ACHIEVING TURKEY’S INDC TARGET: ASSESSMENTS BY MULTIPLIER ANALYSIS, COMPUTABLE GENERAL EQUILIBRIUM, AND STRUCTURAL DECOMPOSITION ANALYSIS METHODS

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IZMIR UNIVERSITY OF ECONOMICS
GRADUATE SCHOOL OF SOCIAL SCIENCES

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ABSTRACT

ACHIEVING TURKEY'S INDC TARGET: ASSESSMENTS BY MULTIPLIER ANALYSIS, COMPUTABLE GENERAL EQUILIBRIUM, AND STRUCTURAL DECOMPOSITION ANALYSIS METHODS

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Turkey expressed its intention to decrease emissions level at a rate of 21% from business as usual in its Intended Nationally Determined Contribution (INDC). This emissions reduction target is important but, Turkey faces unemployment problems and needs to sustain its growth. In this study, two Environmentally Extended Social Accounting Matrices (SAM), based on 2002 and 2012 Input-Output data, were created. Emissions reduction potentials of the National Climate Change Action Plan (NCCAP) together with the INDC were calculated by Multiplier Analysis method and more conceivable alternative policies to reduce emissions to the target level were proposed. Various policies that aimed only to boost the economic growth were generated by using SAM Multipliers and their emissions reduction potentials were calculated by Multiplier Analysis method. To enhance policy options, a multi-gas multi-sector CGE model was developed and alternative tax policies to achieve the INDC target were generated and analyzed. To support decision making, Structural Decomposition Analysis method was applied to 2002 and

2012 Environmentally Extended SAMs and drivers of emissions increase in this period were determined. The study finds that both the preparation and implementation of the previous national documents are problematic, and that Turkey was not meticulous about implementation of the climate mitigation policies in these documents. The study also finds that reaching the emissions target with the INDC policies seems impossible and alternative policies which were essentially motivated by the NCCAP and the INDC documents yet fell behind the 21% target. The study concludes that more forceful policies are needed and recommends that the INDC target and document itself should be revised substantially.

Keywords: environmentally extended SAM; multiplier analysis; CGE; SDA; NCCAP; INDC; climate change mitigation; Turkey

ÖZET

TÜRKİYE INDC HEDEFİNİ BAŞARMAK: ÇARPANLAR ANALİZİ, HESAPLANABİLİR GENEL DENGE VE YAPISAL AYRIŞTIRMA METOTLARI İLE DEĞERLENDİRMELER

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Türkiye, Niyet Edilen Ulusal Katkı Beyanı'nında (INDC), niyetini %21'e varan artıştan azaltım olarak açıklamıştır. Bu azaltım hedefi Türkiye için önemlidir, fakat, işsizlik problemleri ile karşı karşıyadır ve büyümesini sürdürmeye ihtiyacı vardır. Bu çalışmada, 2002 ve 2012 yılları girdi-çıktı tablolarını temel alan iki Çevresel Genişletilmiş Sosyal Hesaplar Matrisi (SHM) geliştirimiştir. Ulusal İklim Değişikliği Eylem Planı ile beraber Niyet Edilen Ulusal Katkı Beyanı belgelerinin emisyon azaltım potansiyelleri Çarpanlar Analizi yöntemi ile hesaplanmıştır ve emisyonu hedeflenen seviyeye indirmek için daha akla yatkın alternatif politikalar önerilmiştir. SHM Çarpanlarını kullanarak sadece ekonomik büyümeyi hedef alan çeşitli politikalar oluşturulmuş ve bunların emisyon azaltım potansiyelleri Çarpanlar Analizi yöntemi ile hesaplanmıştır. Politika opsiyonlarını artırmak amacıyla, çok gazlı çok sektörlü bir Hesaplanabilir Genel Denge modeli geliştirilmiş ve INDC hedefini başarmak için alternatif vergi politikaları oluşturulup analiz edilmiştir. Karar almayı desteklemek için, Yapısal Ayrıştırma Analizi yöntemi 2002 ve 2012 Çevresel Genişletilmiş SHM'lere uygulanmış ve bu dönemde emisyon artışına sebep olan faktörler belirlenmiştir. Çalışma daha önceki ulusal dökümanlarının hem hazırlanışının hem de uygulamasının sorunlu olduğu ve Türkiye'nin bu dökümanlardaki iklim değişikliği azaltım politikalarını uygulamada titiz olmadığı kararına varmıştır. Çalışma aynı zamanda INDC'deki politikalarla hedefe ulaşmanın mümkün olmadığı ve Ulusal İklim Değişikliği Eylem Planı ve INDC dökümanlarından esinlenerek hazırlanan alternatif poltikaların da %21'lik hedefin gerisinde kaldığı kararına varmıştır. Çalışma daha zorlayıcı politikaların gerektiği sonucuna varmış ve INDC hedefinin ve dökümanın kendisinin büyük oranda gözden geçirilip düzeltilmesini tavsiye etmiştir.

Anahtar Kelimeler: çevresel genişletişmiş SHM; çarpanlar analizi; hesaplanabilir genel denge modeli; yapısal ayrıştıma analizi; ulusal iklim değişikliği eylem planı; niyet edilen ulusal katkı beyanı; iklim değişikliği azaltımı; Türkiye

This thesis is dedicated to my lovely parents and sister, İsmail Alkan, Nazmiye Alkan, and Hatice Uslu….

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CHAPTER 1: INTRODUCTION

As scientists became more certain of the adverse effects of pollution on human life, pollution reduction has become a greater policy concern. Air quality in terms of pollution in cities and greenhouse effects are two of the major concerns, and these concerns have led to international collaborative actions. These collaborations conclude a number of international treaties and mechanisms aimed at reducing pollution. Most commonly known examples of such undertakings for greenhouse gases are the United Nations Framework Convention on Climate Change (UNFCCC) as a framework for international cooperation to combat climate change, the Kyoto Protocol as an international agreement entered into force in 2005 to set binding emission reduction targets, and the Intended Nationally Determined Contributions (INDCs) as mechanisms outlining and communicating the countries' post 2020 climate actions.

The year 2015 was a milestone in climate change actions, as 196 Parties came together, 147 Parties submitted 119 Intended Nationally Determined Contributions (INDCs) (28 EU member countries submitted one aggregate INDC) which covered 86% of global emissions [1,2]. The Paris Agreement also was signed with the objective to keep the global temperature below 1.5 or 2 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change [3]. INDCs were adopted as the national plans solely addressing climate change mitigation after 2020 and were submitted prior to the Paris Conference of the Parties (COP 21). Each party will continue to prepare, communicate and submit its Nationally Determined

Contribution (NDC) at the end of every five-year period as the Paris Agreement requires [3]. The agreement is binding as monitoring and reporting by technical experts is required but flexible as each Party can establish its targets and modes of implementation [4]. Furthermore, both Annex 1 and non-Annex 1 countries have to prepare the NDCs and are eligible for stock taking of emissions and expert reviews as required in the agreement [3]. Although the INDCs vary in structure and content, and are insufficient to reverse the upward trend of global emissions by 2025 or 2030 and to keep the global temperature below the so-called 2 °C limit; the agreement indicates a significant increase in the number of countries taking climate actions, including developing countries. The agreement also promises hope for broad adoption with flexibility in determining commitments and with the requirement of regular reporting and external monitoring, even though it does not include any enforcement mechanism. In contrast to the Kyoto period, the INDCs created a growing awareness among developing countries about the need to take an active role in mitigation.

Turkey submitted its INDC to the UNFCCC in 2015, before the COP 21, with an emissions reduction target of a level of emissions 21% lower than the business as usual scenario by 2030 [5]. Since 1990, greenhouse gas emissions in Turkey increased by 122% to 475.1 Mt CO_2 eq. in 2015 [6]. The highest portion of total greenhouse gas emissions, 71.56%, originated from the energy sector; 12.78% originated from industrial processes, 12.08% from agriculture, and 3.56% from waste [6]. Absorption by land increased from 30.3 Mt CO_2 eq. in 1990 to 64 Mt CO_2 eq. in 2015, an increase of 111.92% [6]. As seen from Figure 1, the rise in greenhouse gas emissions per capita is steeper than the population increase, indicating a tendency towards carbon-intensive activities. For the year 2014, Turkey (4.49 metric tons per capita) still has the lowest values in per capita greenhouse gas emissions among all OECD countries (9.53 metric tons per capita) and the EU (6.38 metric tons per capita)

[7]. Despite this relatively low level compared to the OECD average and EU, its trend in emissions per capita is a cause for concern.

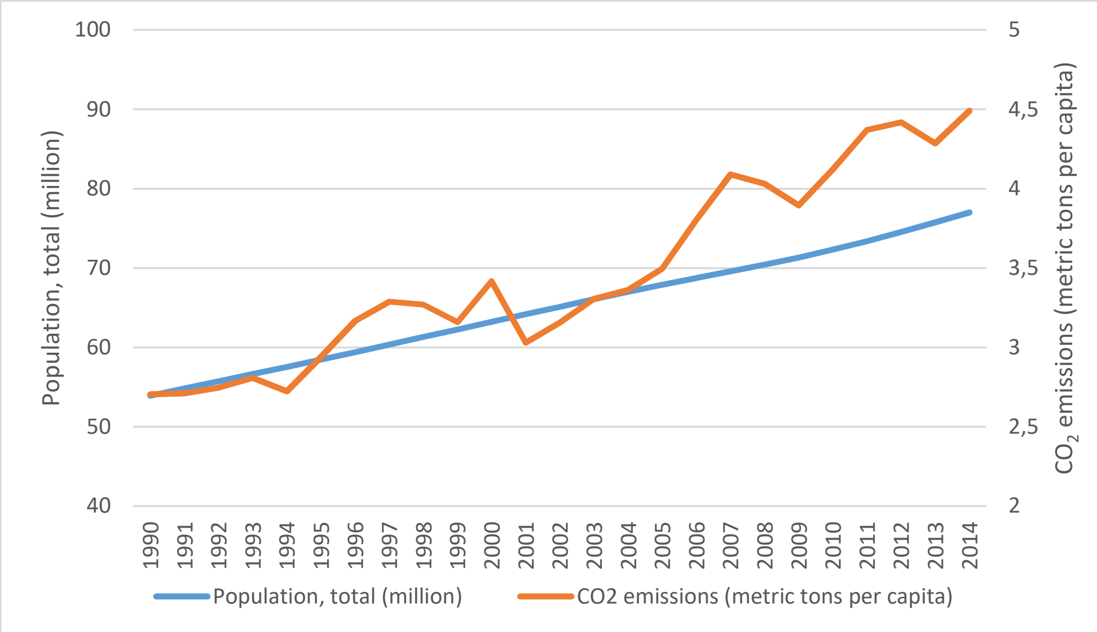


Figure 1. Greenhouse Gas Emissions per Capita and Population between 1990 and 2014 (Source: Compiled from World Bank [7,8]).

However, climate change is not the only issue that Turkey faces. Currently, Turkey's economy faces important risks. Challenges include long standing unemployment and sustaining economic growth in the face of domestic threats and regional uncertainties. The Turkish economy experienced periods of high growth in the last decade made possible by strong domestic demand but overly funded by debt-creating capital inflows. Turkey's current account position has severely deteriorated since the early 2000s. Due to high import dependency in production, high global risk as well as weak and unstable liquidity conditions, the current account deficit has been a great cause for concern. According to Kara and Sarıkaya [9], the 2011 policies of the Central Bank of Turkey which aimed to remove financial excesses and avoid significant exchange rate deterioration helped remove the cyclical part of the deficit, but the remaining sizeable part requires structural reforms which would bring about significant sacrifices in economic growth in the short term.

Many consider high current account deficits to be a key economic weakness in the Turkish economy.

Moreover, Turkey has become increasingly more volatile politically and socially over the last decade. Widespread street protests took place against the government in the summer of 2013, known as Gezi Park Protests [10]. In June 2015, a controversial election took place and the following year Turkey witnessed its most severe terrorist attacks ever, with several bomb attacks the following year [11]. The Syrian civil war caused mass migration, placing an additional important social burden on Turkey [12,13]. After the failed coup attempt in July 2016, a state of emergency was declared which has yet to be lifted, adding to the uncertainty surrounding the Turkish economy.

To achieve strong and sustainable growth, domestic savings should increase, domestic demand to GDP ratio should decrease, and exports should be considerably strengthened. This can be seen by comparing 2000-2016 period averages of gross domestic savings (% of GDP) (TR: 23.36, others: 25.83), final consumption expenditure (% of GDP) (TR: 76.64, others: 74.16), and exports of goods and services (% of GDP) (TR: 22.50, others: 26.21) ratios of Turkey and the 16 countries above of Turkey in GDP ranking [8,14].

The unemployment rate has also increased in the post-2000 period. According to the "Employment Outlook 2017" report of the OECD [15], unemployment in Turkey exhibited an upward trend from 2012 to a peak of 11.7% in February 2017 and is expected to remain at 10% until the end of 2018, in sharp contrast with the OECD average (5.9% in 2017).

Given the expanding international dimension of climate change mitigation, environmental concerns have become a fertile ground for scholarly debate. Studying a combination of economic and emissions mitigating policies is a common practice in this line of debate. After Parties signed the Paris Agreement, many scientists conducted studies on vagueness and comparability of INDCs, Pauw et al. [16], Seo [17], Winkler et al. [18]; the gap between the global target and national contributions, Benveniste et al. [19], Höhne et al. [20]; and supplies and uses of financial resources under the UNFCCC, Ghezloun et al. [21], Zhang and Pan [22]. There were studies assessing the INDCs and evaluating implications of the policies set forth therein on a single country, Djurovic et al. [23], Chunark et al. [24], Siagian et al. [25], Oshiro et al. [26], Wu et al. [27], Rasiah et al. [28], Busby and Shidore [29]; and on multiple countries, Lee et al. [30], Liu et al. [31]. As the INDCs are considered the first emissions reduction pledges for many developing countries and due to the slightly more binding structure of the Paris Agreement compared with the Kyoto Protocol, INDCs of developing countries have many aspects to study. As a developing country and in regard to the concerns mentioned above, this study aims to analyze the INDC document of Turkey. This study addresses the following previously unanswered questions: What is the emissions mitigation potential of the INDC? What are the emissions mitigation potentials of the previous national documents, i.e., the National Climate Change Action Plan (NCCAP) developed by the Ministry Environment and Urbanization [32]? To what extent were these policies put into practice? Are alternatives to the INDC policies needed? Which policies will be more effective in reaching the INDC target? Which points are pointed out in the 10 year-data between 2002 and 2012? Can the target be achieved by policies that boost the economy? To answer these questions, two Environmentally Extended Social Accounting Matrices (SAM) were prepared from 2002 and 2012 input-output tables and Multiplier Analysis, Computable General Equilibrium (CGE), and Structural Decomposition Analysis (SDA) were conducted. The second chapter reviews literature of the study field. Environmentally Extended SAM construction steps were explained in the third chapter. In the fourth chapter, the goals of the previous national climate change documents were transformed to policies, alternative policies to the INDC's, alternative policies to grow the economy were generated, and

Multiplier Analysis method was applied to the 2012 Environmentally Extended SAM to analyze these policies. In the fifth chapter, a multi-gas multi-sector CGE model (MGMSCGE) was developed and alternative tax policies to reach the emissions mitigation target in the INDC were generated and analyzed in this model. In the sixth chapter, SDA was applied to 2002 and 2012 Environmentally Extended SAMs and validity of the proposed policies were argued. The seventh chapter concludes.

CHAPTER 2: LITERATURE REVIEW

Researchers have assessed the impacts of climate policies by various analytical methods. In this chapter, modeling types literature and decomposition analysis literature in climate change mitigation field were reviewed.

2.1. MODELING TYPES LITERATURE IN CLIMATE CHANGE MITIGATION

Modelling options can be grouped into three [33]: Integrated Assessment Models (IAMs), top-down and bottom-up models, and Multi-Criteria Analysis. IAMs consider both the economic and biophysical systems and their interactions, such as how increased GHGs in the atmosphere affect temperature, and how temperature change causes quantifiable economic losses. Top-down and bottom-up models are two approaches in Cost-Benefit Analysis (CBA). Top-down models evaluate the system based on aggregate economic variables, whereas bottom-up models consider technological options or project-specific climate change mitigation policies. Multi-Criteria Analysis (MCA) is applied when it is difficult to reduce all objectives to a single metric, and due to nature of the analysis, the researcher does not have to determine how outcomes are traded-off. A significant number of climate policy assessments have been conducted with the help of climate policy models; Stern Report employed the PAGE model [34], US Environmental Protection Agency (EPA) suggested policies using the EMPAX-CGE model [35], Hu et al. [36] compared global warming policies by using the DICE model, and Toshiyuki and Goto [37] examined the legal validity of US Clean Air Act by using Data Envelopment Analysis (DEA) model.

More recent studies concentrate on the INDCs and the Paris Agreement. Qi and Weng [38], analyzed the impacts of a linked Emissions Trading System (ETS) for Annex 1 countries to achieve the INDC emissions reduction target. Running a multi-regional CGE model, they concluded that a linked ETS would have different impacts on output, energy consumption and GDP of the participating country depending on whether it is a permit exporter or importer but would slightly increase the economic aggregate of the participating countries. Gu and Wang [39], employed a climate-economy integrated assessment model to investigate the possibility of achieving the global INDC target with the existing R&D investment rates. They concluded that even if most of the countries achieved their INDC targets by 2030, the 2 °C target would be difficult to achieve without higher R&D investment rates. They suggested that if transfer of advanced low-carbon technologies to developing countries increased and if a policy mix including different mitigation measures in addition to R&D development was implemented, temperature increase could remain below 2 °C. Dong, et al. [40] predicted the possibility of achieving emissions reduction targets of the ten most emitting countries by analyzing CO_2 emissions, primary energy consumption, and share of renewable energy data between 1991 and 2015. They used trend extrapolation and back propagation (BP) neural network methods to overcome the weakness of Multiple Linear Regression (MLR) and the assumptions of Environmental Kuznets Curve (EKC). The study concluded that China, India and Russia would achieve their targets, but USA, Japan, Germany and South Korea would not; the remaining countries, namely, Saudi Arabia, Iran and Indonesia would be a matter of debate in the future as they had not committed to any targets.

