geliri, devlete kurumlar vergisi ve yurt dışına sermaye transferi olarak aktarılmaktadır.

Hanehalkları işgücü, toprak ve su tarafından yaratılan katma değeri gelir olarak doğrudan almaktadırlar. Hanehalklarına da devletten ve yurt dışından gelir transferi yapılmaktadır. Hanehalkı bu gelirleri tüketim harcamaları yapmak, gelir vergisi ödemek ve tasarruf yapmak için kullanmaktadır. Tüketim doğrusal harcama sistemi yöntemi ile modellenmiştir. Buna göre hanehalkı geçimlik tüketim seviyesinin üzerinde tükettiği ürün miktarı kadar fayda elde etmektedir.

Dinlence zamanı da fayda fonksiyonuna dâhil edilmiştir. Kalibrasyon ile ilgili güçlükleri aşmak için işgücüne dâhil olan işsiz nüfusun hâlihazırda iş aramayan kısmını dinlence zamanının bir göstergesi olduğu varsayılmıştır. İşgücüne dâhil olmayan nüfus ise (öğrenciler, ev hanımları, emekli kişiler vs…) geçimlik dinlence seviyesi olarak kabul edilmiştir. Bu yaklaşım, hanehalkının işgücü arzı davranışını modelleme imkânı tanısa da mevcut tüketim sisteminde geçimlik dinlence miktarının içsel hale getirilmesi mümkün olmadığı için işgücüne katılım hala dışsal olarak ele alınmak zorundadır. Ne var ki, işgücüne katılımın sabit dışsal bir değişken olarak kalmasının önüne geçmek için iş gücüne katılımın bir “hareket kuralı” çerçevesinde belirlendiği varsayımı yapılmıştır. Buna göre, işgücüne katılım reel ücretlerdeki değişimin bir fonksiyonudur. Reel ücretler arttıkça işgücüne katılım da artmaktadır.

Hanehalkının tasarruf davranışı model kapama kuralları ile belirlenmektedir. Makro düzeyde tasarrufların yatırımlar tarafından belirlendiği ve toplam absorpsiyondaki düzeltmelerin tüm ürünlere aynı ölçüde yansıdığı varsayılmıştır. Dolayısıyla, yatırımların absorpsiyon içindeki payı sabit olup iktisadi birimlerin tasarruf oranları yatırımları finanse edecek şekilde eşit oranda ölçeklendirilmektedir.

Devlet ile ilgili herhangi bir davranışsal varsayım yapılmamıştır. Devlet vergi toplamakta ve yurt dışından gelir transferleri almaktadır. Devlet gelirleri kamu tüketimi, kamu tasarrufu, yurt içindeki kurumlar ve kişiler ile yurt dışına gelir transferi ödemeleri yapmak için kullanılmaktadır. Toplam devlet harcamalarının toplam absorpsiyon içindeki payı sabittir. Devlet tasarruflarının esnek, vergi oranlarının ise sabit olduğu varsayılmıştır.

Dış âlemler hesabı Türkiye'ye ithal malları arz edip, Türkiye'den ihracat mallarını talep etmektedir. Ayrıca yurtiçi kurumlara gelir transferi ödemeleri yapmakta ve onlardan gelir transferi ödemeleri almakta ve Türkiye'ye yatırım yapmaktadır. İthalat, Armington yaklaşımı ile modellenmiştir ve sabit esneklikli bir dönüşüm fonksiyonu tarafından yönetilmektedir. Buna göre, ithal edilen ürünler yurt içinde üretilen ürünlerle tam ikame malları değildir ve ithalat talebi ile yerli mal talebi bir ikame esnekliği tarafından belirlenmektedir. Dış âlem tasarrufu her zaman cari açığı finanse edecek şekilde ithalat ve ihracat arasındaki farka eşittir. Yurt içindeki kurumlara ve bu kurumlardan yapılan gelir transferlerinin bu kurumların gelirleri içindeki payı sabittir.

Çalışmamızda kullanılan sosyal hesaplar matrisi Yiğiteli (2010) tarafından hesaplanmış olan toplulaştırılmış sosyal hesaplar matrisine dayanmaktadır. Yiğiteli (2010) sosyal hesaplar matrisi 2008 yılı için gelir gruplarına göre 5 çeşit hanehalkının tüketimi için kayıt dışı işgücü, kayıtlı işgücü, toprak ve sermaye kullanarak üretim yapan 49 sektör içermektedir. Bu bölümün amaçları doğrultusunda bu sosyal hesaplar matrisi yedi sektör ve bir hanehalkı içerecek şekilde toplulaştırılmış ve daha sonra 12 IBBS-1 bölgesine ayrılmıştır. Girdi çıktı tablosunun bölgeselleştirilmesi Artırılmış Flegg Mekânsal Orantılama (Augmented Flegg Location Quotiens – AFLQ) yöntemi ile yapılmıştır. sosyal hesaplar matrisinin diğer satır ve sütunları belirli varsayımlar altında çeşitli veri setleri kullanılarak yapılmıştır.

Türkiye, coğrafi ve sosyal özellikleri bakımından birinden çok farklı bölgelere sahiptir. Bu farklılıklar üretim ve tüketim desenlerindeki farklılıklar olarak ekonomiye de yansımaktadır. Farklı bölgesel yapılar karmaşık bir ekonomik ilişkiler ağı ortaya çıkarmaktadır. İklim değişikliğinin muhtemel etkilerinin tam olarak anlaşılabilmesi bu karmaşık ilişkiler ağının da dikkate alınması gerekmektedir.

Tezin ikinci bölümünün amaçlarına uygun olarak bitki su gereksinimi modelinden elde edilen verim ve sulama gereksinimleri değişimleri hesaplanabilir genel denge modeline iklim şokları olarak sokulmuştur. Verimlerdeki değişim, tarım sektöründe toplam faktör verimliliği şoku olarak; sulama gereksinimlerindeki değişim ise üretim fonksiyonunun sulanan toprak-sulama suyu kademesindeki Leontieff katsayısının, yani birim alan için gereken su miktarının, artışı şeklinde modele dâhil edilmiştir. Benzetimler 2008-2099 yılları için karşılaştırmalı statik deneyler şeklinde yapılmaktadır.