A limited number of studies have also employed climate policy models with different aims in Turkey. One of the earliest studies in the field, Telli, Voyvoda and Yeldan [41], intended to study the economic impacts of various possible mitigation policies because of accession negotiations with the EU which set an ambitious target to reduce its greenhouse gas emissions 20% below the level of 1990 by 2020, in compliance with the Kyoto Protocol. With this motivation, they developed a CGE model, projected for the 2006-2020 period, and concluded that possible emissions mitigation targets could worsen the existing state of employment and create a need to finance mitigation investments. They proposed a policy reducing existing tax rates and applying carbon and energy taxes. In another study, Akin-Olcum and Yeldan [42] analyzed several Emissions Trading System regimes for Turkey under the EU 20-20-20 emissions target and its revised version, 30%. The authors built a multi-regional, multi-sectoral applied general equilibrium model, and found that Turkey would have economic gains from linking with the EU ETS under the 20% cap, but it would suffer critical output loss under the 30% cutback. Bouzaher, Sahin and Yeldan [43] built a 12-sector, dynamic CGE model which included CO_2 and Particulate Matter (PM10) emissions, solid waste and waste water discharges. The authors aimed to identify viable policies for the 2010-2030 period to realize green growth in Turkey. They proposed a policy that consisted of taxing emissions from PM10 and CO_2, taxing solid waste and waste water discharge, and spending the revenue for creating green jobs as well as R&D induced innovation.

Acar and Yeldan [44] assessed the impact of current coal subsidies on macro indicators and CO_2 emissions by running a multi-region CGE model between 2015 and 2030. They found that elimination of subsidies for coal results in a slight reduction in GDP, but a substantial decrease in CO_2 emissions. The study was written at the time of Turkey's INDC submission, but it was not conducted in the INDC context. The authors referred to the emissions reduction target of the INDC document as they compared the official business as usual (BAU) projections with their own BAU projections.

They found the official projections too high and not in line with the recent Turkish historical pathway. Kolsuz and Yeldan [45] implemented an applied general equilibrium model with the aim of increasing employment, abatement of environmental pollution, and reaching a higher rate of disposable income. They concluded that a policy introducing environmental taxes on pollutants, creating an institutional mechanism to earmark these tax revenues for green employment, and halving the existing labor taxes within a more flexible labor market could expand labor employment by 9.2%, expand GDP by 1.6%, and reduce total CO_2 eq. emissions by 19.7% by 2030 in comparison to the business as usual path.

Two studies were conducted on Turkey’s INDC document, one of them was made before submission of the INDC and one after. The report entitled “Low carbon Development Pathways and Priorities for Turkey” was prepared in partnership of WWF-Turkey and Istanbul Policy Center (IPC) [46]. A CGE model was developed to determine a low carbon development pathway up to 2030. The report was prepared before the Paris Conference, and even before the submission of Turkey’s INDC. The authors created three scenarios: official plans scenario which used growth rates of official economic program, business as usual scenario based on more realistic growth rates, and 2 °C pathway scenario which included mitigation policies. A policy introducing a carbon tax whose proceeds will be used to fund investments in renewable energy and assuming autonomous energy efficiency gains was proposed. However, as the proposed policy would realize only two thirds of the total emissions reduction needed to meet the 2 °C target as calculated by the authors by using Climate Change Reference Calculator (CERC), additional policies from other studies were also proposed, without being simulated by the CGE model. The study also explored the case of late implementation and concurred with studies from other parts of the world: late action can cause devastating impacts and economic damage.

Turkish Industry and Business Association (TUSIAD) released a report entitled "Addressing Climate Change from An Economic Policy Perspective" after the INDC was submitted [47]. The report aimed to address the policy options for Turkey considering the relevant practices worldwide in the post-2020 period. A dynamic CGE model was formulated to measure potential economic effects of applying a tax to reduce emissions in Turkey under two scenarios created by the authors: A reference scenario including an energy tax for achieving the 21% reduction target and an alternative scenario including the energy tax accompanied by a reduction in other taxes, such as the tax on employment. The reference scenario reduced emissions by 21% but caused an 8.7% decline in national income; and the alternative scenario reduced emissions by 15.5% but caused a 3.7% decline in national income. Unfortunately, it was impossible to conduct another analysis for the Emissions Trading System due to lack of detailed carbon emissions data at the sectoral level and unsuitability of the theoretical basis for this kind of modelling. The study concluded by suggesting a comprehensive policy package consisting not only of implementing the ETS and/or neutral taxation but also of adopting new measures and technologies to increase energy efficiency, subsidies and practices to spread the use of renewables, and tax advantages for low-carbon products. The authors claimed that such a package would increase employment and provide incentives for investing in alternative technologies for the transition towards a low-carbon economy.

2.2. DECOMPOSITION METHODS LITERATURE IN CLIMATE CHANGE MITIGATION

In climate change mitigation, decomposition analysis shows us environmental and economic factors behind the change in greenhouse gas emissions in a period and determining the crucial factors help to make effective policies to reduce emissions. Grossman and Krueger [48] were the first to use a decomposition analysis for environmental studies in member countries of the North American Free Trade Agreement and concluded that economic growth ended to decrease pollution problems. Similarly, Torvanger [49] analyzed the change in emissions in the industrial sectors of nine OECD countries. This method was also applied to studies by the International Energy Agency [50].

The most used decomposition techniques are the Index Decomposition Analysis (IDA) and the Structural Decomposition Analysis (SDA). They have been developed independently and applied extensively in energy use and emissions. IDA is often applied by researchers who want to know about the drivers of energy use or emissions in an energy or emissions intensive sector, such as industry. SDA is used by researchers who wish to know the drivers behind increases in energy consumption or emissions in the whole economy by the way the method uses input-output tables as data.

These two methods are characterized by specific techniques and approaches as they have been developed quite independently. There are studies comparing the two methods, e.g. Ang and Zhang [51], Ang [52], Hoekstra and van der Bergh [53,54] and Su and Ang [55]. IDA method was applied more than SDA to understand the drivers in greenhouse gas emissions [56]. Although, its flexibility in formulation and need of a relatively less data than SDA, the IDA method covers only the direct effects, ignores the effects of the indirect and final demands which are named consumption perspective [57]. Recently, IDA has been employed to decompose changes in energy consumption, such as Tunç et al. [58], Oh et al. [59], Lin and Du [60], Xu and Ang [61], and Colinet and Román [62]; and in CO2 emissions, such as Lee and Oh [63], Lu et al. [64], Dong et al. [65], and Duarte et al. [66] among other topics.

SDA uses data from input-output Tables and SAMs and offers a broader range of information than IDA does. The typical SDA studies are able to provide a more detailed structural factors, such as the Leontief effect (or technical effect) [67] and can shape socio-economic drivers from both production and final demand perspectives. In other words, other decomposition methods than SDA do not allow researchers to analyze so deeply into the internal production linkages within an economy, thus can't help to see their implications on changes of greenhouse gas emissions [68].

Changes in CO2 emissions can be broken down into determinants such as energy intensity, emission intensity, production recipe (technology), final demand distribution (household, government, investment, and rest of world), final demand mix (shares of sectors), affluence, and population. Energy and emission intensity factors can be evaluated after adding these substances to SAM in physical amounts. The latter factors' impacts are calculated by decomposing the SAM accounts.

In the study of Su and Ang [55], the new methodological developments in SDA in 2000s were examined and the study came to a conclusion that the majority of the studies in that period dealt with decomposition of changes in energy consumption or emissions in a single country. However, the most recent studies have mostly been multi-region studies that investigate changes in emissions resulting from trade in a specific country or changes in global emissions resulting from international trade.

There have been many single-region SDA studies determining the drivers behind the changes of greenhouse gas emissions of a range of countries or regions, e.g. the study of Feng et al. [69] for the USA, the studies of Duan and Jiang [70], Gui et al. [71], Lin and Xie [72], Xiao et al. [73] for China, the study of Yamakawa and Peters [74] for Norway, the study of Brizga et al. [68] for the Baltic States, the study of Cansino et al. [75] for Spain, and the studies of Freitas and Kaneko [76] and Perobelli et al. [77] of Brazil. The multi-region SDA is based on multi-region input-output tables. It includes drivers behind greenhouse gas emissions, such as emission intensity, production recipe, and final demand but not limited to those, as it traces changes in international trade patterns of both intermediate and final products (see also Wiedmann [78]; Arto and Dietzenbacher [79], Malik and Lan [80]). The international trade does not only allow the separation of production and consumption of products and embodied emissions [81] but also allows to significant net growth of global CO2 emissions [79,80,82]. The most recent multi-region SDA studies are used to identify these impacts, such as Alcántara and Duarte [83], de Nooij et al. [84], Hasegawa [85], Baiocchi and Minx [86], Arto and Dietzenbacher [79], Malik and Lan [80], Jiang and Guan [87], Hoekstra et al. [82], Peters et al. [81].

Ediger and Huvaz [88] decomposed the primary energy use into production, structural and intensity factors in agriculture, industry and services sectors of the Turkish economy for the 1980-2000 period. They employed the additive version of the Log Mean Divisa Index (LMDI) method and concluded that significant variations occurred in the sectoral energy use during the 1982, 1988-1989, 1994 and 1998-2000 periods were mostly due to governmental policies. Lise [89] investigated the factors that explain CO2 emissions in Turkey for the period 1980-2003 upon the projections of the OECD and the UNDP and World Bank: OECD [90] projected 7% growth potential, and the UNDP and World Bank [91] projected six-fold emissions increase by 2025 with respect to 1990. The analysis concluded that the most effective factor in the rise of CO2 emissions was scale; carbon intensity and change in composition of the economy contributed at lower rates; but energy intensity was responsible for the modest reduction in CO2 emissions.

Tunç et al. [58] employed LMDI method to identify the factors that contribute to changes in CO2 emissions in 1970-2006 period. The authors divided Turkish economy into three sectors, agriculture, industry and services; and aggregated energy sources into four groups, solid fuels, petroleum, natural gas and electricity to determine impacts of changes in economic activity, activity mix, sectoral energy intensity, sectoral energy mix, and CO_2 emissions factors. They found economic activity and intensity are the main factors determining changes in CO_2 emissions. In the study of Akbostancı et al. [92], changes in CO_2 emissions of Turkish manufacturing industry which covers 57 sectors economic and fuel consumption data in 1995-2001 period, were decomposed into five components; changes in activity, activity structure, sectoral energy intensity, sectoral energy mix and emission factors by applying LMDI method. Total industrial activity and energy intensity were the primary factors determining the changes in CO_2 emissions in the manufacturing industry in the 1995-2001 period. It is also indicated that iron and steel basic industries; manufacture of cement, lime and plaster; manufacture of synthetic resins, plastic materials and manmade fibers except glass; and petroleum refineries sectors dominated the industrial CO_2 emissions in the Turkish manufacturing industry. Kumbaroğlu [93] decomposed Turkish CO_2 emissions in the 1990-2007 period year-by-year by the refined Laspeyres method. The author identified whether three factors, carbon intensity, emission intensity, and scale, accelerate or reduce emissions in electricity, manufacturing, transportation, building, and agriculture sectors. According to the results of the study, during the 1990-2007 period, scale factor was the major source of emissions growth in the electricity, manufacturing, and transportation sectors; energy intensity was the major source of emissions growth in household; both scale and energy intensity were the major sources of emissions growth in agriculture sector. The study concluded that energy intensity improvements and reducing carbon intensity in the manufacturing and transport sectors; compositional changes in electricity production towards natural gas and renewables; energy conservation measures, use of renewables, and behavioral changes in consumption in the building sector; and best practice farming methods in agriculture are prominent policies to reduce CO_2 emissions.

Unlike the previous modeling studies, emissions mitigation potentials of two national documents, the NCCAP and the INDC were examined over an Environmentally Extended SAM created for the year 2012. The goals in the NCCAP and INDC documents were transformed to policies as final demand shocks and Multiplier Analysis method was employed to analyze these policies. Because, these goals were direct expressions, such as utilizing all hydroelectric potential or reducing illicit use and losses in electricity distribution, and despite lack of measurability in general, these goals found to be more suitable to be expressed as final demand shocks. The NCCAP policies results helped to interpret the tenacity of Turkey in implementing climate policies by comparing the emissions mitigation potential of the NCCAP for the 2015 year with the actual emissions inventory in 2015. INDC policies results answered the question whether its own policies could achieve the 21% target. More conceivable alternative policies to the INDC policies were generated by the author and analyzed by Multiplier Analysis method. SAM multipliers were calculated, various policies to boost the economy were generated and their emissions performance were shown by employing Multiplier Analysis method as well. Additionally, alternative tax policies generated by the author and were examined by a static CGE model which was developed by the author in compliance with the actual Environmentally Extended SAM.

Another Environmentally Extended SAM for the year 2002 was created and drivers of greenhouse gas emissions increase between 2002 and 2012 years were determined by employing SDA method. Most papers use a reduced number of decomposition factors from a range of four or five [94], however, this study decomposed Turkish greenhouse gas emissions change into 5 effects: emission intensity (emission coefficient), intermediate input mix, final demand mix (shares of sectors), per capita expenditure, and population. After determining crucial factors of emissions increase, efficiency of the policies proposed by the study were examined.

CHAPTER 3: DATA: ENVIRONMENTALLY EXTENDED SAM

In order to assess the potential and the efficiency of mitigation goals, Turkish data was organized in the form of Environmentally Extended SAMs. Sectors were determined to correspond to the sectors in the National Inventory Reports (NIRs) and the sectors in the national climate change documents [5,6,32]. Two SAMs were constructed with data from different national economic statistics and extended to Environmentally Extended SAMs with emissions and other environmental data published by public institutions. The Environmentally Extended SAM construction steps are detailed in Table 1 and sectoral mapping is given in Table 2.

SAM is a representation of all socio-economic transactions in a matrix and provides a numeric definition of resource allocation of the economic cycle [95,96]. SAM is a two-entry accounting system, grounded on the principle of equal row and column totals. The rows of SAM show the income of accounts, columns show expenditures. In Table 3, SAM for an open economy is shown through five essential accounts: production activities, products, institutions, saving-investment and rest of world [97].

Data for the SAM were collected from different economic statistics published by public institutions. This study takes the two most recent Turkish input-output tables, 2002 and 2012, as base and uses 2002 and 2012 values of all other variables and indicators. The aggregate SAM was constructed and then balanced to determine the general structure of the actual SAM [98,99]. They are presented in Table 4 and Table 5.

Sectors in the SAM were determined by considering emissions potentials of them. After carefully reviewing the sectors in the last NIR document and the sectors in the national climate change documents [5,6,32], the sectors of the SAM were determined as: agriculture, coal mining, petroleum and natural gas extraction, food, coke and refined petroleum products, chemistry, mineral, metal, waste, railway transport, highway transport, water transport, air transport, industry, service, electricity from coal, electricity from petroleum, electricity from natural gas, electricity from hydropower, and electricity from renewable resources. Subsequently, a sectoral mapping between these sectors and the sectors in the input/output table was generated, and the requisite aggregation and disaggregation operations were determined.

The above sectors were also grouped into the following main sectors: agriculture, energy, industry, transportation, and waste. The main sectors were included to ease generation of policies because the goals in the NCCAP and INDC documents had been grouped into these main sectors. The main sectors are also listed in the sectoral mapping.

The SAM was constructed following the steps described in the literature, and all the steps are given in detail in Table 1.

The SAM was then transformed into an Environmentally Extended SAM. Environmentally Extended SAM is an extension of SAM consisting of economic and environmental activities in a unique framework. Environmentally Extended SAM is necessary because SAM ignores the relationship between the environment and the economy. Transformation is usually done by adding three types of accounts: substances, depletable resources, and environmental themes. The Environmentally Extended SAM constructed for 2012 year includes greenhouse gases as substances, hard coal and lignite as depletable resources, and total inventories of greenhouse gases in CO2 eq. unit as environmental themes. This Environmentally Extended SAM was prepared for Multiplier Analysis and CGE methods. In the 2002

Environmentally Extended SAM, coal data was excluded as this data was only used for determining drivers of emissions by employing SDA method. In line with common practices, the SAM accounts are in monetary units and the environmental accounts are in physical units.

Table 1. Environmentally Extended SAM construction steps

Step	SAM
1	An aggregate SAM was constructed by gathering data from different economic statistics published by public institutions [98,99,100,101]
2	Sectors were determined by reviewing the sectors in the last NIR document [6] and the sectors in the national climate change documents [5,32].
3	A sectoral mapping between the sectors determined by the Author and the sectors in the input-output table was generated. Some sectors in the input-output matrix were aggregated, some of them were disaggregated.
3.1	Aggregation was simple, it was sum of the related sectors.
3.2	Disaggregation was applied to "mining and quarrying", "land transport services and transport services via pipelines" and "electricity, gas, steam and air conditioning" sectors in the input-output table.
3.2.1	Mining and quarrying sector in the input-output table was disaggregated into coal mining; petroleum, natural gas extraction; and other mining sectors according to production values in the TurkStat's Annual Industry and Service Statistics prepared in NACE rev 2 classification [102,103,104,105,106].
3.2.1	Land transport services and transport services via pipelines sector in the input-output table was disaggregated into highway and railway transport sectors according to production values in the TurkStat's Annual Industry and Service Statistics prepared in NACE rev 2 classification [102,103,104,105,106].
3.2.1	Electricity sectors were obtained by disaggregating electricity, gas, steam and air conditioning sector in the input-output table. But, as Nace rev 2 does not distinguish among resources of electricity, this time TurkStat's Annual Industry and Service Statistics could not be used. Electricity Generation and Shares by Energy Resources statistic was used to disaggregate electricity sectors [107]. As these statistics give only shares based on production amounts, these shares were used to disaggregate electricity sectors in all parts of the SAM; input-output shares, labor and capital accounts, taxes, import, and all final demand accounts.
4	The sectors were grouped into the main sectors as in the national documents: agriculture, energy, industry, transportation, waste.
5	The aggregate SAM was disaggregated into the sectors.
5.1	Intermediate inputs, expenditures made for labor and capital, export and import values were taken directly from the input-output tables of TurkStat [98, 100].
5.2	Indirect and direct taxes were taken from the Consolidated Budget Revenues table of General Directorate of Budget and Fiscal Control [99, 101].
5.3	Household consumption, government expenditure, and investment values were taken from the input-output table but as row and column totals of production account did not amount to the same, the total difference was allocated among these accounts according to their shares.
5.4	Household savings was calculated by subtracting total household expenditure and direct taxes from household income.

5.5	Foreign savings was taken as the difference between imports and exports.
5.6	Government borrowing was calculated by subtracting government expenditure from government income.
	Environmentally Extended SAM
6	Hard coal and lignite reserves were put in columns of these resources and row of coal mining sector; use amounts in 2012 were taken from TurkStat Solid Fuel Statistics Press Releases [108-111] and put in rows of these resources and columns of coal-using sectors and household.
7	CO_2, N_2O, CH_4, HFCs, PFCs, SF_6 and NF_3 gases' inventories were taken from the National Inventory Report 2016 of Turkey for the year 2002 and 2012 [6] and were put in columns of these gases and rows of the sectors. Rows of these gases were left blank.
8	The column of environmental theme account includes gross greenhouse gas emissions of the sector in CO_2 eq. unit. The column total of this account is equal to Turkey's total GHG inventory. This total was put in the cell in intersection of environmental theme and capital accounts, as is usually done in an Environmentally Extended SAM. This total is treated as a natural capital in economy.

Table 2. Sectoral mapping

Sectors in input-output table 2012 and in NACE rev.2	Sector	Main sector
Products of agriculture, hunting and related services	agriculture	agriculture
Products of forestry, logging and related services		
Fish and other fishing products; aquaculture products; support services to fishing		
Mining and quarrying	na (dissagregated to "coal mining"+"petroleum,nat.gas extraction"+"mining (excluding coal,nat.gas and petroleum")	
Coal and lignite mining (NACE rev.2)	coal mining	energy
Extraction of crude petroleum and natural gas (NACE rev.2)	petroleum, nat.gas extraction	
Coke and refined petroleum products	coke,refined petroleum	
Electricity, gas, steam and air conditioning	na (dissagregated to "elec.coal"+"elec.pet."+"elec.nat.gas"+"elec.hydro"+"elec.renew")	
na (not existing in input-output or NACE rev.2)	elec.coal	
na (not existing in input-output or NACE rev.2)	elec.pet.	
na (not existing in input-output or NACE rev.2)	elec.nat.gas	
na (not existing in input-output or NACE rev.2)	elec.hydro	
na (not existing in input-output or NACE rev.2)	elec.renew	
Food, beverages and tobacco products	food	industry
Chemicals and chemical products	chemistry	
Basic pharmaceutical products and pharmaceutical preparations		
Rubber and plastic products		
Other non-metallic mineral products	mineral	
Basic metals	metal	
Mining support service activities+ Other mining and quarrying+ Mining of metal ores (NACE rev.2)	industry	
Textiles, wearing apparel, leather and related products		

Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	
Paper and paper products	
Printing and recording services	
Fabricated metal products, except machinery and equipment	
Computer, electronic and optical products	
Electrical equipment	
Machinery and equipment n.e.c.	
Motor vehicles, trailers and semi-trailers	
Other transport equipment	
Furniture and other manufactured goods	
Repair and installation services of machinery and equipment	
Natural water; water treatment and supply services	
Constructions and construction works	
Wholesale and retail trade and repair services of motor vehicles and motorcycles	service
Wholesale trade services, except of motor vehicles and motorcycles	
Retail trade services, except of motor vehicles and motorcycles	
Warehousing and support services for transportation	
Postal and courier services	
Accommodation and food services	
Publishing services	
Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services	
Telecommunications services	
Computer programming, consultancy and related services; Information services	
Financial services, except insurance and pension funding	

Insurance, reinsurance and pension funding services, except compulsory social security
Services auxiliary to financial services and insurance services
Real estate services excluding imputed rents
Imputed rents of owner-occupied dwellings
Legal and accounting services; services of head offices; management consulting services
Architectural and engineering services; technical testing and analysis services
Scientific research and development services
Advertising and market research services
Other professional, scientific and technical services and veterinary services
Rental and leasing services
Employment services
Travel agency, tour operator and other reservation services and related services
Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services
Public administration and defence services; compulsory social security services
Education services
Human health services
Residential care services; social work services without accommodation
Creative, arts, entertainment, library, archive, museum, other cultural services; gambling and betting services
Sporting services and amusement and recreation services
Services furnished by membership organisations

Repair services of computers and personal and household goods		
Other personal services		
Services of households as employers; undifferentiated goods and services produced by households for own use		
Land transport services and transport services via pipelines	na (disaggregated to highway transport and railway transport)	
Other passenger land transport + Freight transport by road and removal services + Transport via pipeline (NACE rev.2)	highway transport	transportation
Passenger rail transport, interurban + Freight rail transport (NACE rev.2)	railway transport	
Water transport services	water transport	
Air transport services	air transport	
Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other waste	Waste	waste

Table 3. Basic Social Accounting Matrix (SAM) structure for an open economy

	Activities	Products	Institutions	Saving-Investment	Rest of World	Total
Activities		Domestic supplies (DC)				Total supply
Products	Intermediate inputs (INT)		Consumption (C)	Investment (I)	Export (X)	Total demand of products
Institutions	National Income (Y)					National income
Saving-investment			Savings		Foreign savings (M-X)	Total savings
Rest of World		Import (M)				Rest of world income
Total	Production cost	Total supply of products	National income	Total investment	Rest of world expenditure	

Source: Adapted from Erten [97].

Table 4. 2002 Aggregated SAM

		Production	Factors of Production		Household	Government	Saving/Investment	Rest of world	Total
			Labor	Capital					
Production		329,918,517			249,024,673	47,977,676	66,102,143	64,538,368	757,561,377
Factors of production	Labor	92,431,093							92,431,093
	Capital	211,170,724							211,170,724
Household			92,431,093	211,170,724					303,601,817
Government		39,551,165			20,077,498				59,628,663
Saving/Investment					34,499,646	11,650,987		19,951,510	66,102,143
Rest of world		84,489,878							84,489,878
Total		757,561,377	92,431,093	211,170,724	303,601,817	59,628,663	66,102,143	84,489,878	

Source: Compiled from Turkstat [98]; General Directorate of Budget and Fiscal Control [99].

Table 5. 2012 Aggregated SAM

		Production	Factors of Production		Household	Government	Saving/Investment	Rest of world	Total
			Labor	Capital					
Production		1,490,848,056			1,019,043,334	241,346,560	425,512,803	322,634,496	3,499,385,249
Factors of production	Labor	438,577,769							438,577,769
	Capital	941,948,340							941,948,340
Household			438,577,769	941,948,340					1,380,526,109
Government		179,686,122			63,502,297				243,188,419
Saving/Investment					297,980,477	1,841,858		125,690,468	425,512,803
Rest of world		448,324,964							448,324,964
Total		3,499,385,250	438,577,769	941,948,340	1,380,526,108	243,188,419	425,512,803	448,324,964	

Source: Compiled from Turkstat [100]; General Directorate of Budget and Fiscal Control [101]

Coal, petroleum, natural gas and land are usually added to Environmentally Extended SAMs as depletable resources, but of these, this study includes only coal in this account because Turkey is very poor in petroleum and natural gas resources. It has a small amount of hard coal and a significant amount of lignite coal reserves. However, lignite coals in the country has low-calorific values. The reports by the Turkish Hard Coal Enterprise Institution [112] and by the Turkish Coal Enterprises Institution [113] state that Turkey has 1.3 billion tons of hard coal and 14.1 billion tons of lignite coal reserves. The report of the Turkish Coal Enterprises [114], states that calorific values of the reserves are between 1000 kcal/kg and 4200 kcal/kg, and 90% of the reserves have lower values than 3000 kcal/kg. The report also states that Turkish lignite reserves are more appropriate for electricity production due to their calorific values. Kara [115] determines the future of lignite reserves in Turkey as ambiguous, as costs are too high to compete with imported coal and they have high greenhouse gas emissions levels. He claims that they will be an option in the future only if coal, petroleum and natural gas prices increase altogether and new plants are established which are environmentally friendly and highly compatible with local reserves. Nevertheless, Turkey is already building new coal-fired electricity plants and will continue to build as stated in the development plans of the Ministry of Development and the strategy documents of the Ministry of Environment and Urban Planning. It wants to reduce foreign dependency by utilizing all domestic coal reserves. Accordingly, coal use and reserves were added to this study. Land is another depletable resource generally included in Environmentally Extended SAMs, but is excluded in this study, as the INDC target omitted Land Use and Land Use Change (LULUCF) emissions.

In the environment, there exist different types of substances which cause damage to natural resources basically in the form of pollution of air, water, and soil. This study, however, included only greenhouse gases as substances. The gases included are CO_2, N_2O, CH_4, HFCs, PFCs, SF_6 and NF_3.

The column of environmental theme account shows sector specific gross greenhouse gas emissions of Turkey in CO_2 eq. unit. The column total of this account is equal to Turkey's total GHG inventory. The 2002 Environmentally Extended SAM is given in Appendix A, 2012 is given in Appendix B.

CHAPTER 4: ASSESSMENTS OF NCCAP AND INDC DOCUMENTS AND PROPOSING CONCEIVABLE POLICIES BY MULTIPLIER ANALYSIS

The most convenient way to transform a SAM into a model is to assume that all relations are linear, and to take prices as constant. In this way, SAM can be used to analyze impacts of shocks given to exogenous variables. This method is known as SAM Multiplier Analysis, an extension of Input-Output Analysis. SAM multiplier analysis helps to determine impacts of policies which were defined as final demand shocks.

4.1. METHOD: MULTIPLIER ANALYSIS AND MULTIPLIERS

Recent literature suggests that CGE models are the method of choice in climate change modeling in Turkey. However, in this chapter, SAM Multiplier Analysis was employed instead. The reason was that the goals in the national documents were more amenable to being treated as final demand shocks than to being defined with other economic tools such as taxes/subsidies, quotas or price ceilings/floors which are applied in CGEs.

Another important point is that while SAM Multiplier Analysis is for simulating short run adjustments, in this study, the method is also used to simulate the goals in the INDC document which were planned for 2030. For the goals stated as ratios, targeted ratios were compared with existing ratios in 2012, and differences were applied as shocks. For the goals given in values not ratios, existing values in 2012 were updated to 2030 by using the growth rate in the INDC document, then targeted values were compared with these updated values and the differences were applied as shocks. Thus, without updating the SAM to 2030, goals were transformed to shocks, and SAM Multiplier Analysis was applied for long term in good faith and with confidence.

As for choosing SAM Multiplier Analysis over Input-Output method, SAM is regarded as a more thorough methodology because a traditional input-output model focuses on flows among actors involved in production but a SAM also includes the interdependence of production with the rest of society [116-117]. Traditional Input-Output multiplier analysis takes two forms: open and closed. The open model is criticized for underestimating the regional economic impacts because keeping households exogenous to the model omits the impact of households' spending of wage income as a result of the change in final demand for an industry's output [118-120]. In closed form, household consumption (in column) and labor income (in row) are included in the endogenous matrix, so in the Leontief inverse. Such an inclusion solves the problem above and provides a square invertible matrix, but it is not a consistent approach as incomes from capital and other factors which belong to households are not included in the endogenous matrix. In contrast, SAM includes all factor accounts and the household account in the endogenous matrix more properly.

The main limitation of SAM Multiplier Analysis is that it allows changes only in exogenous accounts. Closure of the SAM (definition of endogenous accounts) in the most appropriate manner is key in this method. Different closure rules were adopted by scientists in previous studies, i.e., Sánchez Chóliz and Duarte [121] described an alternative approach that defining only the household as exogenous account and examining the economic system impacts resulting from changes in household consumption behavior. In this study, the inter-industry transaction submatrix was closed to contain all the necessary behavioral and technical relationships of the economic system in a consistent manner. The exogenous accounts were composed of the government, saving-investment, and exports. Another rationale was that these accounts are commonly used policy tools in an economy; government expenditure is used as a direct policy tool, and export and saving-investment are used as indirect policy tools. This allowed changes only in these accounts so only these were subject to shocks. However, the goals in the national climate change documents of Turkey cover the entire economy which necessitate shocks over total final demand including household consumption. Thus, the effects of the shocks could be higher.

Developing the predictive SAM model starts with determining exogenous accounts in an attempt to examine impacts resulting from different final demand accounts. Defining the endogenous transactions as production, factors of production, and households helps to focus on the interaction between two sets of agents (production activities and households) interacting through two sets of markets (factors and commodities) [122]. This structure was followed in this study; production, labor, capital, and household accounts of the SAM were set as endogenous; government, saving-investment, and rest of world accounts were set as exogenous.

A SAM along these lines is presented in Table 6.

Table 6. Aggregated industry by industry SAM layout

Receipts	Expenditures			
		Endogenous Accounts Industry, Factors, Household	Exogenous accounts Government, Saving-investment, Rest of world	Total
Endogenous accounts	Industry Factors Household (i,j)	S	F	x^d
Exogenous accounts	Government Saving-investment Rest of world (u,v)	M	G	xe^d
	Totals	x^{sT}	xe^{sT}	

Source: Adapted from Martinez de Anguita and Wagner [120]

Table 7. Endogenous accounts of an aggregated SAM -the transaction matrix (S)

Receipts	Expenditures			
		Industry	Factors	Household
	Industry	S_{11}	0	S_{13}
	Factors	S_{21}	0	0
	Household	0	S_{32}	0

Source: Adapted from Martinez de Anguita and Wagner [120]

The endogenous account, S, of Table 6 is composed of the inter-industry transaction matrix, S_{11}, value added matrix, S_{21}, distribution matrix, S_{32}, and consumption of household vector, S_{13}, accounts; these are represented in Table 7. The final demand matrix, F, which defines the exogenous account, is composed of the government and saving-investment components of the institution account and exports. The matrix, M, in Table 6 defines the exogenous accounts. It is composed of the government and saving-investment components of the institution accounts and import receipts. Finally, the intersection of the column and row vector exogenous accounts gives a matrix, G, denoting transshipments.

In order to assess the mathematics implied by these matrices, let x^d be a column vector of the sum of the row elements of the industry, factors and household, and x^{sT} is the row vector of the sum of the column elements in the industry, factors and household accounts. x^{sT} is the transpose of x^d. xe^d is the column vector of the sum of the row elements of the government, saving-investment and rest of world accounts, and xe^{sT} is the row vector of the sum of the column elements in the same accounts. xe^{sT} is once more the transpose of xe^d.

$$x_i^d = \sum_j S_{ij} + \sum_v F_{iv}$$

$$xe_u^d = \sum_j M_{uj} + \sum_v G_{uv}$$

$$x^{sT} = x^d$$

$$xe^{sT} = xe^d$$

The interindustry transactions are defined by matrix S_{nxn}. The column vector of final demands (f_{nx1}) is calculated using Equation (1):

$$\begin{bmatrix} F_{1G} F_{1In} e_1 \\ . \quad . \quad . \\ . \quad . \quad . \\ . \quad . \quad . \\ F_{nG} F_{nIn} e_n \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = f \qquad (1)$$

and the total output by industry is defined as the nx1 column vector x^d. As can be seen by equation (1), the final demand vector will include exports. The output is sold to other industries as inputs into their production process; to final consumption by government, private investment, or to exports.

$$\sum_j S_{1j} + f_1 = x_1^d \qquad (2)$$

The total output of industries in terms of sales or receipts can be written in matrix notation as:

$$S\begin{bmatrix}1\\ .\\ .\\ .\\ 1\end{bmatrix}+f=\begin{bmatrix}x_1^d\\ .\\ .\\ .\\ x_n^d\end{bmatrix}=x^d \qquad (3)$$

The problem with equation (3) is that it is descriptive but not predictive. To convert equation (3) into a predictive model, the changes in final demand must be tied to changes in production. Leontief [123] accomplished this by using the transactions matrix, S, whose column elements, S_{ij}, show the flow from industry i to industry j and assuming constant returns to scale. That is, if the amount of the output that an industry produces doubles, x^d_j, they must use twice the amount of inputs, S_{ij}, for i=1,2,…,n. This allows the amount of input use to be tied directly to the amount of output produced. Mathematically, constant returns to scale imply a ratio of input to output or S_{ij}/x^d_j. This ratio is called a technical coefficient and is denoted as a_{ij}:

$$a_{ij}=\frac{S_{ij}}{x_j^d} \qquad (4)$$

or in matrix notation as:

$$A=S(X^d)^{-1} \qquad (5)$$

where $(X^d)^{-1}$ denotes a diagonal matrix whose diagonal elements are defined as the total output of each industry, x^d_j. The jth column of the technical coefficient matrix, A, defines the jth industry's production function. The assumptions of constant returns to scale imply that production technology is held constant. Given equation (5), it can be shown that:

$$Ax^d = S \begin{bmatrix} 1 \\ . \\ . \\ . \\ 1 \end{bmatrix}$$

$$Ax^d + f = x^d$$

$$f = x^d - Ax^d$$

$$f = (I-A)x^d$$

$$x^d = (I-A)^{-1} f$$

$$\Delta x^d = (I-A)^{-1} \Delta f \qquad (6)$$

where I denotes the identity matrix and Δ denotes a change. Equation (6) can be used to predict the change in the output, Δx^d, given a change in final demand, Δf. The $(I-A)^{-1}$ term is called the Leontief inverse.

After stating how the change in the output is calculated, change in pollutants and depletable resources can be calculated as follows:

$$\Delta d = D(I - A)^{-1} \Delta f = D \Delta x^d \qquad (7)$$

$$\Delta p = P(I - A)^{-1} \Delta f = P \Delta x^d \qquad (8)$$

where D is a matrix defining the depletable resource amount used to produce 1.00 monetary unit output of ith sector, P is a matrix defining pollutant amount released to environment by producing 1.00 monetary unit output of ith sector.