Bulgular

Benzetim sonuçlarına göre iklim değişikliğinın sebep olduğu verim ve sulama gereksinimlerindeki değişimler üretim deseni ve göreceli fiyatları sert bir biçimde değiştirecektir. Bunun sonucunda tarım ve gıda üretimi önemli ölçüde azalacak, bu ürünlerin fiyatları ise buna paralel olarak ciddi oranda yükselecektir. Kıyı bölgeleri iklim değişikliğinin ekonomik etkilerinden 2060'lı yıllara kadar daha az etkilenecek ancak bundan sonra bu etkiler önemli ölçüde kötüleşecektir. Bütün dönemlerde göreceli olarak daha az sulu üretim yapan bölgeler üzerinde iklim değişikliğinin etkileri daha az olumsuzdur ve bu, sulama gereksinimlerindeki artışın verimlerdeki düşüşler kadar önemli olduğunu göstermektedir. Refah göstergelerinde de benzer bir desen gözlemlenmektedir. Doğu bölgelerindeki Hanehalkları iklim değişikliğinden daha az etkilenmektedirler.

2035 yılından sonra dış dış ticaret hacmi ciddi oranda düşmektedir. Sanayi dışındaki bütün sektörlerde dış ticaret dengesi kötüleşmekte ancak toplam cari açık azalmaktadır. Tarım ve gıda sektörlerinde ithalata bağımlılık artmakta ve bu da orta ve uzun vadeli politika tasarımlarında gıda güvencesi ile ilgili politikaların önemini göstermektedir.

Birinci bölümde elde edilen bulgular literatürdeki ulusal veya küresel düzeyde yapılmış olan diğer çalışmaların bulguları ile de uyumludur. İklim değişikliğinin iktisadi etkileri bölgelere göre farklılıklar göstermektedir. Örneğin, iklim değişikliği bazı bölgelerde refah kaybına neden olmamaktadır. Bunun anlamı iklim değişikliği politikasının tasarlanmasında bölgeler arasındaki farklılıkların dikkate alınması gerektiğidir. Pek çok çalışma tarafından öngörüldüğü gibi olumsuz etkiler 2030'lu yıllardan sonra özellikle aşırı olayların daha sık olarak yaşanması yoluyla daha belirgin hale gelmektedir. En kötümser durumda gayri safi yurt içi hasıla (GSYİH) kayıpları %10'a kadar yükselmektedir.

Bölüm 3: İklim Değişikliği, Tarım ve Ticari Serbestleşme: Türkiye için Dinamik HGD Analizi

Tezin üçüncü bölümünde dinamik bir hesaplanabilir genel denge modeli geliştirilmiştir. Bu model ulusal düzeydedir ve tüm Türkiye'yi tek bir bölge olarak ele almaktadır. Modelde tarım sektörü daha detaylı olarak inceleme yapmak amacıyla alt sektörlere ayrıştırılmıştır. Ayrıca modelin dış âlemler hesabı beş ticaret ortağını içerecek şekilde yeniden tasarlanmıştır.

Geliştirilen bu modelle iklim değişikliği ve ticari serbestleşme benzetimleri yapılarak dış ticareti serbestleştirmenin iklim değişikliğinin olumsuz etkilerini hafifletip hafifletmediği incelenmiştir. Kullanılan iklim değişikliği senaryosu, birinci bölümde kullanılan senaryonun detaylı bir versiyonudur. Dış ticaret serbestleşmesi senaryosu ise Türkiye'nin AB'ne uyguladığı gümrük vergilerinin kaldırılması şeklinde tasarlanmıştır. İklim değişikliği bütün dünyayı etkileyecek bir olgu olduğu için küresel çapta tarımsal fiyatların değişmesi kaçınılmazdır ve bu, dış ticaret serbestleşmesinin olası etkileri üzerinde önemli farklılıklar yaratabilir. Ne var ki tarım fiyatlarındaki bu olası değişimin yönü ve büyüklüğü bilinmemektedir. Tarım fiyatlarındaki belirsizliği analize dâhil etmek için dünya tarım fiyatlarının normal bir dağılımdan geldiğini ve bu dağılımın ortalamasının ve standart sapmasının iklim değişikliği tarafından değiştirileceği varsayılmıştır. Kötüleşen ortalama şartları ve artan iklim riskini betimlemek için dünya fiyatlarının dağılımının ortalamasının artacağı, ancak standart sapmasının aynı kalacağını varsayılmıştır. Bu varsayım altında elde edilen model sonuçları iklim değişikliğinin dünya fiyatları üzerindeki etkisinin ne kadar önemli olduğuna dair sonuçlar üretmek için kullanılmıştır.

Model ve Kullanılan Veri Seti

Bu bölümün amaçlarına uygun olarak, ikinci bölümde geliştirilmiş olan statik hesaplanabilir genel denge modeli Thurlow'un (2004) yöntemi izlenerek özyinelemeli dinamik hale getirilmiştir. Dinamik süreç sermaye birikimi, üretkenlik, nüfus ve işgücüne katılımdaki büyüme süreçleri üzerinden işlemektedir. Dinamik hesaplanabilir genel denge modeli tarafından kullanılan sosyal hesaplar matrisi, ikinci bölümde kullanılan sosyal hesaplar matrisinin üzerinde yapılan üç değişiklikle elde edilmiştir. Öncelikle, bölüm 2'de kullanılan sosyal hesaplar matrisi bölgeler üzerinde toplulaştırılarak ulusal sosyal hesaplar matrisi elde edilmiştir. İkinci olarak, daha detaylı bir inceleme yapılabilmesi amacı ile tarım sektörü 13 alt sektöre ayrılmıştır. Bu alt sektörler: buğday, mısır, pirinç, diğer tahıllar, yağlı tohumlar, şeker pancarı, diğer tarla bitkileri, meyve, sebze süt ürünleri, et, diğer hayvancılık faaliyetleri ve son olarak diğer tarımsal faaliyetlerdir. Tarım dışı sektörler birinci bölümdeki halleri ile kalmıştır: Gıda üretimi, tekstil, enerji, diğer snayi üretimi, özel hizmetler ve kamu hizmetleri. Son olarak, sosyal hesaplar matrisinin dış âlemler hesabı 5 bölgeye ayrıştırılmıştır. Bu bölgeler: Avrupa Birliği ülkeleri, diğer Avrupa ülkeleri, Kuzey Amerika, Orta Doğu ve Kuzey Afrika ile Dünyanın geri kalanıdır.