The economic impacts calculated by the Leontief inverse can be measured in terms of direct, indirect, and induced effects. Direct effects are production changes associated with the immediate effects of final demand changes. For example, a change in the demand for agriculture would cause the farmer to produce more output. Indirect effects are production changes in backward-linked industries caused by the changing input needs of directly affected industries. For example, the agriculture sector would demand more fertilizer, electricity, and road transport, causing an increase in production from these industries. Induced effects are the changes in household consumption caused by changes in employment generated from the direct and indirect effects. The change in final demand would cause income and employment to increase, and trigger consumption in the economy in general. For example, the induced effect would include the purchases of newly employed due to increase in agricultural production. These effects can be obtained by decomposing SAM Accounting Multiplier which is explained below, however these impacts are more appropriate for analyzing sector specific effects than macroeconomic indicators. There are three general economic impacts that are of most concern: (1) output; (2) employment (wage related); and (3) value added (or income or GDP). Multipliers are basically a ratio of total impacts to initial impacts. Total impacts are defined as direct plus indirect plus induced. All multipliers are derived from the Leontief inverse, $(I\text{-}A)^{-1}$.

Table 8. SAM multiplier classifications

Multiplier	Notation	Total effect	Direct effect
Accounting multiplier			
SAM-Accounting	AC		
Industry account multiplier			
SAM-output/output	O/O	Output	Output
SAM-income/output	I/O	Income	Output
SAM-value added/output	VA/O	Value added	Output
SAM-employment/output	Emp/O	Employment	Output

Source: Adapted from Martinez de Anguita and Wagner [120]

SAM accounting multiplier: The jth sector's SAM accounting multiplier, $SAM^{(AM)}{}_{j}$, is calculated by summing the columns of the Leontief inverse, $((I\text{-}A)^{-1})_{ij}$:

$$\text{SAM}_j^{AM} = \sum_i ((\text{I-A})^{-1})_{ij} \text{ ; for all j} \qquad (9)$$

Thus, a SAM accounting multiplier is calculated for each sector, primary factor of production, household.

SAM output/output multiplier: The most basic multiplier is the output/output multiplier or just output multiplier. A SAM output/output multiplier, $SAM^{(O/O)}{}_j$, for the jth industry is given by equation (10):

$$\text{SAM}_j^{(OO)} = \sum_{i=1}^{n} ((\text{I-A})^{-1})_{ij} \text{ ; j=1,...,n} \qquad (10)$$

where i,j = 1, . . . ,n denote the n sectors and $((I\text{-}A)^{-1})_{ij}$ denotes an element of the SAM's accounting multiplier matrix. This multiplier defines the total value (direct plus indirect plus induced effect) of production from all the sectors of the economy that is necessary in order to satisfy one monetary unit worth of final demand for industry j's output. The direct effect, as before, is defined as 1.00 monetary unit.

SAM employment/output multiplier: Let ω^T denote a 1xn row vector given by equation (11):

$$\omega^T = \left[\frac{w_{L1}}{x_1} \ \cdots \ \frac{w_{Ln}}{x_n}\right] \qquad (11)$$

where w_{Lj} denotes the wage payments by the jth sector. A SAM income/output multiplier, $SAM^{(I/O)}{}_j$, for the jth sector is given by equation (12):

$$\text{SAM}_j^{(IO)} = \sum_{i=1}^{n} \omega_i \, ((\text{I-A})^{-1})_{ij} \text{ ;j=1,...,n} \qquad (12)$$

where i,j = 1, . . . ,n denote the n sectors, ω_i denotes the ith element of the ω^T 1 × n row vector given by equation (11), and $((I-A)^{-1})_{ij}$ denotes an element of the SAM's accounting multiplier matrix. This multiplier defines the total value (direct plus indirect plus induced effect) of wage income generated from all the economy's sectors that is necessary in order to satisfy one monetary unit worth of final demand for sector j's output. The direct effect, as before, is defined as 1.00 monetary unit.

SAM value-added/output multiplier: Value-added/output multiplier, $SAM^{(VA/O)}{}_j$, for the jth sector is given by equation (13):

$$SAM_j^{VAO}=\sum_{i=1}^{n} \upsilon_i((I-A)^{-1})_{ij} \;\; ;j=1,...,n \qquad (13)$$

where i,j = 1, . . . ,n denote the n sectors, υ_i denotes the ith element of the υ^T 1 × n row vector given by the following equations (14) and (15):

$$[s_{21}]^T=[1...1]S_{21} \qquad (14)$$

$$\upsilon^T=\left[\frac{(s_{21})_1}{x_1^d} \;\; \frac{(s_{21})_2}{x_2^d} \;\; ... \;\; \frac{(s_{21})_n}{x_n^d}\right] \qquad (15)$$

and $((I-A)^{-1})_{ij}$ denotes an element of the SAM's accounting multiplier matrix. This multiplier defines the total value added generated (direct plus indirect plus induced effect) from all the region's industries that is necessary in order to satisfy one monetary unit worth of final demand for sector j's output. The direct effect, as before, is defined as 1.00 monetary unit.

4.2. NATIONAL DOCUMENTS POLICIES, ALTERNATIVE POLICIES, AND RESULTS OF THE ANALYSIS

Six simulation categories were created: NCCAP, INDC, emissions decreasing, developmental, GDP increasing, and employment increasing. The primary aim of the NCCAP, INDC, and emissions decreasing simulations was emissions mitigation. The NCCAP simulations were conducted to investigate the emissions and economic effects of this document. The INDC simulations were conducted for the INDC document. Emissions decreasing simulations were the author's own policies presented as alternatives to the INDC's. The goals in the NCCAP and the INDC were interpreted as efficiency or transition to low carbon economy policies and emissions decreasing simulations were in accordance with this interpretation. In these three simulation categories, two types of shocks were applied: "increasing efficiency" and "transferring volume". Increasing efficiency type shocks were planned as decrease shocks where the same amount of output could be obtained with less input. This led to a decline in emissions and coal use, since less input was used, but no shrinkage in the economy, as the same amount of output was produced. In these simulations, changes in emissions, hard coal use and lignite use were taken into consideration, but changes in output, employment, and GDP were ignored. In fact, increasing efficiency arises from technological development and necessitates changes in input-output (technical) coefficients. Pal and Pohit [1240 **68] decreased the technical coefficient of related input in the event of an efficiency increase and added this share to the capital input. However, to avoid complicating the model further, the technical coefficients were not changed in this study. Transferring volume type shocks reallocated output from high emitting to low emitting sectors for transition to a low-carbon economy. When substitution between transferring and receiving sectors was very low, it was assumed that excess demand in the transferring sector could be met by imports, and excess supply in the receiving sector could be sold to the government and to the rest of world. In this type of shocks, changes in output, employment and GDP were taken into account together with changes in emissions and coal use.

The essential aim of developmental, employment increasing, and GDP increasing simulations was increasing gross output, employment, and GDP respectively. These three simulation categories were created by the author according to output, employment and GDP multipliers calculated from the SAM. The multipliers are given in Table 9. In these three simulation categories, two types of shocks were applied: "increasing efficiency" and "transferring volume". Increasing efficiency type shocks were planned as increase shocks, where more output could be obtained with the same amount of input. This resulted in economic growth since more output was produced but did not change emissions level or coal use amounts since the same amount of input was used. This time, changes in emissions, hard coal use and lignite use were ignored but changes in output, GDP, and employment were taken into consideration. Transferring volume types shocks reallocated output from sectors in the zero or low multiplier categories to sectors in the high or very high multiplier categories. When substitution between transferring and receiving sectors was very low, it was assumed that excess demand in the transferring sector could be met by imports, and excess supply in the receiving sector could be sold to the government and to the rest of world. Changes in all six indicators; emissions, hard coal use, lignite use, output, employment, and GDP were taken into account.

Treating efficiency differently in emissions mitigation policies and economic growth policies and achieving transition to low carbon economy via transfers from high to low emitting sectors may be appraised as useful approaches for other studies.

Table 9. Multipliers calculated from the Extended Social Accounting Matrix.

	Agriculture	Coal Mining	Petroluem, Natural Gas Extraction	Food	Coke, Refined Petroleum	Chemistry
Accounting multipliers	7.57	2.91	2.91	7.73	3.23	4.16
Output/output multipliers	3.88	1.86	1.86	4.29	2.27	2.64
Employment/Output multipliers	0.37	0.16	0.16	0.45	0.14	0.25
Value added/output multipliers	1.85	0.52	0.52	1.72	0.48	0.76

	Mineral	Metal	Waste	Railway transport	Highway transport	Water Transport
Accounting multipliers	6.58	4.3	4.38	6.82	6.87	7.04
Output/output multipliers	3.79	2.82	2.57	3.7	3.71	3.8
Employment/Output multipliers	0.44	0.22	0.26	0.36	0.39	0.45
Value added/output multipliers	1.4	0.74	0.9	1.56	1.58	1.62

	Air transport	Industry	Service	Elec.coal	Elec.pet.	Elec.nat.gas
Accounting multipliers	5.36	5.76	7.75	7.37	7.37	7.37
Output/output multipliers	3.2	3.38	3.97	4.64	4.64	4.64
Employment/Output multipliers	0.4	0.37	0.65	0.38	0.38	0.38
Value added/output multipliers	1.08	1.19	1.89	1.36	1.36	1.36

	Elec.hydro	Elec.renew.	Labor	Capital	Household
Accounting multipliers	7.37	7.37	7.24	7.24	6.24
Output/output multipliers	4.64	4.64	-	-	-
Employment/Output multipliers	0.38	0.38	-	-	-
Value added/output multipliers	1.36	1.36	-	-	-

Source: Author's calculations.

Shocks were exogenous final demand shocks, as multiplier analysis is a method calculating output change arising from a change in exogenous final demands; namely government expenditure, investment, and export in this model. Shocks results could be summed, multiplied, or divided, and proposed as policy mixes. An identifying number was given to each shock and changes in emissions, output, employment, GDP, hard coal use, and lignite use (six indicators) were calculated. Shocks and their results are given in tables in each subheading. Detailed explanations of shocks are given in Appendix C.

4.2.1. NCCAP Policies

To evaluate the implementation performance of previous emissions policies of the Turkish Government, all of the following recent documents were examined: Turkey's Strategic Vision 2023, 10th Development Plan, New Investment Incentive Plan, Input Supply Strategy and Action Plan, Energy Efficiency Strategy Paper, Electricity Market and Security of Supply Strategy Paper, and the most recent strategy papers of the Ministry of Environment and Urbanization, the Ministry of Energy and Natural Resources, the Ministry of Development, the Ministry of Industry and Trade, and the Ministry of Science, Industry and Technology. Some of these documents did not include any emissions mitigation policies or goals and many of those did, did not have measurable ones. The few documents with measurable policies and goals presented further challenges for scenario analysis. Emissions targets and policies could not be aggregated into one sector, and also, they were in various units, not monetary units. Furthermore, these documents gave different years of completion for some of the same targets. Only the National Climate Change Action Plan (NCCAP) included appropriate emissions mitigation goals and was comprehensive; therefore, this document was taken as the basis for evaluating the performance of emissions mitigation policies of the previous documents. NCCAP simulations category was created. All of the goals in the

NCCAP were examined, and measurable goals were transformed into shocks. Before that, the goals which had a different deadline than 2015 were revised for 2015, demoted to 2015. In this way, simulation results could be compared with the existing emissions inventory in 2015. The reader is referred to Appendix C for detailed information about transforming the NCCAP goals to shocks.

Five of the seven main sectors in the NCCAP document were included. Forestry was left out of this study as it is a LULUCF sector. Building was also excluded due to lack of separate data for public, private, and residential buildings. In addition, residential buildings were high in number, therefore, the building sector should have been evaluated within consumer side, rather than producer side. Eight shocks were generated from the NCCAP goals. Shocks and their results are given in Table 10.

Table 10. National Climate Change Action Plan (NCCAP) policies and results

Sector	Policy for 2015	Shock Number	Change of Total Greenhouse Gas Inventory (%)	Change in Employment (%)	Change in GDP (%)	Change in Output (%)	Change in Hard Coal Use (%)	Change in Lignite Use (%)
ENERGY	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of primary energy sectors (coal mining; petroleum and natural gas extraction; manufacturing of coke and refined petroleum) with an aim of reducing primary energy intensity.	NCCAP 01	−0.09	na	na	na	−0.05	−0.06
	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of all electricity producing sectors with an aim of increasing efficiency.	NCCAP 02	−0.63	na	na	na	-0.83	−1.79
	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from coal electricity sector to hydro electricity sector at a rate of 16.3% of total electricity exogenous final demand with an aim of increasing clean energy in energy production.	NCCAP 03	−0.82	0.00	0.00	0.00	−2.18	−4.92
	INCREASING EFFICIENCY TYPE SHOCK: A decrease shock in all electricity sectors at a rate of 2.18% with an aim of reducing losses and illicit use in electricity distribution.	NCCAP 04	−0.14	na	na	na	−0.18	−0.39

TRANSPORTATION	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to railway transport at a rate of 10% of highway transport exogenous final demand with an aim of ensuring balanced utilization of transport modes.	NCCAP 05	−0.22	−0.05	−0.01	0.00	0.00	0.00
	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to water transport at a rate of 10% of highway transport exogenous final demand with an aim of ensuring balanced utilization of transport modes.	NCCAP 06	−0.30	0.08	0.02	0.01	0.00	0.02
	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to railway transport at a rate of 20% of highway transport exogenous final demand with an aim of ensuring balanced utilization of transport modes.	NCCAP 07	−0.44	−0.09	−0.02	0.00	0.00	−0.01
WASTE	INCREASING EFIICIENCY TYPE SHOCK: A 10% decrease in all waste amount with an aim of ensuring effective waste management.	NCCAP 08	−0.05	na	na	na	−0.02	−0.02
Total			−2.69	−0.06	−0.01	0.01	−3.25	−7.16

Source: Compiled from NCCAP document [32] and author's calculations.

The first four shocks were in the energy main sector. Primary energy efficiency shock, NCCAP01, caused minute reductions in emissions and coal use. Electricity efficiency shock, NCCAP02, resulted in significant declines in emissions level and coal use. Transfer shock from fossil electricity sectors to the hydro electricity sector, NCCAP03, aimed to utilize entire technical and economic potential for hydroelectric energy. It provided the biggest emissions reduction among other shocks and was far better in coal use also. NCCAP04 which foresees reducing losses and illicit use in electricity distribution, performed better in emissions mitigation and coal use than NCCAP01 but fell short compared to the other two scenarios.

NCCAP05, NCCAP06, NCCAP07 shocks were applied in the transport main sector as transfer shocks. NCCAP05 and NCCAP07 were the same transfers, transfers from highway to railway transport, but they were in different amounts. They both decreased emissions and caused very small declines in employment and GDP. NCCAP06, a transfer from highway to water transportation, decreased emissions but increased employment, GDP, and output very slightly.

NCCAP08 was the only shock in the waste sector, a 10% decrease in waste amount. Emissions decrease amounted to 0.05%, hard coal use and lignite use decreased at same rates, 0.02%.

Total emissions reduction obtained from NCCAP simulations was 2.69%. Employment decreased at a rate of 0.06%; GDP decreased at a rate of 0.01%; and output increased at a rate of 0.01%. Decrease in coal use was greater than in emissions, hard coal and lignite use decreased at rates of 3.25% and 7.16%, respectively. Consequently, if Turkey had applied the NCCAP policies between 2012 and 2015, emissions level in 2015 would be 436.82 Mt CO_2 eq., 2.69% less than the existing 2012 level, 448.9 Mt CO_2 eq. However, the actual figure was 475.1 Mt CO_2 eq., 5.84% more than the 2012 level. It can therefore be considered that in the 2012-2015 period, the application of NCCAP policies failed to reach expectations.

4.2.2. INDC Policies

In the INDC simulations, measurable goals in the Turkish INDC document were determined and transformed into final demand shocks. Many of the INDC document goals did not have quantitative targets. The INDC gave reference to some national strategy and action plans for detailed information about these goals. These documents were reviewed with the hope to quantify the goals but it was found that they had been prepared for purposes that were completely different from the INDC and so were found inadequate for this purpose. Only three shocks could be generated from the INDC document goals, and all of them were in the energy main sector. Different from the NCCAP shocks, the INDC shocks were calculated by taking into account a growth rate taken from the INDC document. In the INDC, only the emissions level was estimated for the year 2030 and no estimates were given for any other values. Growth rate of emissions was calculated as 5.51% per year. When transforming the INDC goals into shocks, firstly, existing 2012 values were extrapolated for 2030 by applying this growth rate. Secondly, differences between these updated values and targeted values were determined. These differences constituted the shocks. The Environmentally Extended SAM was never updated but changes required by the goals for the year 2030 were calculated and applied as shocks on the Environmentally Extended SAM. Detailed information about transformation of the INDC goals to shocks are given in Appendix C. The shocks and their results are summarized in Table 11.

INDC01 and INDC02 shocks were transfer shocks, transferring volume to renewable and hydroelectricity sectors, respectively. INDC02 further reduced emissions and coal use compared to INDC01 because it was a greater shock. INDC03 shock was a decrease shock at a rate of 15% which aimed at reducing electricity transmission and distribution losses. INDC03 gave a better result than INDC01 in emissions reduction, but there was a less decrease in coal use. It is because INDC01 replaces coal with renewable resources but INDC03 decreases final demands of all electricity producing sectors.

Table 11. Intended Nationally Determined Contribution (INDC) policies and results

Sector	Policy for 2030	Shock Number	Change of Total GHG Inv.(%)	Change in Employment (%)	Change in GDP (%)	Change in Output (%)	Change in Hard Coal Use (%)	Change in Lignite Use (%)
ENERGY	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from coal electricity sector to renewable electricity sector at a rate of 14.3% of total electricity exogenous final demand with an aim of increasing renewable resources in production.	INDC01	−0.72	0.00	0.00	0.00	−1.91	−4.30
	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts first from coal electricity, then petroleum electricity, then natural gas electricity sectors to hydro electricity sector at a rate of 32.4% of total electricity exogenous final demand with an aim of tapping the whole hydroelectric potential.	INDC02	−1.54	0.00	0.00	0.00	−3.79	−8.55
	INCREASING EFFICIENCY TYPE SHOCK: A decrease shock in all electricity sectors at a rate of 15% with an aim of reducing electricity transmission and distribution losses.	INDC03	−0.94	na	na	na	−1.25	−2.68
Total			−3.20	0.00	0.00	0.00	−6.95	−15.53

Source: Compiled from INDC document [5] and author's calculations.

These three shocks reduced emissions by 3.20%, a far weaker decrease than the INDC target. Output, employment and GDP changes were zero; hard coal use and lignite use changes were significant, −6.95% and −15.33%, respectively. It appears impossible to reach the INDC emissions mitigation target based on its own policies.

4.2.3. Emissions Decreasing Policies

Emissions decreasing simulations were generated with an aim of reaching the INDC emissions mitigation target by employing policies that are more plausible than the INDC policies. The target year for these shocks was also 2030. Various shocks were essentially motivated by the NCCAP and the INDC documents. As a result, some emissions decreasing shocks ended up being the same with some of the NCCAP and the INDC shocks above. The remaining shocks were generated by the author taking emission coefficients into account. To generate these shocks, sectors were categorized into four: very high, high, low and zero. The identification of the four categories was performed in three steps. Initially, each sector's CO_2 equivalent emissions total was taken from the Environmentally Extended SAM, these totals were divided by gross output of the same sector, and emission coefficients were calculated for each sector. These coefficients were in kg CO_2 equivalent per thousand Turkish Lira. Then, mean of these coefficients (coefficient mean) was calculated, 428 kg CO_2 eq./thousand TL. Finally, another mean (gross mean) was calculated as 109 kg CO_2 eq./thousand TL by dividing total emissions inventory by total gross output in the economy. Sectors with emission coefficients greater than coefficient mean were classified as "very high", those with emission coefficients between coefficient mean and gross mean were classified as "high", those with coefficients less than gross mean were classified as "low", and, those with zero emissions were classified as "zero". This categorization can be seen in Table 12.

Fourteen shocks were prepared in total in all main sectors (energy, industry, transportation, waste and agriculture). The shocks and their results are presented in Table 13. The first eight shocks were in the energy main sector. The primary energy shock, EMIS01, which was the same as the first NCCAP shock, had weak results for emissions, hard coal use and lignite use. EMIS02 and EMIS05 were the same shocks in magnitude but were instigated by different policies, increasing efficiency in electricity use and reducing losses in electricity distribution, respectively. The reduction in emissions for both was 0.63% and the reductions in hard coal and lignite use amounts were 0.83% and 1.79%, respectively. These shocks performed better than the primary energy shock, EMIS01. EMIS04 aimed to apply co-generation technology in coal, petroleum and natural gas electricity sectors. It produced a similar result to EMIS02 and EMIS05 in emissions reduction and coal use despite being a smaller volume shock.

EMIS03, which incidentally is the same as the second INDC shock, transfers electricity production to hydroelectricity sector away from electricity generating sectors using coal, petroleum and natural gas, in that order. This policy achieved the largest emissions reduction and the most significant reduction in coal use as the most aggressive policy in the energy main sector.

EMIS06 was a transfer shock to renewable electricity sector from coal electricity sector. Emissions reduction was 0.14%, hard coal use reduction was 0.38%, and lignite use reduction was 0.85%. EMIS08 was a transfer shock from natural gas sector to renewable electricity sector and brought 0.12% reduction in emissions. EMIS06 performed better than EMIS08 in coal use reduction as expected. EMIS07 was a transfer shock from electricity generation using petroleum sector to renewable electricity sector; but as the share of petroleum is very low, the change in emissions was very low and the changes in other indicators were zero. Sum of these transfer shocks, EMIS06, EMIS07, and

EMIS08, provided less emissions reduction than EMIS04, the increasing efficiency shock at the same rate in the same sectors.

Table 12. Sector categories according to output, employment, value added multipliers and emission coefficients

Sectors	Output Multiplier	Category	Employment Multiplier	Category	Value Added Multiplier	Category	Emission Coefficient (kg CO_2 eq./billion TL)	Category
Agriculture	3.88	high	0.37	high	1.85	very high	279.48	high
Coal mining	1.86	zero	0.16	zero	0.52	zero	188.50	high
Petroleum, natural gas extraction	1.86	zero	0.16	zero	0.52	zero	146.98	high
Food	4.29	high	0.45	high	1.72	very high	11.90	low
Coke, refined petroleum	2.27	zero	0.14	zero	0.48	zero	62.63	low
Chemistry	2.64	low	0.25	low	0.76	zero	52.17	low
Mineral	3.79	high	0.44	high	1.40	high	1084.06	very high
Metal	2.82	low	0.22	zero	0.74	zero	104.01	low
Waste	2.57	zero	0.26	low	0.90	low	388.47	high
Railway transport	3.70	high	0.36	high	1.56	high	102.13	low
Highway transport	3.71	high	0.39	high	1.58	high	266.58	high
Water transport	3.80	high	0.45	high	1.62	high	79.28	low
Air transport	3.20	low	0.40	high	1.08	low	139.50	high
Industry	3.38	low	0.37	high	1.19	low	27.53	low
Service	3.97	high	0.65	very high	1.89	very high	0.00	zero
Elec.coal	4.64	very high	0.38	high	1.36	high	1873.27	very high
Elec.pet.	4.64	very high	0.38	high	1.36	high	1435.07	very high
Elec.nat.gas	4.64	very high	0.38	high	1.36	High	1040.99	very high
Elec.hydro	4.64	very high	0.38	high	1.36	High	0.00	zero
Elec.renew	4.64	very high	0.38	high	1.36	High	0.00	zero
	Category	Interval	Category	Interval	Category	Interval	Category	Interval
	zero	>0	zero	>0	Zero	>0	zero	=0
Categorization information	low	>2.64	low	>0.23	Low	>0.8	low	<109
	high	>3.55	high	>0.35	High	>1.23	high	<428
	very high	>4.46	very high	>0.47	very high	>1.66	very high	>428

Source: Author’s calculations. See in text for classifications.

Table 13. Emissions decreasing policies and results

Sector	Policy for 2030	Shock Number	Change of Total Greenhouse Gas Inventory (%)	Change in Employment (%)	Change in GDP (%)	Change in Output (%)	Change in Hard Coal Use (%)	Change in Lignite Use (%)
ENERGY	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in primary energy sectors (coal mining, petroleum natural gas extraction, coke,refined petroleum) with an aim of reducing primary energy intensity.	EMIS01	−0.09	na	na	na	−0.05	−0.06
	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of all electricity producing sectors with an aim of raising efficiency in electricity use.	EMIS02	−0.63	na	na	na	−0.83	−1.79
	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts first from coal electricity, then petroleum electricity, then natural gas	EMIS03	−1.54	0.00	0.00	0.00	−3.79	−8.55

	electricity sectors to hydro electricity sector at a rate of 32.4% of total electricity exogenous final demand with an aim of tapping the whole hydroelectric potential.							
	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in coal, petroleum and natural gas electricity production with an aim of increasing efficiency by co-generation technologies.	EMIS04	−0.53	na	na	na	−0.71	−1.53
	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in all electricity producing sectors with an aim of reducing losses and illicit use in electricity distribution.	EMIS05	−0.63	na	na	na	−0.83	−1.79
	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from coal electricity to renewable electricity with an aim of increasing share of clean energy in electricity production.	EMIS06	−0.14	0.00	0.00	0.00	−0.38	−0.85
	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand	EMIS07	−0.003	0.000	0.000	0.000	0.000	0.000

	accounts from petroleum electricity to renewable electricity with an aim of increasing share of clean energy in electricity production.								
	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from natural gas electricity to renewable electricity with an aim of increasing share of clean energy in electricity production.	EMIS08	−0.12	0.00	0.00	0.00	0.00	0.00
INDUSTRY	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from mineral sector to service sector with an aim of decreasing greenhouse gas intensity per GDP produced in industry main sector.	EMIS09	−0.18	0.03	0.02	0.00	−0.01	−0.02
TRANSPORTATIO N	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from highway transportation to railway transportation with an aim of decreasing CO_2 equivalent intensity in transportation.	EMIS10	−0.22	−0.05	−0.01	0.00	0.00	0.00
	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts	EMIS11	−0.30	0.08	0.02	0.02	0.00	0.02

	from highway transportation to water transportation with an aim of decreasing CO_2 equivalent intensity in transportation.							
	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in highway transportation.	EMIS12	−0.90	na	na	na	−0.41	−0.50
WASTE	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in waste sector.	EMIS13	−0.05	na	na	na	−0.02	−0.02
AGRICULTURE	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in agriculture sector.	EMIS14	−0.76	na	na	na	−0.38	−0.45
Total			−6.09	0.06	0.03	0.02	−7.40	−15.54
Policy mix proposed by the author			−4.54	0.06	0.03	0.02	−3.61	−6.99

Source: Author’s calculations.

In the industry main sector, only one shock was run. EMIS09, a 10% transfer shock from mineral (very high emitting) to service (zero emitting), reached 0.22% decrease in emissions accompanied by a 0.05% decrease in employment and a 0.01% decrease in GDP.

In transportation main sector, increasing efficiency shock to be achieved by convincing people to use more public transport and putting sustainable transport solutions into practice, EMIS12, achieved the greatest emissions reduction among other shocks in transportation, 0.9%. It also decreased hard coal and lignite use at rates of 0.41% and 0.5%, respectively. Transferring volume from highway to railway shock, EMIS10, did not perform as well as transferring volume from highway to seaway shock, EMIS11. EMIS11 decreased emissions level to a greater extent than EMIS10 and also increased employment, GDP, and output.

A 10% decrease shock, EMIS13, aimed at efficiency in waste management. The shock resulted in a 0.05% decrease in emissions, 0.02% decrease in hard coal use, and 0.02% decrease in lignite use. Changes in output, employment and GDP were ignored as it was an increasing efficiency shock.

A 10% decrease shock in agriculture, EMIS14, is planned to be achieved by fuel savings, avoiding excess use of fertilizers, and implementing modern practices. Emissions, hard coal use and lignite use decreased at rates of 0.76%, 0.38% and 0.45%, respectively.

When all of the emissions decreasing shocks were considered, a policy mix consisting of all shocks except EMIS03 achieved a 4.54% reduction in emissions level. Hard coal use and lignite use in this policy mix decreased at rates of 3.61% and 6.99%. This policy mix, combination of all shocks except EMIS03, also failed to reach the INDC emissions mitigation target. The economy did not shrink but grew, although very slightly. Employment, GDP, and output increased at rates of 0.06%, 0.03%, and 0.02%. This was an expected result because the shocks were either increasing efficiency or transferring volume shocks, increasing efficiency shocks were planned so as not to change output levels and transferring volume shocks were planned in such a way so that gains or losses were allowed only due to transfers among sectors.

EMIS03 envisaged transferring production away from coal, petroleum, and natural gas electricity generation towards hydroelectricity to tap into the entire hydroelectricity potential in Turkey. It was not preferred as it meant increasing hydroelectric capacity by 60.67% which is technically possible but not plausible from an economic point of view. Furthermore, hydro electricity production has detrimental impacts on land use and wild life.

Even though the policy mix presented above was far from achieving the target of 21%, it consisted of more conceivable policies than the INDC policies. The proposed policies are greater in number, spread throughout the economy, and easier to implement.

4.2.4. Multiplier Policies

In each platform and each document submitted or published, Turkey repeats its determination to sustain economic growth while mitigating emissions. This study presents simulations based on output, employment, and GDP multipliers that enhance growth and increase employment to address the question of whether sustaining economic growth is possible while realizing the INDC target.

Sectors having high multiplier values have a greater effect on the economy than those with low multiplier values. Therefore, sectors were categorized into four levels according to their multiplier values: very high, high, low and zero. Categorization was based on the mean and standard deviation of multipliers and can be seen in Table 12. Sectors which have multipliers greater than the mean plus one standard deviation were classified as "very high". Sectors with multipliers between the mean and mean plus one standard deviation were classified as "high". Sectors with multipliers between the mean and one standard deviation less than the mean were classified as “low”. Finally, sectors with multipliers between one standard deviation less than the mean and zero were classified as “zero”.

Only the energy, industry, and agriculture main sectors were subjected to multiplier shocks. Waste and transportation sectors were left out of the multiplier analysis as it is not reasonable to boost the economy by promoting these sectors.

GDP multiplier shocks and output multiplier shocks occurred the exact same even though multipliers and sector categories were different. For this reason, the shocks and their results are given together in Table 14 but separately in Appendix C. OUT01 was a 10% increase shock given to all electricity producing sectors due to efficiency increase. Output, GDP, and employment increases were very low and change in emissions, hard coal use and lignite use were ignored. OUT02 was a 10% transfer shock from low output sectors, chemistry, metal and industry, to high output sectors, service, mineral and food. Output increased at a rate of 0.78% but the increase in GDP and employment was much greater, 2% and 2.23%, respectively. However, this shock caused emissions level and lignite use to increase as well, at rates of 0.68% and 0.94%, respectively. OUT03 shock was an increasing efficiency shock and caused the highest levels of increase in macroeconomic indicators; 5.30% in output, 6.22% in GDP, 6.47% in employment. Changes in emissions level and coal use were ignored. OUT04 was an increase shock in the agriculture sector and outperformed OUT01 in all macroeconomic indicators; output increased at a rate of 0.5%, GDP and employment increased at rates of 0.61 and 0.38, respectively. When all of the output shocks were considered, OUT02 and OUT03 policies stood out. These shocks brought about significant increase also in employment and GDP. However, rather than achieving any reduction in emissions level, they increased.

When employment increasing shocks were considered, EMP01 shock was the same as OUT01 shock, and these could be interpreted as weak shocks. EMP02 was a 10% transfer shock from sectors having low employment multiplier, chemistry and metal, to sectors having high employment multiplier, service, mineral, food and industry. It caused low rates of increase in output, GDP, and employment; also, emissions level increased. EMP03 was the largest shock which was a 10% increasing efficiency shock in food, mineral, service, and industry sectors. The shock produced 8.42%, 9%, 9.23% increases in output, GDP, and employment, respectively. This shock was a larger version of OUT03 shock. EMP04 was the same as OUT04 and performed best in GDP. Employment increasing policies and their results are listed in Table 15. These shocks led to the same conclusion as the output increasing shocks that is none was capable of reducing emissions.

Table 14. Developmental and GDP increasing policies and results

Sector	Policy for 2030	Shock Number	Change of Total Greenhouse Gas Inv. (%)	Change in Emp. (%)	Change in GDP (%)	Change in Output (%)	Change in Hard Coal Use (%)	Change in Lignite Use (%)
ENERGY	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of all electricity producing sectors.	OUT01/GDP01	Na	0.10	0.12	0.16	na	Na
INDUSTRY	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from chemistry, metal, industry sectors to service, mineral, food sectors.	OUT02/GDP02	0.68	2.23	2.00	0.78	−0.26	0.94
	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of food, mineral, service sectors.	OUT03/GDP03	Na	6.47	6.22	5.30	na	Na
AGRICULTURE	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of agriculture sector	OUT04/GDP04	Na	0.38	0.61	0.50	na	Na
Total			0.68	9.19	8.95	6.73	-0.26	0.94

Source: Author’s calculations.

Table 15. Results of employment increasing policies generated by the author

Sector	Policy for 2030	Shock Number	Change of Total Greenhouse Gas Inv. (%)	Change in Emp. (%)	Change in GDP (%)	Change in Output (%)	Change in Hard Coal Use (%)	Change in lignite Use (%)
ENERGY	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of all electricity producing sectors.	EMP01	Na	0.10	0.12	0.16	na	na
INDUSTRY	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from chemistry, metal sectors to service, mineral, food, industry sectors.	EMP02	0.08	0.34	0.32	0.16	−0.28	0.15
	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of food, mineral, service, and industry sectors.	EMP03	Na	9.23	9.00	8.42	na	na
AGRICULTURE	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of agriculture sector.	EMP04	Na	0.38	0.61	0.50	na	na
Total			0.08	10.05	10.05	9.23	−0.28	0.15

Source: Author’s calculations.

4.3. DISCUSSION OF THE RESULTS

Comparison of the results of the NCCAP simulation with the existing 2015 emissions inventory showed that Turkey missed an opportunity to decrease its emissions by 2.69%, but emissions increased by 5.84% instead. This raises doubt about Turkey's determination in the climate mitigation field.

INDC simulation results suggest that the INDC policies can only reduce emissions level by 3.20% even though the policies require major changes in the economic structure and are difficult to implement. In addition, very few of the INDC goals are measurable, unambiguous, and reportable. Thus, only three goals, all in the electricity sectors, could be transformed into policies. Two of the three measurable policies in the document concerned shifting electricity production to renewable and hydro electricity generation sectors; however, recently Turkey has pursued a strong commitment to utilizing all its coal reserves. Turkey hopes to decrease dependency on imports in energy with this decision, which is set out in the strategy documents of the Ministry of Energy and Natural Resources and in the 5-year development plans of the Ministry of Development. In light of all this, the INDC document can't be considered to be convincing.

Among the emissions decreasing policies, two seem promising in the energy main sector: the policy of increasing efficiency in electricity generation from fossil fuels by implementing cogeneration technologies, and the policy of replacing fossil fuels with renewable resources in electricity production. Turkey should give priority to coal when implementing the latter, because coal has a higher potential in emissions reduction. Reducing losses and preventing illicit use in electricity distribution and raising efficiency in electricity use are other notable policies in the energy main sector. Increasing efficiency in road transportation by convincing people to use more public transport and putting sustainable transport solutions into practice is notable among other policies in the transportation main sector. Transferring volume to low emitting modes also contributes significantly. Increasing efficiency by land consolidation and applying modern and sustainable practices in vegetal and animal production in the agriculture sector is also effective. In the high emitting mineral sector, shrinking domestic production and importing from the countries that produce with low-carbon technologies, is the most effective policy in the industry main sector in the short term. However, given the high trade deficits in Turkey, this is unlikely to be possible in the near future. These policies should be of top priority for Turkey.