İklim değişikliği senaryolarının altında AB ile Türkiye arasında meydana gelecek bir ticari serbestleşmenin etkilerini incelemek için 2008-2099 yılları arasında üç senaryo benzetimi yapılmıştır. Öncelikle ekonominin uzun vadeli ortalama büyüme desenini taklit eden bir referans senaryo oluşturulmuştur. Referans senaryonun sonuçları diğer senaryolar için kıyas noktası olarak kullanılmıştır. İklim değişikliği senaryosunda verim ve sulama suyu gereksinimlerindeki değişimler referans senaryodaki varsayımların üzerine iklim şoku olarak eklenmektedir. Son olarak Türkiye'nin tek taraflı olarak ithalat vergilerini kaldırdığı durumun benzetimi yapılmıştır. İklim değişikliği ve ithalat vergilerinin tek taraflı kaldırılması senaryolarının benzetimi 48 farklı dünya fiyat değişikliği varsayımı altında yapılmıştır. Varsayılan dünya fiyat değişimi serileri Gaussyan Dördülleme yöntemi kullanılarak dünya fiyatlarının geçmiş yıllarda gözlemlenen istatistiksel özellikleri kullanılarak hesaplanmıştır.

Benzetim sonuçlarına göre iklim değişikliği %3.5'e varan GSYİH kayıplarına neden olabilecektir. GSYİH'deki kayıpların ana etmenleri özel tüketimlerdeki düşüşler ve ithalatta meydana gelen belirgin artışlardır.

İthalat vergilerinin kaldırılması iklim değişikliğinin Türkiye ekonomisi üzerindeki bu olumsuz etkilerini kısıtlı bir şekilde azaltmaktadır. Ticari serbestleşmenin sağladığı refah artışı, iklim değişikliğinin sebep olduğu refah kayıpları ile kıyaslandığında oldukça küçük kalmaktadır. Ne var ki, ticari serbestleşmenin refah arttırıcı etkisi, iklim değişikliğinin etkileri kötüleştikçe – özellikle 2060'lı yıllardan sonra – artmaktadır. Bunun sebebi, dış ticaret serbestleşmesinin iktisadi birimlere hem üretim hem tüketim sürecinde daha fazla ikame olanağı vermesidir. Dış ticaret serbestleşmesi altında ekonominin temel intibak mekanizması üretimde ara malı girdilerinin faktörlerle ve tüketimde ithal malların yerli mallarla ikame edilmesidir. Bunun sonucunda sektörel düzeyde önemli değişiklikler gözlenmektedir. Buğday, pirinç ve diğer tahıllar dış ticaret serbestleşmesinden en fazla etkilenen sektörler olarak ön plana çıkmaktadır. İklim değişikliği önemli ölçüde verimlilik kaybına sebep olduğu için bu ürünler hem yerel hem de ithal alternatifleri karşısındaki rekabet güçlerini önemli ölçüde kaybetmektedirler. Üretimleri, ihracatları ve fiyatları önemli ölçüde gerilediği için bu ürünler ithal mallarla en fazla ikame edilen ürünlerdir. Diğer taraftan mısır, yağlı tohumlar, meyve ve işlenmiş gıda dış ticaret serbestleşmesinden olumlu etkilenmektedirler. Bu ürünlerin üretim ve ihracatları artmakta fiyatları düşmekte ve ithalatları çok fazla değişmemektedir. İklim değişikliği şoklarından sonra daha verimli hale geldikleri için üretim faktörlerinin bu sektörlerdeki istihdamında artış gözlenmektedir.

AB ülkelerinden yapılan ithalatta belirgin artışlar meydana gelmekte ve bu da iç piyasadaki fiyatların önemli ölçüde düşmesine sebep olmaktadır. Bunun neticesinde tarımsal üretim düşmektedir. Yerel fiyatlarda meydan gelen düşüş, dış ticaret yapılan diğer bölgelere uygulanan ithalat vergilerinden düşük olduğu için diğer bölgelerden yapılan ithalatta düşüşler görülmektedir. Bunun neticesinde toplam ithalat azalmaktadır. Dolayısıyla AB ile yapılan dış ticaret serbestleşmesi dış ticaret kayması yaratmaktadır.

Bu bölümde sunulan analiz pek çok yönden geliştirilebilir. Örneğin, diğer ülkeler de iklim değişikliğinden etkilenecekleri için Türk ihracat mallarına talepleri ve Türkiye'ye yaptıkları ithalat arzı da bundan etkilenecektir. Böyle bir değişiklik iklim değişikliğinin ve dış ticarette serbestleşmenin Türkiye üzerindeki etkilerini değiştirebilir. İkinci olarak AB ile tek taraflı yapılacak olan bir dış ticaret serbestleşmesi Türkiye'nin dış ticaret politikasındaki tek seçenek değildir. Diğer bölge ve ülkelerle yapılacak olan bir dış ticaret anlaşmasının etkileri çok daha büyük olabilir. Son olarak, bu bölümde tek bir küresel dolaşım modelinin sonuçları kullanılmıştır. Farklı küresel dolaşım modellerinin kullanılması iklim değişikliğinin olası sonuçları konusunda daha bütüncül bir analiz yapılmasına olanak tanıyabilir.

Bölüm 4: İklim Değişikliğine Küresel bir Adaptasyon Aracı olarak Dış ticaret Politikaları

Tezin dördüncü bölümünde, iklim değişikliğinin küresel ekonomi üzerindeki etkisi incelenmiş ve değişik ticari serbestleşme politikalarının bu etkilerle etkileşimi incelenmiştir. Bu amaçla dördüncü bölümde GTAP modeli kullanılmıştır. GTAP literatürde dış ticaret politikası analizi için sıkça kullanılan detaylı bir küresel hesaplanabilir genel denge modelidir. GTAP'in tezin dördüncü bölümde kullanılan versiyonunda 16 bölge ve 15 aktivite vardır ve GTAP 7 veri tabanını kullanmaktadır. Benzetimler konusunda tezin dördüncü bölümde de üçüncü bölümünde izlenen yaklaşım izlenmiştir. Modele 25 farklı iklim yansıtımından gelen iklim şokları sokularak referans senaryolar oluşturulmuş, daha sonra dış ticaret serbestleşmesi benzetimlerinin sonuçları bu referans senaryoların sonuçları ile kıyaslanmıştır.