The policy mix proposed by the author among emissions decreasing policies provides a 4.54% decrease in emissions level. This policy mix is economy-wide and easier to implement compared to the policies in the INDC document, yet the 21% target can't be achieved. Achieving the INDC emissions mitigation target does not seem possible, either through increasing efficiency shocks or transferring volume to low carbon economy shocks, or with any mixes of them. Achieving the target requires producing forceful policies.

Multiplier simulations generated by the author showed that boosting the economy is possible by increasing efficiency in sectors with high multipliers or transferring volume to these sectors, but this results in higher not lower emissions. This indicates that it is impossible to achieve such a high target with policies that involve only economic concerns.

It is necessary to point out an important issue about the goals in the NCCAP and INDC documents and the way in which they were transformed into shocks. The NCCAP and INDC goals were set over the entire economy, however this study generated shocks over exogenous final demand accounts. Household consumption was not included because the household account is taken as endogenous in the Multiplier Analysis method in order to comprise income effects. As exogenous final demand accounts constituted 49% of total final demand in this Environmentally Extended SAM, the NCCAP and the INDC simulations results can be interpreted as being higher than they currently were. Emissions decreasing shocks generated by the author can be interpreted the same, as these were also set over the entire economy. Although this is the issue, this does not change conclusions drawn on the NCCAP and the INDC documents and the emissions decreasing simulations since the emissions target is so far off from any simulation outcome.

CHAPTER 5: ASSESSMENTS OF ALTERNATIVE TAX POLICIES BY A MULTI-GAS MULTI-SECTOR CGE (MGMSCGE) MODEL

CGE models simulate the general equilibrium economies based on Walrasian economic equilibrium system. They look at the economy as a complete system and describe a competitive economy with agents representing consumers, producers, government, investment, and rest of world. They use pure economic tools as taxes/subsidies, price controls, and quotas, and other climate mitigation tools also can be run in CGE models, such as Emissions Trading Systems.

5.1. METHOD: CGE

CGE models have high-degree theoretical consistency and predicts values of all variables in the system as they link each sector to the other better than other model types. CGE models allows both backward and forward impacts of shocks superior to Multiplier Analysis Method which allows only backward impacts. Prices can change and are useful to balance the economy in CGE and it differs from constant-price Multiplier Analysis. Additionally, CGE models allows non-linear function types.

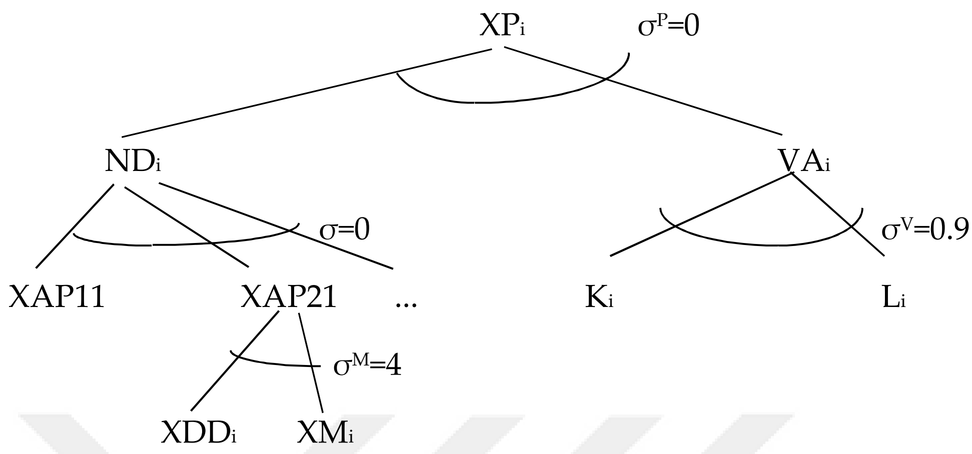
CGE models require big data which increases complexity of model as it involves making numerous assumptions about nesting structures, function types, and parameters. CGE models are generally criticized due to these uncertainties. They are also qualified as black boxes due to difficulty to assess drivers of the results. Rose [125] claims that CGE models are based on more restrictive assumptions than Input-Output and SAM models and Klijs et al. [126] supports this argument by stating that CGE models are not standardized and come in many forms.

In this chapter, a 20-sector static CGE model was developed and named Multi-Gas Multi-Sector CGE Model, MGMSCGE. It includes one representative household agent, one government agent, and one investment agent, one Armington agent and it is a single region and open economy CGE model. The existing 2012 Environmentally Extended SAM was used as data without making any change. When deciding the nesting structures, function types, and parameters, common practices were preferred to overcome the drawbacks mentioned above.

Production

Each sector produces one type of commodity. Good market is perfectly competitive. There are four production factors: intermediate inputs, capital, and labor. Labor and capital are mobile across sectors. Wage (W) is equal in each sector but interest rate (R) is different. Sectors' Intermediate input demands are provided from domestic production and import. An Armington agent decides how much will be met from domestic production or import. For this decision, Armington model can be seen below.

Production, XP, has a nesting structure as below. It is modelled with Constant Elasticity of Substitution (CES) functions.



In the first level, intermediate input composite (ND_i) and value-added composite (VA_i) trades off. In the second level on left hand side, intermediate input composite is decomposed into input-output matrix. In the second level on right hand side, value added composite is decomposed into labor (L_i) and capital (K_i). In the third level, input-output is decomposed into domestic production and import.

In the top nest, gross output, XP_i, decomposes to intermediate input composite and value-added composite. This is a profit maximization problem with a CES type production function.

$$max_{XPi,NDi,VAXPEi}\prod = XP_i PX_i - PVA_i VA_i - PND_i ND_i$$

$$s.t. \qquad XP_i = \left(\alpha_i^{nd} ND_i^{\left(\frac{\sigma P-1}{\sigma P}\right)} + \alpha_i^{va} VA_i^{\left(\frac{\sigma P-1}{\sigma P}\right)}\right)^{\left(\frac{\sigma P}{\sigma P-1}\right)}$$

$$ND_i = \alpha_i^{nd}\left(\frac{PX_i}{PND_i}\right)^{\sigma P} XP_i \qquad (16)$$

$$VA_i = \alpha_i^{va}\left(\frac{PX_i}{PVA_i}\right)^{\sigma P} XP_i \qquad (17)$$

$$PX_i = \left(\alpha_i^{nd} {PND_i}^{1-\sigma P} + \alpha_i^{va} {PVA_i}^{1-\sigma P}\right)^{\left(\frac{1}{1-\sigma P}\right)} \qquad (18)$$

ND_i= intermediate input composite

VA_i= value-added composite

PX_i= production price of gross output

PND_i= price of intermediate input composite

PVA_i= price of value-added composite

XP_i= gross output

$\alpha^{nd}{}_i$, $\alpha^{va}{}_i$= share parameters

σ^P= elasticity of substitution in value added and intermediate decomposition function

In perfect competition assumption, the output price, PP_i, is equal to the unit cost of production multiplied by production tax, $\tau^P{}_i$.

$$PP_i = (1 + \tau_i^P)PVA_i \qquad (19)$$

PP_i= output price

$\tau^P{}_i$= production tax

PVA_i= price of value-added composite

Aggregate intermediate demand (ND_i) is decomposed into the input-output matrix. A simple Leontief structure is assumed, therefore there is no substitution across intermediate inputs.

$$min_{NDj,XAPij} C = \sum_{i=1}^{14} PA_i XAP_{ij}$$

$$s.t. \qquad ND_j = min\left\{\frac{XAP_{1j}}{a_{1j}}, \frac{XAP_{2j}}{a_{2j}}, \dots\right\}$$

$$XAP_{ij} = a_{ij} ND_j \qquad (20)$$

$$PND_j = \textstyle\sum_{i=1}^{20} a_{ij} \left(1 + \tau_{ij}^{itp}\right) PA_i \qquad (21)$$

$$a_{ij} = \frac{XAP_{ij}}{ND_j}$$

$$\sum_{i=1}^{14} a_{ij} = 1$$

ND_j= intermediate good composite

XAP_{ij}= intermediate goods demand of sector j from sector i

a_{ij}= technology matrix parameter

PND_j= price of intermediate good composite

PA_i= price of Armington good

The value-added composite is decomposed into capital and labor. As labor is mobile across sectors wage rate is the same in all sectors.

$$min_{VAi,Li,Ki} C = W\ L_i + R_i\ K_i$$

$$s.t. \qquad VA_i = \left(\alpha_i^l \left(\lambda_i^l\right)^{\sigma V-1} Ld_i^{\frac{\sigma V-1}{\sigma V}} + \alpha_i^k \left(\lambda_i^k\right)^{\sigma V-1} Kd_i^{\frac{\sigma V-1}{\sigma V}}\right)^{\frac{\sigma V}{\sigma V-1}}$$

$$Ld_i = \alpha_i^l \left(\lambda_i^l\right)^{\sigma V-1} \left(\frac{PVA_i}{W}\right)^{\sigma V} VA_i \qquad (22)$$

$$Kd_i = \alpha_i^k \left(\lambda_i^k\right)^{\sigma V-1} \left(\frac{PVA_i}{R_i}\right)^{\sigma V} VA_i \qquad (23)$$

$$PVA_i = \left(\alpha_i^l \left(\frac{W}{\lambda_i^l}\right)^{1-\sigma V} + \alpha_i^{kf} R_i^{1-\sigma V}\right)^{\frac{1}{1-\sigma V}} \qquad (24)$$

VA_i= value-added composite

Ld_i= labor demand

Kd_i= capital demand

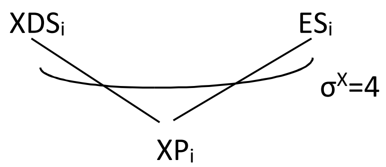
W= wage rate

R_i= interest rate

α^l_i, α^k_i= share parameters

σ^V= elasticity of substitution in value-added decomposition function

For all sectors, producer decides how much to produce for export and for domestic markets in the upper, reverse nest. This decision is made in a Constant Elasticity of Transformation (CET) functional form.



$$max_{XPi,XDSi,ESi}\prod = PP_i XP_i - PD_i XDS_i - PE_i ES_i$$

$$s.t. \qquad XP_i = \left((g_i^d)^{\frac{-1}{\sigma X}} XDS_i^{\frac{\sigma X+1}{\sigma X}} + (g_i^e)^{\frac{-1}{\sigma X}} ES_i^{\frac{\sigma X+1}{\sigma X}} \right)^{\frac{\sigma X}{\sigma X+1}}$$

$$XDS_i = g_i^d \left(\frac{PD_i}{PP_i} \right)^{\sigma X} XP_i \qquad (25)$$

$$ES_i = g_i^e \left(\frac{PE_i}{PP_i} \right)^{\sigma X} XP_i \qquad (26)$$

$$PP_i = \left(g_i^d PD_i^{1+\sigma X} + g_i^e PE_i^{1+\sigma X} \right)^{\frac{1}{1+\sigma X}} \qquad (27)$$

PX_i= production price of gross output

XP_i= gross output

PD_i= price of domestic production

XDS_i= domestic supply

PE_i= export price

ES_i= aggregate export supply

σX= elasticity of transformation between domestic production and export

g^d_i, g^e_i =share parameters

Consumption

A Representative Household tries to maximize its utility. Household consumption from each sector, XAC_i, is determined according to the sector's initial share in disposable income, Y*. The Armington good, XAC_i, which is produced from domestic production and import in the Armington Model. The RH owns primary factors of production, capital and labor, and rent them to all sectors. The RH's income, YH, comes from these payments and from transfers made by the government. Disposable income, Y*, equals to after-tax household income adjusted by depreciation, DeprY.

$$YH = \sum_{i=1}^{20} \left(W\ L_i^d + R_i K_i^d \right) + P\ TR_h^g \qquad (28)$$

$$Y^* = (1 - \kappa)YH - DeprY \qquad (29)$$

$$XAC_i = \frac{\mu_i Y^*}{\left(1 + \tau_i^{itc}\right) PA_i} \qquad (30)$$

$$S^h = Y^* - \sum_{i}^{20} \left(1 + \tau_i^{itc}\right) PA_i XAC_i \qquad (31)$$

$$DeprY = P\ \ DeprY_0 \qquad (32)$$

YH= household income

W= wage rate

R_i= interest rate

L^d_i= labor demand

K^d_i= capital demand

P= GDP price deflator

TR^g_h= transfer from government to household

Y*= disposable income

κ= direct tax rate

DeprY= depreciation

XAC_i= Armington good consumed by household

μ_i= share parameter

τ^{itc}_i= tax rate on consumption

PA_i= price of Armington good

S^h= household savings

Armington Agent

There is an Armington agent aggregating all demands for a sector and determining domestic production and import rate for that sector. Armington demand for a sector, XA_i, is allocated to domestic goods, XDD_i, and imports, XM_i.

$$max_{XAi,XMi,XDDi}\prod = PA_i XA_i - [PM_i XM_i + PD_i XDD_i]$$

$$s.t. \qquad XA_i = \left(\alpha_i^d XDD_i^{\frac{\sigma M-1}{\sigma M}} + \alpha_i^m XM_i^{\frac{\sigma M-1}{\sigma M}}\right)^{\frac{\sigma M}{\sigma M-1}}$$

$$XA_i = \sum_{j=1}^{20} XAP_{ij} + XAC_i + XAG_i + XAI_i \qquad (33)$$

$$XDD_i = \alpha_i^d \left(\frac{PA_i}{PD_i}\right)^{\sigma M} XA_i \qquad (34)$$

$$XM_i = \alpha_i^m \left(\frac{PA_i}{PM_i}\right)^{\sigma M} XA_i \qquad (35)$$

$$PA_i = \left(\alpha_i^d PD_i^{1-\sigma M} + \alpha_i^m PM_i^{1-\sigma M}\right)^{\frac{1}{1-\sigma M}} \qquad (36)$$

XA_i= Aggregated Armington demand

XAP_{ij}= intermediate input demand i for producing j

XAC_i= Armington good consumed by household

XAG_i= Armington government expenditure

XAI_i= Armington investment demand

XDD_i= aggregate domestically produced domestically consumed good

XM_i= aggregate import demand

PA_i= price of Armington good

PD_i= price of domestic good

PM_i= price of imported good

α^d_i, α^m_i= share parameter

Investment

There is an agent representing investment and investment is savings determined. Aggregate investment is the sum of domestic savings (household+government), foreign savings, and depreciation. Investment expenditure in each sector, XAI_i, is determined by using a CES expenditure function. As substitution elasticity in this model is zero, each XAI_i is determined according to its initial share in total investment, XI.

$$PI\ \ XI = S^h + S^g + ER\ S^f + DeprY \qquad (37)$$

$$XAI_i = \alpha_i^I \left(\frac{PI}{(1+\tau_i^{iti})PA_i} \right)^{\sigma I} XI \qquad (38)$$

$$PI = \left(\sum_{i=1}^{20} \alpha_i^I \left((1+\tau_i^{iti})PA_i \right)^{1-\sigma I} \right)^{\frac{1}{(1-\sigma I)}} \qquad (39)$$

XI= aggregate investment

PI= investment price deflator

S^h= household savings

S^g= government savings

ER= exchange rate

S^f= foreign savings

DeprY= depreciation

XAI_i= Armington investment demand

τ^{iti}_i= tax rate taken from investment

PA_i= price of Armington good

α^I_i= share parameter

Government

Government revenues consists of incomes from direct tax (κ YH), indirect taxes (ItaxY), tariffs (TradeY), and production tax (τp PX XP). Government expenditure is allocated to sectors in constant shares (Leontief form). The aggregate government expenditures, XG, is constant. The model to determine government demand has a CES expenditure function with a zero elasticity. Each XAGi is determined according to its initial share in total government expenditure, XG.

$$ITaxY = \sum_{i=1}^{20} PA_i \left(\sum_{j}^{20} \tau_{ij}^{itp} XAP_{ij} + \tau_i^{itc} XAC_i + \tau_i^{itg} XAG_i + \tau_i^{iti} XAI_i \right) \qquad (40)$$

$$TradeY = ER \sum_{i=1}^{20} \tau_i^m WPM_i XM_i + \sum_{i=1}^{20} \tau_i^e PE_i ES_i \qquad (41)$$

$$GRev = ITaxY + TradeY + \sum_{i=1}^{20} \tau_i^p PX_i XP_i + \kappa\, YH \qquad (42)$$

$$XG = XG0 \qquad (43)$$

$$XAG_i = \alpha_i^g \left(\frac{PG}{(1 + \tau_i^{itg}) PA_i} \right)^{\sigma G} XG \qquad (44)$$

$$PG = \left(\sum_{i=1}^{20} \alpha_i^g \left((1 + \tau_i^{itg}) PA_i \right)^{1-\sigma G} \right)^{\frac{1}{(1-\sigma G)}} \qquad (45)$$

$$S^g = GRev - PG\, XG - P\, TR_g^h \qquad (46)$$

ITaxY= indirect taxes

PA_i= price of Armington good

τ^{itp}_{ij}= intermediate input use tax rate

XAP_{ij}= intermediate goods demand of sector j from sector i

τ^{itc}_{i}= household consumption tax rate

XAC_{i}= Armington good consumed by household

τ^{itg}_{i}= government consumption tax rate

XAG_{i}= Armington government expenditure

τ^{itg}_{i}= investment tax rate

XAI_{i}= Armington investment demand

TradeY= income from tariff rates

ER= exchange rate

τ^{m}_{i}= import tariff rate

WPM_{i}= world import price

XM_{i}= aggregate import demand

τ^{e}_{i}= export tariff rate

PE_{i}= export price

ES_{i}= aggregate export supply

Grev= government revenue

τ^{p}_{i}= production tax rate

PX_{i}= production price of gross output

XP_{i}= gross output

κ= direct tax rate

YH= household income

XG= aggregate government expenditure (constant)

α^{g}_{i}= share parameter

PG= government expenditure price

S^{g}= government savings

P= GDP price deflator

TR^{g}_{h}= transfer from government to household

Trade prices

World import price, WPMi, is given, small country assumption is hold. Import price, PMi, is determined by multiplying exchange rate (ER) with tariff (τmi) adjusted world import price. It is assumed that Turkey's export volume is limited. World export price, WPEi, is determined by dividing tariff (τei) adjusted export price to exchange rate.

$$PM_i = ER(1 + \tau_i^m)WPM_i \qquad (47)$$

$$PE_i = ER \;\; WPE_i/(1 + \tau_i^e) \qquad (48)$$

PM_i= import price

ER= exchange rate

τm_i= import tariff rate

WPM_i= world import price

PE_i= export price

$\tau^e{}_i$= export tariff rate

WPE_i= world export price

Goods market equilibrium

Domestic market for domestic production clears by equalizing domestic good demand, XDDi, with domestic good supply, XDSi. Export market is the same. Because of small country assumption in import, there is no market clearing equation for import.

$$XDD_i = XDS_i \qquad (49)$$

$$ED_i = ES_i \qquad (50)$$

Factor market equilibrium

Labor is mobile across sectors and wage is the same in each sector. Labor supply, Ls, is a function of wage with a supply elasticity of ωL.

$$Ls = \chi^{l}\left(\frac{W}{P}\right)^{\omega L} \qquad (51)$$

$$Ls = \sum_{i=1}^{20} Ld_i \qquad (52)$$

$$\chi^{l} = Ls0\left(\frac{P}{W0}\right)^{\omega L} \qquad (53)$$

ωL= aggregate labor supply elasticity

χ^l= labor supply shift parameter

Ls0= initial labor supply

W0= initial wage

The capital market is modelled using a CET supply allocation function. Aggregate capital is allocated across sectors according to sector-specific rates of return. When the transformation elasticity is finite, the allocation is imperfect and sectoral rates of return will not be uniform. In the extreme, with a zero transformation elasticity, capital would be completely sector specific. Aggregate capital stock, *TKs*, is constant. Capital sectoral allocation, *Ks*, is determined using the reduced form CET supply functions, with an infinite elasticity, the law of one price holds. Trent is average rate of return. With an infinite elasticity, the aggregate rate of return is determined by an equilibrium condition. The last equation determines the equilibrium rate of return specific to each sector.

$$TK^{s} = TK_{0}^{s} \qquad (54)$$

$$K_i^s = \chi_i^k \left(\frac{R_i}{Trent}\right)^{\omega K} TK \qquad (55)$$

$$Trent = \left(\sum_{i=1}^{20} \chi_i^k \left(R_i\right)^{1+\omega K}\right)^{\frac{1}{(1+\omega K)}} \qquad (56)$$

$$K_i^d = K_i^s \qquad (57)$$

$$\chi_i^k = \left(\frac{K0_i^s}{TK0}\right)\left(\frac{Trent0}{R0_i}\right)^{\omega K} \qquad (58)$$

TK= aggregate capital stock

TK0= initial aggregate capital stock

K^s_i= capital supply

χ^k_i= capital supply shift parameter

Trent= average rate of return

ωK= capital mobility elasticity (transformation elasticity)

K0si= initial capital supply

Trent0= initial average rate of return

$R0_i$= initial interest rate

Closure

Real government savings, RS^g, is equal to division of government savings to GDP price deflator. Fiscal closure is provided when real government saving is equalized to its initial value. External closure is equal to current account balance. Nominal GDP at factor cost, GDPFC, is the sum of all factors' income. Real GDP at factor cost is equal to the sum of all factors' income at real prices. And, GDP deflator is given in the last equation.

$$RS^g = S^g/P \qquad (59)$$

$$RS^g = RS_0^g \qquad (60)$$

$$\sum_{i=1}^{20} WPE_i ED_i + S^f = \sum_{i=1}^{20} WPM_i XM_i \qquad (61)$$

$$GDPFC = \sum_{i=1}^{20} (W\ Ld_i + R_i Kd_i) \qquad (62)$$

$$RGDP = \sum_{i=1}^{20} (W_0 \lambda_i^l Ld_i + R0_i \lambda_i^k Kd_i) \qquad (63)$$

$$P = GDFC/RGDP \qquad (64)$$

RS^g= real government savings

$RS0^g$= initial real government savings

S^f= foreign savings

GDPFC= GDP at factor cost

RGDP= real GDP

5.2. ALTERNATIVE TAX POLICIES AND RESULTS OF THE ANALYSIS

Only one simulation category was created and named Alternative tax policies. Alternative tax policies have been generated for the same purpose as the emissions decreasing policies given in section 4.2.3. These policies placed taxes on various goods in different levels of production and consumption to be alternatives to the INDC policies. As in emissions decreasing policies, these policies were inspired by the NCCAP and the INDC documents, and sector categorization according to emission coefficients was also used. Thirteen shocks were prepared in total in all main sectors (energy, industry, transportation, waste and agriculture). These taxes were placed on intermediate inputs when the policy interested only producers and on final goods consumed by the household, government and investment agents when the policy interested both producers and consumers. Income of the taxes applied to intermediate inputs, household consumption, and investment were transferred directly to households. Taxes are applied by government and income belongs to government in a general economy, however, income of the taxes applied to emissions were transferred to the household by the government in this model. If the government had kept these taxes income to itself, this would have been transferred directly to investment account as government savings. As the model was static, any income transferred to investment account remained as investment expenditures, did not create any wealth for today. The second reason was that investment expenditure structure does not represent the overall expenditure structure of the economy. The third reason was that the effects of taxation could be measured directly. These taxes were already in the model but their initial values were zero, and after simulations, they constituted the emissions taxes.

An identifying number was given to each shock and changes in emissions, output, employment, and GDP were calculated. The shocks and their results are presented in Table 16 and detailed in Appendix C.

Almost all policies ended up with decrease in emissions but they also caused declines in economic indicators, employment, GDP and output. The first seven shocks were in the energy main sector. The primary energy policy, ALT01, placed 10% taxes on coal mining, petroleum and natural gas extraction, and coke and refined petroleum products. Each sector that used these sectors' products as intermediate inputs and the household, government, and investment agents that consumed these products, paid these taxes. This policy ended up with 0.539% decrease in emissions. Employment, GDP, and output decreased at rates of 0.819%, 0.882%, and 0.218%.

The second policy, ALT02, aimed at reducing electricity use in the entire economy. 10% taxes placed on sectors that electricity is used as intermediate input and all agents that consumed electricity as final good. Emissions reduction was 2.070%; employment, GDP, and output decreased at rates of 0.813%, %0.840, and %0.283. This was an efficient policy.

Levying 10% taxes on all sectors that used fossil fuel electricity (electricity production from coal, petroleum, and natural gas) and subsidizing all sectors that used hydroelectricity at the same rate constituted the third policy, ALT03. As the objective of the policy was utilizing more of hydroelectric potential, taxes were applied only in production processes. It was efficient with 0.639% emissions reduction rate. This policy caused decreases in employment and GDP at 0.402% and 0.401 rates, and output decreased at a lower rate, 0.098%. The fourth policy, ALT04, aimed at increasing efficiency in fossil fuel electricity production by implementing co-generation technologies. Implementing co-generation technologies in coal, petroleum, and natural gas electricity production could increase efficiency, and emissions per output could decrease in this way. Fossil fuel electricity use in production was taxed at 10% rates. This policy decreased emissions at a greater rate than ALT03 but decreased employment, GDP, and output at a greater rate as well. Emissions decrease was 0.964%; employment, GDP, and output decreases were 0.618%, 0.615%, and 0.149% respectively.

The last three policies in the energy main sector, ALT05, ALT06 and ALT07, placed taxes on coal, petroleum, and natural gas electricity input use and subsidized renewable electricity input use. ALT05 and ALT07 taxed electricity from coal and natural gas sources respectively, and subsidized electricity from renewable sources. They were efficient in emissions reduction with 0.331% and 0.532% rates respectively. ALT06 that taxed electricity production from petroleum increased emissions at a rate of 0.031%, but changes in emissions and all other economic indicators were minute. ALT05 and ALT07 were efficient among these three transfer policies.

The only policy in the industry main sector belonged to the mineral sector which had the highest emission coefficient. This sector's products used as intermediate inputs were taxed at a 10% rate. Emissions reduction was low with 0.157% rate. But, decreases in employment and GDP were high with 0.542% and 0.502% rates and decrease in output was minute.

Two of three policies in the transportation main sector, ALT09 and ALT10, tried to decrease emissions per transport by transferring volume from highway to other modes. In these policies, taxes and subsidies were placed on both production and consumption sides. ALT09 levied 10% taxes on highway transportation and subsidized railway transportation at the same rate. Emissions decreased at 0.329% rate, and employment, GDP, and output decreased at 0.493%, 0.854%, and 0.061% rates respectively. ALT10 levied taxes on highway transportation and subsidized water transportation, and came up with decreases in emissions, employment, GDP, and output at rates of 0.326%, 0.403%, 0.756%, and 0.054% respectively. The last policy in the transport main sector, ALT11, placed taxes only on highway transportation to direct people to public transportation and increase efficiency in the sector. Results of the policy were approximately the same with the ALT09. Emissions decreased at 0.330% rate, and employment, GDP, and output decreased at 0.494%, 0.856%, and 0.061% rates respectively. When these three policies considered, none of them was superior to the other and each was preferable.

Levying taxes on waste production, ALT12, could decrease waste amount, and emissions from waste could be decreased in this way. This policy placed 10% taxes on both producers and consumers. Emissions reduction was only 0.107%, and employment, GDP, and output decreases were 0.204%, 0.218%, and 0.025% respectively.

The last policy, ALT13, levied taxes on agricultural products used as intermediate inputs and consumed by the household, government and investment agents. ALT13 aimed at increasing efficiency in agriculture and decreasing emissions in this way. Emissions decreased at 0.035% rate, and employment, GDP, and output decreased at 0.008%, 0.673%, and 0.033% rates. As decrease in emissions was minute, this policy was not preferred.

Total emissions reduction potential of the thirteen policies would be 6.328% with declines at rates of 5.315% in employment, 7.114% in GDP, and 1.084% in output. This emissions reduction potential was insufficient for Turkey and it was quite costly. Thus, a policy mix excluding inefficient ALT08 and ALT13 policies was proposed. Total emissions reduction of the policy mix was 6.136%, employment decreased at a rate of 4.765%, GDP decreased at a rate of 5.939%, and output decreased at a rate of 1.075%. Emissions reduction potential of the policy mix was far from the INDC target. Even though, the proposed policy mix provides practices that needed to be prioritized.

Table 16. Alternative tax policies and results

Sector	Policy for 2030	Shock number	Change of total green. gas inv. (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)
ENERGY	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in primary energy sectors (coal mining, petroleum,natural gas extraction, coke,refined petroleum).	ALT01	-0.539	-0.819	-0.882	-0.218
	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in all electricity producing sectors.	ALT02	-2.070	-0.813	-0.840	-0.283
	Place a 10% intermediate input use tax (τitp) on electricity producing sectors from coal, petroleum, and natural gas; give a 10% subsidy to electricity production from hydro energy.	ALT03	-0.639	-0.402	-0.401	-0.098
	Place 10% intermediate input use taxes (τitp) on fossil electricity producing sectors, coal, petroleum, and natural gas.	ALT04	-0.964	-0.618	-0.615	-0.149
	Place a 10% intermediate input use tax (τitp) on coal electricity production and give a 10% subsidy to renewable electricity production.	ALT05	-0.331	-0.205	-0.204	-0.050
	Place a 10% intermediate input use tax (τitp) on petroleum electricity production and give a 10% subsidy to renewable electricity production.	ALT06	0.031	0.019	0.019	0.005
	Place a 10% intermediate input use tax (τitp) on natural gas electricity production and give a 10% subsidy to renewable electricity production.	ALT07	-0.532	-0.333	-0.332	-0.081
INDUSTRY	Place a 10% intermediate input use tax (τitp) on mineral sector.	ALT08	-0.157	-0.542	-0.502	-0.042
TRANSPOR	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation and give 10% subsidies on the same points in railway transportation.	ALT9	-0.329	-0.493	-0.854	-0.061

TATIO N	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation and give 10% subsidies on the same points in water transportation.	ALT10	-0.326	-0.403	-0.756	-0.054
	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation.	ALT11	-0.330	-0.494	-0.856	-0.061
WAST E	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in waste.	ALT12	-0.107	-0.204	-0.218	-0.025
AGRI CULT URE	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in agriculture.	ALT13	-0.035	-0.008	-0.673	0.033

Source: Author’s calculations.

5.3. DISCUSSION OF THE RESULTS

Alternative tax policies in the energy main sector are the most efficient policies, only ALT01, primary energy tax policy performed a bit worse than the other energy policies. These policies decreased emissions at highest rates but declines in the economic indicators were the least. Taxing policy with the aim of reducing electricity use in both production and consumption sides contributes the most to emissions reduction. Taxing fossil fuel electricity use in production with the aim of directing electricity producers to adopt co-generation technologies is promising. The policies using tax and subsidy options together to transfer electricity production volume to hydro and renewable sources are promising as well. The second best policies included in the policy mix belongs to the transportation main sector. It can be seen that emissions reduction costed more in transportation policies. Taxing highway transportation alone, taxing highway and subsidizing railway and water transportations are prominent. But, transfer to railway and water transportation requires high rates of subsidies in these sectors. Taxing waste sector with an aim of decreasing waste amount was included into the policy mix proposed, as well. These policies should be the priorities in climate change mitigation policy making in Turkey. The policies in the industry and agriculture main sectors considered as inefficient.

The policy mix proposed in this chapter provides a 6.136% decrease in emissions level. This policy mix was consisting energy, transportation, and waste sectors. The 21% target still can't be achieved even though some policies applied tax rates over 20% by adding consumption taxes on intermediate input use taxes. In addition, GDP decreased at 5.939% with this policy mix. Achieving the INDC emissions mitigation target does not seem possible only by taxing emissions.

There are two limitations of the MGMSCGE model developed by the author. In modeling the production part, “one sector produces one unique product” assumption was adopted and electricity product was produced by five separate sectors. However, electricity is the same product regardless of the source. These sectors could have been modeled as producing the same single product, in this way, transfers between sectors (suppliers) would have been easier and more consistent. Such a modeling can be done by developing a separate model to be linked to the CGE or modeling it in the CGE. Modeling in the CGE requires a different nesting structure, different intermediate input use, and separate factor endowments to produce electricity. In both case, consumption and production structure of the main model becomes complex a lot. Instead, taxing and subsidizing tools were employed together so as to change the supplier sector from one to another. The second limitation was about extending the model with dynamics. Such a model would have created a structure that allowed autonomous efficiency improvements and presented green investment as a policy option.

CHAPTER 6: DETERMINING THE DRIVERS OF CHANGES IN EMISSIONS INVENTORY BETWEEN 2002-2012 BY STRUCTURAL DECOMPOSITION ANALYSIS

Decomposition analysis has been widely used to study the driving forces of changes of an aggregate indicator over time. It is useful to analyze changes in indicators such as gross output, labor demand, value added, energy demand, and greenhouse gas emissions. When greenhouse gas emissions are the concern, effectiveness of the existing or planned policies can be evaluated and improved by the results taken from the decomposition analysis. Stated in other words, the previous knowledge of factors of greenhouse gas emissions can allow to know the exact relations between the economy and greenhouse gas emissions. In this way, meeting economic growth targets and even decreasing greenhouse gas emissions can be possible without ignoring the link between energy consumption and growth [127].

6.1. METHOD: STRUCTURAL DECOMPOSITION ANALYSIS

Data of this study comprises two conjugated Environmentally Extended SAMs belonged to 2002 and 2012 years. 2002 and 2012 years Environmentally Extended SAMs are given in Appendix A and B respectively. Another step before applying SDA was to deflate the 2012 Environmentally Extended SAM to 2002. CPI index was taken from the World Bank [8].

SDA method can be expressed in two forms: additive and multiplicative. Additive version of this method is utilized in which the change in one variable is decomposed as summation of changes in the components of that variable. Additive form is applied in this study since this form has been overwhelmingly applied in SDA [55]. There are various decomposition techniques given in the additive form. They include ad hoc, the logarithmic mean Divisia index (LMDI-I and LMDI-II), the Dietzenbacher and Los (D&L), the Sun's (S/S), and the mean rate of change index (MRCI) techniques. In the study of Su and Ang [55], 43 SDA studies conducted in the 1999-2010 period were grouped into four categories according to the techniques they used, ad hoc, D&L, LMDI, and others, and the number of studies using D&L, LMDI, ad hoc, and others were 23, 5, 11, and 4, respectively. D&L decomposition technique was chosen in this study as well. Because, this technique had a vast theoretical and empirical literature which eases application of the technique and comparability of the results.

Traditionally, SDA has been developed for applications based on input-output tables but was applied to SAMs in this study. Because input-output tables focus primarily on analyses related to production and do not cover all relevant aspects related to income distribution, however, a SAM includes socio-economic information. The application allows to integrate the primary effects of income generation (through demand on the sector and linked sectors) and the secondary effects of income re-distribution (through institutional transfers) into a single decomposition. Applying SDA to SAMs follows similar steps with input-output analysis. The method is based on the general formula of multiplier analysis and differs from input-output only in determining endogenous accounts as clarified below. The study of Saari et al. [128] is the only study applying SDA to SAM in the literature. On contrary to this study’s claim, the authors claim that applying SDA to SAM requires a non-trivial extension of the methodology.

SDA method is derived from the SAM multiplier equation as follows:

$$\Delta x^{d} = (I - A)^{-1}\Delta f \qquad (65)$$

where Δx^d denotes the change in the output, $(I\text{-}A)^{-1}$ term is the Leontief inverse (L), Δf is a given change in final demand, A denotes the technical coefficients matrix and I denotes the identity matrix.