Kullanılan Model ve Veri Seti

GTAP, hanehalkaları, üreticiler ve kamu sektörünün davranışlarını genel denge teorisinin standart varsayımlarını takip ederek modelleyen çok bölgeli, küresel ve statik bir HGD modelidir. Hanehalkları fayda maksimizasyonu yapan ve ekonomide üretilen bütün geliri alan ekonomik birimlerdir. Bu gelir, özel tüketim ve tasarruflara Cobb-Douglas fayda fonksiyonuna göre harcanmaktadır. Yani hane halkının tasarruf kararı tüketim kararı ile eşzamanlı olarak alınmaktadır. Gelir, her biri hane halkının mülkiyetinde olan vasıflı işgücü, vasıfsız işgücü, toprak, sermaye ve doğal kaynaklar tarafından üretilmektedir. Tüketimin değişik mallar arasındaki dağılımı homotetik olmayan sabit fark esneklikli içsel bir fayda fonksiyonuna göre yapılmaktadır. Kamu tüketiminin dağılımı ise ikinci bir Cobb-Douglas üretim fonksiyonuna göre yapılmaktadır. Kamu tüketimi hanehalklarının fayda maksimizasyonunun bir parçası olduğu için vergi gelirleri hanehalklarına gelir transferi olarak geri dönmektedir. Hanehalkları hem özel tüketim hem de kamu tüketimi için ithal malları da tüketmektedir. İthal mallar doğrudan dünyanın geri kalanından alınmaktadır. İthal malların tüketimi Armington yaklaşımı ile modellenmektedir. Dolayısıyla ithal mallarla yerli malları tam ikame malları değildir.

Toplam tasarrufların dağıtılması küresel seviyede olmaktadır. Tüm bölgelerdeki hanehalklarının toplam birikimi bölgelere ve sektörlere, sermayenin fiyatına göre dağıtılmaktadır. Dolayısıyla, modelde yatırımların tasarruflar tarafından belirlendiği neo-klasik bir kapama kuralı varsayılmaktadır. GTAP modelinde yatırımlar sadece sektörlerin sermaye stoğunu değiştirmektedir ve teknolojik değişim veya üretkenliğe bir etkisi yoktur.

Bu bölümün amaçları doğrultusunda GTAP veri tabanının 7. versiyonu kullanılmıştır. GTAP veri tabanı iki yönlü dış ticaret, koruma ve nakliyat verisinin yanı sıra dünya üzerindeki 113 bölgenin ulusal hesapları ile ilgili verileri de içermektedir. Verilerin temel yılı 2004'tür. Veri tabanındaki her bölgede 57 sektör, 4 farklı üretim faktörü ve bir tane hanehalkı bulunmaktadır. Türkiye GTAP veri tabanında tek başına bir ülke olarak yer almaktadır. Çalışmamız için, veriler 16 bölge ve 15 sektör içerecek şekilde toplulşatırılmıştır. Çalışmamızda ayrıca tarımsal üretimin ayrıştırılması ve agro-ekolojik bölgelerde hasat alanlarını da içeren GTAP Toprak kullanımı veri tabanı da kullanılmıştır.

İklim değişikliğinin fiziksel etkilerinin sayısal değerleri genellikle farklı iklim senaryoları ihtiva eden genel dolaşım modelleri ile tahmin edilmektedir. Dünya genelinde iklimin gelecekte nasıl bir durumda olacağını tahmin eden pek çok genel dolaşım modelleri bulunmaktadır. (Randall ve ark., 2007). Ancak değişik genel dolaşım modellerinin yaptıkları öngörüler arasında kayda değer farklılıklar bulunmaktadır (Fischer ve ark., 2005; Schönwiese ve ark., 1987; Stern, 2006). Bu farklı öngörüler, farklı olası gelecek tasarımları olarak düşünülebilir. Eğer gerçekleşen geleceğin bir olasılık dağılımından çekilen bir gözlem olduğu düşünülürse, farklı genel dolaşım modellerinin sonuçları da aynı olasılık dağılımından elde edilen örneklemin elemanları gibi değerlendirilebilir. Bu durumda söz konusu olasılık dağılımı sıcaklık ve yağış gibi temel iklim değişkenlerinin ortalama değerleri ve standart sapmaları ile tanımlanıyor olacaktır. Verim tahminleri bu iklim değişikenlerinin bir fonksiyonu olduğu için, onlar da bir olasılık dağılımına sahip stokastik değişkenler gibi düşünülebilirler. Sonuç olarak, mümkün olduğu kadar fazla farklı genel dolaşım modelinin sonucunun kullanılması dikkate alınan olası gelecek tasarımlarının tahmininin daha yüksek bir hassasiyetle yapılmasına olanak sağlayacaktır.

Bu mantık çerçevesinde, iklim değişikliği kaynaklı verim değişimleri iki farklı kaynaktan derlenmiştir: IFPRI Gıda Güvenliği CASE haritaları veritabanı (IFPRI, 2012) ve Küresel Çevrenin İncelenmesi için Bütünleşik Model (IMAGE) Projesi veritabanı (IMAGE Team, 2009). Her iki kaynak da değişik GDM'lerin farklı iklim senaryoları için elde ettikleri sonuçları kullanarak verim değişimi hesaplaması yapmaktadırlar. IFPRI veritabanı dünya genelinde iki yüz civarında bölgede altı ürün için 2050 yılına kadar 5 yıllık aralıklarla ve çok geniş bir senaryo spektrumunda olası verim değişikliklerini vermektedir. Söz konusu verim değişimleri biyofizik model kullanılarak hesaplanmaktadır. Biyofizik modeline sokulan iklim değişikliği şokları iki farklı genel dolaşım modeli (CSIRO ve MIROC) kullanılarak SRES A1B ve B1 senaryolarının normal, kötümser ve iyimser versiyonlarının benzetimlerinden elde edilmiştir. Veri tabanında ayrıca mükemmel önleme senaryosunun sonuçları da bulunmaktadır. Dolayısıyla IFPRI veri tabanı 15 farklı olası gelecek tasarımı için verim değişimlerini içermektedir. Modeller ve veritabanıyla ilgili detaylı açıklamalar Nelson ve ark. (2010)'da bulunabilir.

IMAGE veritabanı, dünya genelinde SRES A1B, B1, A2ve B2 senaryoları altında 2100 yılına kadar beş yıllık aralıklarla 14 ürün ve/veya ürün kategorisi için verim değişimi tahmini vermektedir. Veri tabanında 17 ülke/bölge bulunmaktadır. Veritabanında sunulan verim değişimleri IMAGE çerçevesinde bulunan karasal modeller tarafından tahmin edilmektedir. Bu modeller LEITAP modeli ile bağlantılıdır ve CO2 yoüunlukları, bulutluluk, sıcaklık ve yağış gibi değişkenleri girdi olarak kullanmaktadırlar. Veritabanında 10 farklı SRES senaryosu varyasyonunun benzetim sonuçları bulunmaktadır. Kullanılan modeller ve veri tabanını ile ilgili detaylı açıklamalar Hoogwijk ve ark. (2005) ve Bouwman ve ark. (2006)'da bulunabilir.

Dış ticaret politikasının iklim değişikliği altındaki etkilerini incelemek için 4 senaryo benzetimi yapılmıştır. İlk olarak, her iklim projeksiyonu için bir referans senaryo (BASE) benzetimi yapılmıştır. Bu referans senaryolarda sadece iklim değişikliği şokları modele sokulmuştur. Daha sonra her bir referans senaryoya üç farklı dış ticaret senaryosu sokularak benzetimler yapılmıştır: AB ve Türkiye arasında iki yönlü dış ticaret serbestleşmesi, dünya genelinde tarım mallarında dış ticaret serbestleşmesi ve dünya genelinde bütün ürünlerde dış ticaret serbestleşmesi.

Bulgular

Sonuçlar iklim değişikliğinin küresel ekonomi üzerindeki etkilerinin geniş bir olasılıklar kümesini kapsadığını göstermektedir. İklim değişikliğinin ekonomi üzerindeki etkisi fiziksel etkilerin büyüklüğü ve karakteristiklerine bağlı olarak olumlu veya olumsuz olabilmektetir. Genel olarak olumsuz etkilerin gözlenmesi ihtimali daha yüksektir. Nihai etki, farklı bölgeler ve bu bölgelerdeki sektörler arasındaki karmaşık etkileşimler neticesinde belirlenmektedir. Bu durum değişik önleyici politkalar için yapılan fayda zarar analizlerinde iklim riskleri arttıkça dikkate alınması gereken belirsizliği arttırmaktadır.

İklim değişikliğinin etkileri bölgeler arasında ciddi değişiklşkler göstermektedir. İklim değişikliği iktisadi refahı sadece Sahra-altı Afrika ve Güney Asya'da olumlu etkilemektedir. Avrupa, Orta duğu ve Kuzey Afrika ise iktisadi refah açısından iklim değişikliğinden en olumsuz etkilenen bölgelerdir. Diğer taraftan, Doğu Asya ve Avrupa’da iktisadi refahın iklim değişikliği senaryoları üzerindeki varyasyonu oldukça yüksektir. Dolayısıyla iklim değişikliğinin bu bölgelerde ciddi refah kaybına neden olacağı söylenebilir.

İklim değişikliğinin refah üzerindeki etkilerinde gözlemlenen yüksek varyasyon, temel makroekonomik değişkenlere tam olarak yansımamaktadır. Pek çok bölge için GSYİH sıfır etrafında yoğunlaşan sınırlı bir dağılıma sahiptir. Diğer taraftan Türkiye, Fas, Orta Doğu ve Kuzey Afrika gibi iklim değişikliğine karşı göreceli olarak daha kırılgan olan bölgelerde GSYİH dahageniş yayılımlı bir dağılıma sahip olup, bu bölgelerde iktisadi etkileşimlerin iklim riskini arttırdığını göstermektedir.

Benzetimlerden elde edilen en önemli sonuç dış ticaret serbestleşmesinin iklim değişikliğinin sebep olduğu refah kayıplarını dünyanın pekçok bölgesi için telafi edebileceğidir. Tüm ürünlerde küresel dış ticaret serbestleşmesinin refah arttırıcı etkileri, dünyanın pek çok bölgesi için iklim değişikliğinin refah seviyesi üzerindeki olumsuz etkilerinden daha fazladır. Ne var ki AB-Türkiye dış ticaret serbestleşmesi gibi bölgesel ticari serbestleşmelerin taraflara sağladığı refah kazancı iklim değişikliğinin sebep olduğu refah kaybına kıyasla oldukça küçüktür.

Türkiye, bütün ürünlerde küresel çapta yapılan bir dış ticaret serbestleşmesi ile iklim değişikliğinin olumsuz etkilerini telafi edebilmektedir. Ayrıca böyle bir senaryoda Türkiye’nin GSYİH’sında artışlar gözlenmektedir. Bunun anlamı küresel dış ticaret serbestleşmesinden sonra Türkiye’nin ihracatının ithalatından daha fazla arttığıdır. Gerçekten de GSYİH’nın bileşenleri incelendiğinde GSYİH’daki değişimin ana belirleyicilerinin ithalat ve ihracat olduğu görülmektedir. Ticari serbestleşmenin Türkiye ekonomisi üzerindeki temel etkisi ara malı ithalatı üzerinden olmaktadır. Sektörler arasında etkiler farkılılık gösterse de, Türkiye’de ithalat talebinin artmasının başlıca sebebi ihracatı artan sektörlerin ithal ara malı taleplerindeki artıştır. Tarım malları ithalatındaki artış gıda, sanayi, hayvancılık ve bitkisel yağ sektörlerinde artan ihracat talebini karşılamak için meydana gelen üretim artışından kaynaklanmaktadır.

Ticari serbestleşmenin gıda güvenliği üzerindeki etkileri, sektörel değişimlerde gözlemlenen varyasyon düşük olmasına rağmen, iklim koşullarına duyarlılık göstermektedir. İklim değişikliğinin etkileri kötüleştikçe dış ticaret serbestleşmesinin gıda güvencesini arttırma etkisi de artmaktadır. Bunun temel sebebi dış ticaret serbestleşmesinin iklim koşulları kötüleştikçe üretimi düşen yerli malların ithal mallarla ikame edilmesini kolaylaştırmasıdır.

Bölüm 5: Sonuç

İklim değişikliği önümüzdeki yüzyılda insanlığın gündemindeki en önemli konulardan birisi olarak kalacaktır. Uyum politikalarının bir an önce hayata geçirilmesi kaçınılmaz bir gerekliliktir. Ne varki, bu politikaların çeşitli maliyetleri bulunmaktadır ve değişik kuşaklar, bölgeler, ülkeler ve sosyal gruplar arasında önemli ödünleşimler içermektedirler. Bu tez potansiyel fayda ve maliyetlere bir nebze de olsa ışık tutmak yolunda bir adımdır. Bunun yanında, ekonominin tarım sektörü üzerinden iklim değişikliği ile etkileşiminin genel bir resmini çizmektedir. Çalışmamızda, önümüzdeki yüzyıl boyunca Türkiye'deki bölgesel ve ulusal ekonomik karar vericiler arasındaki etkileşimlerin yanı sıra Türkiye'nin iklim değişikliği senaryoları altında karşılaşacağı küresel dinamikler incelenmiştir. Bu amaç doğrultusunda bölgesel, ulusal ve küresel hesaplanabilir genel denge modelleri ile bitki su gereksinimi modelini birleştiren bütünleşik bir yaklaşım takip edilmiştir.

Sonuçlar iklim değişikliğinin 2035 yılından itibaren etkili olmaya başlayacağını, 2060 yılından sonra etkilerin ağırlaşacağını göstermektedir. Hem bölgesel hem de küresel etkiler konuma ve tarımsal üretimin yapısına göre değişikliklik göstermektedir. Uluslararası ticaret ekonominin iklim değişikliği şoklarına verdiği tepkide anahtar rol oynamaktadır. Ulusal düzeyde ticaret serbesleştirmesinin etkileri de incelenmiştir. Avrupa Birliği ile yapılacak olan bir ticaret serbestleşmesi refahı arttırmakta ancak bu artış iklim değişikliğinin sebep olduğu zararı karşılamak konusunda düşük kalmaktadır. Ancak refah artışı iklim değişikliğinin etkileri ağırlaştıkça artmaktadır.

Benzetim sonuçları küresel düzeyde iklim değişikliğinin etkilelerinin olası etkilerinin geniş bir yelpazeye yayıldığını göstermektedir. Sonuçlar dünyanın farklı bölgeleri ve bir bölgedeki farklı sektörler için değişiklikler göstermektedir. Diğer taraftan, ticaret serbestleşmesinin etkileri genellikle varsayılan iklim değişikliği senaryosundan bağımsızdır. Sonuçlar, iklim değişikliğinin olumsuz etkilerinin küresel çaptaki yapılacak bir ticaret serbestleşmesi ile hafifletilebileceğini göstermektedir.

Tezde elde edilen bulgular Türkiye'nin iklim politikasında izlenmesi gereken yollarla ilgili de önemli ipuçları sunmaktadır. Sulama projelerinin iklim değişikliğinin olası bölgesel sonuçları dikkate alınarak öncelendirilmesi, kuraklığa dayanıklı tohumlar geliştirmek için AR-GE yatırım ve faaliyetlerinin teşvik edilmesi, sulama suyu kullanımının akılcı bir şekilde düzenlenmesi, değişik bölgeler arasındaki ekonomik bağların geliştirilmesi ekonominin iklim değişikliği karşısındaki direncini arttırmaya yönelik politika alternatifleri olarak değerlendirilebilir. Analizlerimiz ayrıca olası politika seçeneklerinin maliyet ve faydaları açısından dikkatli bir şekilde incelenmesi gerektiğini de ortaya koymaktadır. Örneğin dış ticaret serbestleşmesi ancak küresel düzeyde gerçekleştirildiği takdirde bir uyum aracı olarak etkili olabilmektedir. Diğer taraftan bölgesel dış ticaret anlaşmaları tüketim ve ara malı arzında ikame olanaklarını arttırarak uyum çabalarını destekleyebilir.

Bu tezde geliştirilen modelleme araçları, farklı uyum politikalarının analizi için de kullanılabilir. Örneğin, sulama politikaları ile ilgili daha detaylı veriler modele dâhil edilerek değişik sulama suyu yönetim stratejilerinin uyum aracı olarak ne kadar etkili olacakları test edilebilir. Aynı şekilde, değişik tarım destek politikaları ile ilgili benzetimler yapılarak alternatif destek politikalarının iklim değişikliğine uyum konusunda ne kadar etkili oldukları araştırılabilir. Bir başka politika analizi de araştırma geliştirme politikalarının modellere dâhil edilerek teknolojik gelişmenin adaptasyon için yeni fırsatlar yaratıp yaratmadığını incelemektir.

Tezde sunulan analizler pek çok metodolojik geliştirmenin de önünü açmaktadır. Örneğin, ikinci ve üçüncü bölümlerde sunulan modeller birleştirilerek bölgesel analizler dinamik bir çerçevede yapılabilir. Bir başka olası geliştirme farklı hanehalkları tipleri eklenmesi olabilir. Bu şekilde iklim değişikliğinin ve değişik politika seçeneklerinin gelir dağılımı üzerindeki etkileri incelenebilir. Ayrıca, son bölümde kullanılan model sera gazı salınımlarını içerecek şekilde geliştirilerek, dış ticaret serbestleşmesi politikalarının sera gazı salınımlarını azaltma çabasındaki önleyici polikaları nasıl etkilediği incelenebilir.

APPENDIX F

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Dudu, Hasan
Nationality: Turkey
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EDUCATION

2006 January – 2013 December: Ph.D. in Economics, Department of Economics, Middle East Technical University, Ankara, Turkey

2003 September – 2006 January: M.Sc in Economics, Department of Economics, Middle East Technical University, Ankara, Turkey

1998 June – 2003 June: B.Sc in Economics, Department of Economics, Bogazici University, Istanbul, Turkey.

CERTIFICATES

2012 December, Institut Agronomique Mediterraneen de Montpellier, International Course on Integrated Assesment of Agricultural Systems at Regional Level

2011 July, Purdue University Global Trade Analysis Project, Short Course for Global Trade Analysis

EMPLOYMENT RECORD

Permanent Position
2013 January – Present: Researcher, Institute for Prospective Scientific Studies, European Commision Joint Research Center, Seville Spain

2004 January – 2013 January: Teaching & Research Assistant, Department of Economics, Middle East Technical University, Ankara, Turkey.

Visiting Position

2011 January – 2012 January: Visiting Scholar/Researcher, Department of Agrciultural Economics, Purdue University, West Lafayette, Indiana, United States of America

RESEARCH EXPERIENCE

2009 January – present: Research Assistant, in the project "CAPRI–RD: Common Agricultural Policy Regionalized Impact - The Rural Development Dimension" financed by European Commission, 7th. Framework Programmé on Research, Technological Development and Demonstration.

2006 January – 2011 March: Researcher, in the project "SCENES: Water Scenarios for Europe and for Neighboring States" financed by European Commission, 6th. Framework Programmé on Research, Technological Development and Demonstration.

2010 February – 2010 December: Research Assistant, in the project "State Planning Organization Province Coordination and Monitoring System", financed by Public Research Group of Turkish Science & Technological Research Council of Turkey and commissioned by Software and Data Engineering Department (G222) of Turkish Science & Technological Research Council of Turkey

2009 September – 2009 December: Researcher, in the project "Anatolia Minerals Co. Erzincan Çöpler Gold Mine Project Conflict and Human Rights Assesment", financed by Anatolia Minerals Co. and commissioned by METU Centre for Blacksea and Central Asia Studies and Fund For Peace Institution

2009 September – 2010 December: Researcher in the project "The Impact of Agricultural Enterprises on Productivity and Efficiency of Agricultural Production in Turkey and Chaotic Dynamic Analysis of Selected Products: Problems, Solutions and Policy Proposals", financed by Social Sciences Research Group of Turkish Science & Technological Research Council of Turkey, SOBAG 1001-109K129.

2009 September – 2010 April: Technical Assistant: in the project "Supporting Turkey's Efforts in Migration Management", financed by International Organization for Migration

2009 June – 2009 September: Researcher, in the project "Anatolia Minerals Co. Erzincan Çöpler Gold Mine Project Social Impact Analysis", financed by Anatolia Minerals Co. and commissioned by METU Centre for Blacksea and Central Asia Studies and Environmental Resources Management Consulting

2008 December – 2009 May: Research Assistant, in the project "History of State Planning Organization" financed by History Foundation of Turkey.

2008 December – 2009 January: Research Assistant, in the project "Efficiency Analysis of Forest Revolving Fund Enterprises in Turkey: Problems, Solutions and Policy Recommendations", financed by Social Sciences Research Group of Turkish Science & Technological Research Council of Turkey, SOBAG 1002-107K552.

2006 June – 2008 June: Researcher, in the project, "Macro-Micro Feedback Links of Irrigation Water Management" financed by World Bank.

2005 December – 2006 December: Researcher, in the project "Efficiency Structure of Turkish Agriculture" financed by Social Sciences Research Group of Turkish Science & Technological Research Council of Turkey, SOBAG 1001-105K030.

2003 August – 2006 May: Research Assistant, in the project "Impacts of Agricultural Trade Liberalization between the EU and Mediterranean Countries" (IAMM) financed by European Commission, 6th. Framework Programmé on Research, Technological Development and Demonstration.

PUBLICATIONS

Journal Papers

Çakmak, E., Dudu., H., Eruygur,. O., Ger, M., Onurlu S., Tonguc, Ö., 2013, Participatory Fuzzy Cognitive Mapping Analysis to Evaluate the Future of Water in the Seyhan Basin, Journal of Water and Climate Change, 4(12): 131-145, doi:10.2166/wcc.2013.029

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Books

Çakmak, E.H., Dudu, H., Ocal, N., 2008, Turk Tarim Sektorunde Etkinlik: Yontem ve Hanehalki Duzeyinde Nicel Analiz [Efficiency in Turkish Agricultural Sector: Method and Farm Household Level Quantitative Analysis], (in Turkish) TEPAV Yayinlari: Ankara

Book Chapters

Çakmak, E.H., Dudu, H., 2011, "Agricultural Policy Reform in Turkey: Sectoral and Micro Implications", in "Rethinking Structural Reform in Turkish Agriculture: Beyond the World Bank's Strategy", eds. Karapinar, B., Adaman, F., and Ozertan, G., Nova Science Publishers: New York

Dudu, H., Kilicaslan, Y., 2008, Concentration, Profitability and (In)Efficiency in Large Scale Firms, in Productivity, Efficiency, and Economic Growth in the Asia-Pacific Region, ed. Lee J.D. and Heshmati, A., Physica-Verlag

Working Papers and Conference Proceedings

Dudu, H., Çakmak, E. H., 2013, "Climate Change, Agriculture and Trade Liberalization a Dynamic CGE Analysis for Turkey", Proceedings of "Anadolu International Conference in Economics", Eskisehir, Turkey, June 19-21, 2013

Dudu, H., Çakmak, E. H., 2013, "Trade Liberalization and Productivity Growth: A Recursive Dynamic CGE Analysis for Turkey", Proceedings of "IATRC 2013 Symposium Productivity and Its Impacts on Global Trade", June 2-4, 2013. Seville, Spain

Dudu, H., Çakmak, E. H., 2012, "Climate Change and Agriculture: An Integrated Approach to Evaluate Economy-wide Effects for Turkey", Proceedings of the "UNU-WIDER Climate Change and Development Policy Conference", 28-29 September 2012 Helsinki, Finland

Dudu, H., Çakmak, E. H., 2011, "Regional impact of the climate change: A CGE analysis for Turkey", Working Paper No. 644, Economic Research Forum

Çakmak, E.H., Dudu, H., Eruygur, O., Ger, M., Onurlu, S., Tonguç, Ö., 2010, "Visions for the Future of Water in Seyhan Basin, Turkey: A Backcasting Application", in "Proceedings of iEMSS 2010 International Congress on Environmental Modelling and Software Modelling for Environment's Sake, Ottawa, Canada" eds. David A. Swayne, Wanhong Yang, A. A. Voinov, A. Rizzoli, T. Filatova

Çakmak, E.H., Dudu, H., Saracoglu, S., Diao, X., Roe, T.L., Tsur, Y., 2008, Macro-Micro Feedback Links of Irrigation Water Management in Turkey, World Bank Policy Research Working Paper Series, No. WPS 4781, doi: 10.1596/1813-9450-4781

Dudu, H., Chumi, S., 2008, Economics of Irrigation Water Management: A Literature Survey with Focus on Partial and General Equilibrium Models, World Bank Policy Research Working Paper, No. WPS 4556

Project Reports

Çakmak, E., Dudu, H., Eruygur, O., Aldan, M.C., 2011, Improving National and Regional Time Series Database for Turkey, CAPPRI-RD Deliverable 2.3.3, of the project "CAPRI–RD: Common Agricultural Policy Regionalized Impact - The Rural Development Dimension" financed by European Commission, 7th. Framework Programmé on Research, Technological Development and Demonstration

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Çakmak, E., Dudu, H., Eruygur, O. H., Tonguç, Ö., 2010, Third versions of storylines (enriched with back casting and short term policy options) at the Regional and Pilot Area levels: Seyhan Pilot Area, Turkey, Delivarable DIA2.4/Annex-6 of "Water Scenarios for Europe and for Neighbouring States (SCENES)" Project

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Çakmak, E.H., Tozanli, S., Dudu, H., Kirisci, E. N., 2004 "Characterization of Agricultural and Agro-Industrial Sectors in Turkey", project report for "Impacts of Agricultural Trade Liberalization Between The EU and Mediterranean Countries" (IAMM) financed by European Commission, 6th. Framework Programme on Research, Technological Development and Demonstration

Thesis Work
Dudu, H., 2013, Climate Change, Agriculture and Trade Policy: CGE Analyses at Regional, National and Global Level, Unpublished M.Sc. Thesis, Supervisor: Nadir Öcal, METU Department of Economics.

Dudu, H., 2006, Efficiency in Turkish Agriculture: A Farm Household Level Analysis, Unpublished M.Sc. Thesis, Supervisor: Erol Çakmak, METU Department of Economics.

Conference Presentations
2013, "Climate Change, Agriculture and Trade Liberalization a Dynamic CGE Analysis for Turkey", paper presented at "Anadolu International Conference in Economics", Eskisehir, Turkey, June 19-21, 2013. (with Çakmak, E.H.)

2013, "Trade Liberalization and Productivity Growth: A Recursive Dynamic CGE Analysis for Turkey", paper presented at "IATRC 2013 Symposium Productivity and Its Impacts on Global Trade", June 2-4, 2013. Seville, Spain. (with Çakmak, E.H.)

2012, Climate Change and Agriculture: An Integrated Approach to Evaluate Economy-wide Effects for Turkey, paper presented at “Climate Change and Development Policy Conference”, Helsinki, Finland, 28-29 September 2012, (with Çakmak, E.H.)

2011, “Regional Impact of the Climate Change: A Spatial CGE analysis for Turkey”, paper presented at “The 72nd International Atlantic Economic Conference”, Washington, D.C. USA, 20-23 October 2011, (with Çakmak, E.H.)

2010, “Regional Impact of the Climate Change: A Spatial CGE analysis for Turkey”,paper presented at “International Conference on Economics – Turkish Economic Association”, Kyrenia, Turkish Republic of Northern Cyrprus, 1-3 September 2010, (with Çakmak, E.H.)

2009, “Bank Efficiency and the Market Structure: An Analysis for Turkey”, paper presented at “Anadolu International Conference in Economics”,Eskisehir, Turkey, 17-19 June 2009 (with Eruygur, O.)

2009, “Climate change and Agriculture in Turkey: Economy-wide impact assessment using a CGE model”, paper presented at “Anadolu International Conference in Economics”, Eskisehir, Turkey, 17-19 June 2009 (with Çakmak, E. and Saracoglu S.)

2009, “Climate change and Agriculture in Turkey: Economy-wide impact assessment using a CGE model”, paper presented at “1st International Conference on Global Climate Change and Agriculture”, Namik Kemal University, Tekirdag, Turkey, 27-29 May 2009 (with Çakmak, E. and Saracoglu S.)

2007, “Efficiency in Turkish Agriculture” paper presented at “10th European Workshop on Efficiency and Productivity”, Lille, France, on 27-31 June 2007 (with Çakmak, E. and Ocal, N)

2007, "Efficiency in Turkish Agriculture”, paper presented at "8th Turkish Econometrics and Statistics Congress", Malatya, Turkey, on 24-25 May 2007 (with Çakmak, E. and Ocal, N.)

2007, "Analysis of Nonlinear Dynamics in Turkish Food Sector Price Index”, paper presented at "8th Turkish Econometrics and Statistics Congress", Malatya, Turkey, on 24-25 May 2007 (with Çakmak, E. and Ocal, N.)

2006, “Concentration, Profitability and (In)Efficiency in Large Scale Firms”, paper presented at 5th Asia-Pacific Productivity Conference, Seoul, South Korea, on 17-19 August 2006. (with Kilicaslan, Y.)

EDITORIAL DUTIES

2009 June – 2011 January: Technical Manager, Spectrum: Journal of Global Studies

2008 March – 2009 June: Advisor to the Editor, Iktisat, Isletme ve Finans Dergisi

2005 January – 2009 February: Editorial Assistant, METU Studies in Development

PROFESSIONAL ACTIVITIES

2013, Member of Program Committee, Anadolu International Conference in Economics, Eskisehir, Turkey, 19-21 June

2011, Member of Program Committee, Anadolu International Conference in Economics, Eskisehir, Turkey, 15-17 June

2009, Member of Program Committee, International Conference of Poltical Economy: Adam Smith Today, Kocaeli and Canakkale, Turkey, 1-4 October

2009, Member of Program Committee, Anadolu International Conference in Economics, Eskisehir, Turkey, 17-19 June

2005 September – 2009 September: Member of Board of Executives and Treasurer, Middle East Technical University Faculty Association,

LINGUISTIC SKILLS

Turkish: Native
English: Fluent
Spanish: Beginner

COMPUTER SKILLS

GAMS, GEMPACK, Stata, SPSS, RATS, E-views, MS Office Programs, Website Building with Php and MySQL

APPENDIX G

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☒

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Dudu
Adı : Hasan
Bölümü : İktisat

TEZİN ADI (İngilizce) : Climate Change, Agriculture And Trade Policy: CGE Analyses at Regional, National And Global Level

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☒

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