Technical coefficient matrix is formulated as follows:

$$A = S\left(X^{d}\right)^{-1} \qquad (66)$$

where S denotes the endogenous matrix and $(X^d)^{-1}$ denotes a diagonal matrix whose diagonal elements are defined as the total output of each industry.

Change in pollutant (emissions) is calculated with the following formulas:

$$\Delta p = P(I - A)^{-1}\Delta f = P\Delta x^{d} \qquad (67)$$

where P is a matrix defining pollutant released to environment by producing 1.00 monetary unit output of ith sector.

The first step is defining the first four accounts (production, factors of production, and households) as endogenous and the remaining three accounts (government, saving/investment, rest of world) as exogenous in the SAMs.

If factors behind the change in gross outputs (Δx^d) between two periods are to be decomposed, it can be broken down into that part associated with changes in technology (the Leontief inverse) and that part related to changes in final demand (Δf) over the period. And there are numerous additional options to decompose other than gross output, such as changes in employment, energy use, and carbon emissions and an aggregate indicator can be decomposed into more than two terms. And also, the total change in the Leontief inverse matrix and final demand can further be disaggregated into their own factors.

When time is notated with t, gross outputs for two different periods are defined as follows:

$$x^t = L^t f^t \quad \text{and} \quad x^{t-1} = L^{t-1} f^{t-1} \qquad (68)$$

where $\mathbf{f}^t$ is the vector of final demands in year *t*, and $L^t = (I\text{-}A)^{-1}$ is Leontief inverse in year t. Then the observed change in gross outputs over the period is:

$$\Delta x = x^t - x^{t-1} = L^t f^t - L^{t-1} f^{t-1} \qquad (69)$$

The task is to decompose the total change in outputs into changes in the various components in equation (69). The simplest way to do this means separation into changes in L and f:

$$\Delta L = L^t - L^{t-1} \quad \text{and} \quad \Delta f = f^t - f^{t-1} \qquad (70)$$

A number of alternative expansions and rearrangements of the terms in equation (70) can be derived. For example, using only year-t values for L and only year-(t-1) values for f and replacing L^{t-1} with $(L^t\text{-}\Delta L)$ and f^t with $(f^0\text{+}\Delta f)$, equation (70) can be written as follows:

$$\Delta x = L^t(f^{t-1} + \Delta f) - (L^t - \Delta L)f^{t-1} = (\Delta L)f^{t-1} + L^t(\Delta f) \qquad (71)$$

Alternatively, using only year-(t-1) values for L and only year-t values for f, replacing L^t with $(L^{t-1}\text{+}\Delta L)$ and f^{t-1} with $(f^t - \Delta f)$, equation (70) becomes:

$$\Delta x = (L^{t-1} + \Delta L)f^t - L^{t-1}(f^t - \Delta f) = (\Delta L)f^t + L^{t-1}(\Delta f) \qquad (72)$$

And, two more decompositions can be made for this two-factor equation, using only year-(t-1) values for both factors or only year-t values. In this paper, we adopt the recommendation of Dietzenbacher and Los [129] and employ the average of two polar decomposition formulae to decompose the global growth of CO2 emission into each determinant. Adding equation (71) and (72) gives:

$$2\Delta x = (\Delta L)f^{t-1} + L^t(\Delta f) + (\Delta L)f^t + L^{t-1}(\Delta f)$$
$$\Delta x = \left(1/2\right)(\Delta L)(f^{t-1} + f^t) + \left(1/2\right)(L^{t-1} + L^t)(\Delta f) \qquad (73)$$

where $(\Delta L)(f^{(t-1)}+f^t)$ is technology change and $(L^{(t-1)}+L^t)(\Delta f)$ is final-demand change.

As mentioned above, a product can be decomposed into more factors than two and those factors can be further decomposed into their own factors as well. Additive decompositions with products of more than two terms is the extension of the logic of equations (71) and (72). Let $y^t=x_1^t x_2^t$ represent the general case in which y^t is the product of two variables, and the decompositions of $\Delta y=x_1^1 x_2^1 - x_1^0 x_2^0$ (similar to equation (69)) are seen to be of the forms $\Delta y=(\Delta x_1)x_2^0+x_1^1(\Delta x_2)$ (similar to equation (71)) and $\Delta y=(\Delta x_1)x_2^1+x_1^0(\Delta x_2)$ (similar to equation (72)), respectively. The usual averaging leads to $\Delta y=(1/2)(\Delta x_1)(x_2^0+x_2^1)+(1/2)(x_1^0+x_1^1)(\Delta x_2)$. An approach for the case of more than two terms:

$$y^t = x_1^t x_2^t \dots x_n^t$$
$$\Delta y = (\Delta x_1)(x_2^0 \dots x_n^0) + x_1^1(\Delta x_2)(x_3^0 \dots x_n^0) + \cdots$$
$$+ (x_1^1 \dots x_{n-2}^1)(\Delta x_{n-1})x_n^0 + (x_1^1 \dots x_{n-1}^1)(\Delta x_n)$$

$$\Delta y = (1/2)(\Delta x_1)[(x_2^0 \dots x_n^0) + (x_2^1 \dots x_n^1)] + (1/2)[x_1^0(\Delta x_2)(x_3^1 \dots x_n^1) + x_1^1(\Delta x_2)(x_3^0 \dots x_n^0)] + \cdots + (1/2)[(x_1^0 \dots x_{n-2}^0)(\Delta x_{n-1})x_n^1 + (x_1^1 \dots x_{n-2}^1)(\Delta x_{n-1})x_n^0] + (1/2)[(x_1^0 \dots x_{n-1}^0) + (x_1^1 \dots x_{n-1}^1)](\Delta x_n) \quad (74)$$

In this study, decomposition of CO2 emissions requires a three-term break down into emission coefficient, technology (the Leontief inverse), and final demand. And also, final demand is decomposed into final demand mix (shares of sectors), per capita expenditure, and population. The decomposition equation is:

$$\Delta ghg = (1/2)(\Delta P)[(L^0f^0 + L^1f^1)] + (1/2)[P^0(\Delta L)f^1 + P^1(\Delta L)f^0] + (1/4)[(P^0L^0 + P^1L^1)(\Delta u)(pce^0pop^0 + pce^1pop^1)] + (1/4)[(P^0L^0 + P^1L^1)(u^0\Delta pce\ pop^1 + u^1\Delta pce\ pop^0)] + (1/4)[(P^0L^0 + P^1L^1)(u^0pce^0 + u^1pce^1)\Delta pop] \quad (75)$$

where ghg is greenhouse gas emissions amount, P is emission coefficient, L is Leontief inverse, f is final demand, u is final demand shares, pce is per capita expenditure, and pop is population.

6.2. RESULTS AND DISCUSSION

The findings obtained from the decomposition analysis provide insight into the causes of increase in Turkish CO2 emissions in the period 2002-2012. The results based on equation (75), are presented in total in Table 17 and by sectors in Table 18.

The first part of the equation (75) gives emissions change due to change in emission coefficient (P). Total change due to emission coefficient was positive and 1.88%, meant that emission coefficients increased in the overall economy in this period and contributed to emissions increase, but its share was very low. Change due to emission coefficients can also be named as carbon intensity change. However, when the results are examined by sector, it can be seen that emissions change due to coefficient in household account was positive and counteracted the negative change in production. This can be interpreted as carbon intensity of production decreased but household consumption behaviors became more carbon intensive. In addition, emissions change due to emission coefficient in any sector was negligible.

The second part of the equation (75) shows the effects of production technology on emissions change. Total effect was negative and had a 14.31% share. It can be said that overall production technology, actually input mix of sectors, became less emitting. A sector can contribute positively to emissions change in a period due to its emission coefficient even though its technology becomes less emitting, hereby technology refers to intermediate input mix of the sector which can become less emitting in the period. This result is involved to efficiency.

When contributions of technology change by each sector is examined, increases in waste, electricity production from coal, and electricity production from natural gas sectors are worrying, and agriculture sector surprisingly contributes much to emissions reduction with its change in technology.

The most significant factor became the final demand in the analysis but amount (scale) effect was the determiner, final demand share's impact was negligible. Final demand shares factor contributed to total emissions change at -0.98% rate. When the results due to final demand shares were reviewed, only the agriculture sector seems to have made a significant contribution to reducing total emissions.

Final demand amount was broken into two factors, per capita expenditure and population. The changes in per capita expenditure and population were the most effective factors in emissions change with positive 91.78% and 21.63% shares, respectively. Per capita expenditure's high contribution could be interpreted as consumer behaviors became extremely more carbon intensive during these years. It is a serious concern and there is a room for improvement as shown over population and per capita emissions time series in Figure 1 in Introduction chapter. Population contributed much to emissions increase as well.

When each sector's contribution in per capita expenditure factor is reviewed, it seems that all sectors contributes positively. Agriculture; manufacture of coke, petroleum, nuclear fuel; mineral; metal; highway transportation; industry; electricity production from coal; and electricity production from natural gas sectors are the most contributing ones. When population factor is reviewed, once more all sectors contributes positively and some of the same sectors contributes the most, agriculture, mineral, highway transportation, electricity production from coal, and electricity production from natural gas.

Table 17. Results of SDA decomposition

		amount (kg CO2 eq.)	share (%)
analysis	change in emission coefficient (P)	3 929 490 562	1.88
	change in technology (L)	-29 934 906 362	-14.31
	change in final demand shares (u)	-2 046 823 268	-0.98
	change in per capita expenditure (pce)	191 960 339 462	91.78
	change in population (pop)	45 234 945 802	21.63
	total change in emissions (ghg)	209 143 046 195	
actual values	2002 total emissions	231 552 967 433	
	2012 total emissions	440 696 014 092	
	total change in emissions	209 143 046 658	

Source: Author's calculations.

Table 18. Results of SDA decomposition by sectors

		change due to emission coefficient (P)	change due to technology (L)	change due to final demand shares (u)	change due to per capita expenditure (pce)	change due to population (pop)
	Agriculture	2 507 093 899	-21 265 230 450	-4 555 375 330	29 079 076 211	6 753 067 179
	Coal mining	- 33 410 141	1 704 010 638	-1 725 936 100	1 931 735 362	415 303 471
	Petroleum, natural gas extraction	2 198 251 194	-1 678 521 890	- 857 551 581	1 086 690 377	236 280 175
	Food	-2 343 364 033	-1 371 027 728	- 593 789 971	2 104 771 504	482 614 328
	Manufacture of coke, petroleum, nuclear fuel	-7 462 679 766	759 307 559	55 577 921	4 161 536 429	982 993 899
	Chemistry	-3 602 916 501	-1 312 892 659	1 183 375 943	4 711 360 454	1 139 086 089
	Mineral	3 742 584 639	-4 444 499 101	1 503 382 913	25 299 439 267	6 003 237 391
	Metal production	-5 419 499 377	-1 700 814 451	2 652 107 503	7 830 936 021	1 909 352 430
	Waste	- 2 130 050	8 225 356 891	2 816 525 024	3 248 481 623	832 213 189
	Railway transport	2 522 047	- 7 887 322	1 008 510	18 194 595	4 315 647
	Highway transport	3 549 167 036	-10 599 084 339	- 457 282 885	25 776 347 934	6 069 859 147
	Water transport	662 104 638	- 599 269 358	- 138 442 788	704 288 515	162 899 894
	Air transport	-1 088 069 401	176 324 255	- 152 216 729	1 854 690 706	433 953 849
	Industry	3 517 852 019	-3 240 664 635	703 125 319	11 240 318 543	2 668 008 958
	Service					
	Elec.coal	-4 045 974 703	12 662 675 874	- 819 747 084	25 001 881 370	5 878 683 268
	Elec.pet.	- 336 848 662	-8 951 608 124	- 154 060 050	3 164 055 721	742 785 812
	Elec.nat.gas	-3 513 820 835	8 611 922 544	- 732 384 829	21 971 521 414	5 165 875 142
	Elec.hydro					
Products	Elec.renew.					
Household		15 598 628 558	-6 903 004 066	- 775 139 053	22 775 013 417	5 354 415 936
Total		3 929 490 562	-29 934 906 362	-2 046 823 268	191 960 339 462	45 234 945 802

Source: Author’s calculations.

When the contributions of the two aggregate factors (technology and final demand) to the emission change is examined, it is seen that the technology contributed to the decrease of emissions, but the final demand had an effect that increased the emissions. Therefore, increasing the number of policies on consumption side can contribute significantly to emissions reduction. However, the goals in the national documents were mostly related to production part of the economy.

Emission coefficients contributed positively to the emissions change even its share in total change was low. This means that Turkey increased its emissions per TL instead of decreasing.

Production technology in each sector still needs to become less emitting, but, the waste, electricity production from coal and natural gas sectors of which emissions have increased due to technology in the 2002-2012 period, needs to be rigorously dealt. Efficiency increasing policies should be made in these sectors.

The final demand share impact on emissions change was negligible but final demand amount had the biggest impact; and per capita consumption was the determiner in its own decomposition into per capita expenditure and population. In the consumption side, as mentioned above, policies that reduce per capita consumption should be of first priority and besides, consumers should be directed to less emitting products so as to change final demand shares. Especially, consumption of the products of agriculture, mineral, highway transportation, electricity production from coal and electricity production from natural gas must be decreased.

CHAPTER 7: CONCLUSION

Three analyses were conducted in the study to make policies to achieve the emissions mitigation target in the INDC document of Turkey. Policies generated from NCCAP and INDC documents goals, and alternative policies generated by the author inspired by these national documents and using her own analysis on emission coefficients were analyzed by Multiplier Analysis method and this analysis established the main framework of the study. Multiplier Analysis was preferred as the method to transform NCCAP and INDC goals into policies as these goals were more suitable to be expressed as final demand shocks. In addition, various policies were generated by benefitting SAM multipliers and run by Multiplier Analysis method. To grow the economy, sectors with high multiplier values have been supported by demand transfers to them, and in this way, an attempt has been made to answer the question of whether such policies contribute to the emissions reduction. Various tax policies were also generated to be alternatives to the INDC policies. Similar to the Emissions Decreasing policies, these policies were also inspired by the NCCAP and INDC policies and were based on the author's own emissions grouping. A static, 20-sector CGE model was developed and these tax policies were run in the model to enhance policy options for Turkey. In addition, to evaluate validity of the proposed policies, emissions changes between 2002 and 2012 years were decomposed into five factors by using Structural Decomposition Analysis.

The INDC document contains many goals but very few of them could be transformed to policies due to lack of comprehensiveness or lack of political will. The three policies generated from the document reduced emission at 3.20% rate only. The INDC Content Brief Report of Turkey produced by the World Bank [130] reviewed the INDC under six titles (cost of implementation, capacity building needs, technology needs, unconditional part of mitigation target, conditional part of mitigation target, emissions reduction potential); and unfortunately, the document was found deficient in all of these. There is widespread concern about the accuracy of the INDC BAU projections. The report by WWF-Turkey and IPC [46] which was prepared before the INDC submission, consisted of two different scenarios, official plans scenario with the growth rates of Turkey's official economic program and BAU scenario with more realistic growth rates. Acar and Yeldan [44] found the emissions projection in the INDC too high and not in line with the recent Turkish historical pathway. The report by TUSIAD [47] prepared its own BAU scenario by using Climate Equity Reference Project (CERP) which uses projections of IMF, McKinsey, and the World Bank. In addition, the results of this study show that emissions reduction obtained by applying the NCCAP policies for three years is only slightly less than emissions reduction obtained by applying the INDC policies for ten years. This is not surprising as the NCCAP policies are both numerous and measurable, yet it is disconcerting that the NCCAP is more comprehensive even though it was a reference for the INDC. Moreover, two policies derived from the INDC document were about increasing the shares of electricity from hydro and renewable energy sources which is in contradiction with the recent commitments of Turkey about utilizing all coal reserves in the country.

Comparison of results of the NCCAP simulation with the existing 2015 emissions inventory showed that Turkey could have reduced its emissions by 2.69% from 2012 to 2015, but actual emissions were higher by 5.84%. Although the NCCAP contained a decision on the establishment of a committee to monitor and evaluate the implementation status, this unit has yet to issue such a report. Furthermore, the documents published after the NCCAP and given as references in the INDC document do not include any information about implementation of the NCCAP goals; 10th National Development Plan, National Strategy on Industry, Energy Efficiency Strategy Paper, National Strategy and Action Plan on Recycling, National Legislation on Monitoring, Reporting and Verification of GHG emissions, National Smart Transportation Systems Strategy (2014-2023) and its Action Plan (2014-2016). Turhan et al. [131] also criticized Turkey as maintaining a peculiar position under UNFCCC for two decades, and with the new climate regime now in place, they claimed that the country's mitigation pledges were falling short of expectations both in terms of realistic projections and its ambition to step up in the post-2020 period.

The policy mixes proposed by Multiplier Analysis and CGE analysis have the same aims mostly but their results were different a bit as expected due to the policies generated. Energy and transportation main sectors policies were the most effective in both analyses. Reducing primary energy intensity was not as effective as the other energy policies but it was proposed by both analyses. All of the policies generated for electricity production stood out. The policies generated with the aims of increasing efficiency in electricity production from fossil fuels by implementing cogeneration technologies, replacing fossil fuels with renewable and hydro energy sources, and reducing electricity intensity in production and consumption were very effective.

Increasing efficiency in road transportation by increasing public transport share and putting sustainable transport solutions into practice, and transferring volume to railway and water transportation policies were efficient and proposed by the analyses. The former policy gave better results in the Multiplier Analysis simulation, because, this policy would decrease transportation demand and a decrease shock was a direct expression of this situation. In this way, this policy was superior to the transfer policies. On the other hand, when applying tax and subsidy policy to transfer volume to other modes, subsidies must be at high rates.

To realize the goal of decreasing carbon intensity per GDP in the industrial sectors, a transfer policy from high-emitting mineral sector to service sector was generated in Multiplier Analysis. It was included in the policy mix proposed in Multiplier Analysis. In CGE analysis, all sectors using mineral sector's products as intermediate inputs were taxed to decrease the demand of this sector. However, it was not included in the policy mix proposed by CGE analysis as it decreased employment, GDP and output at much higher rates than emissions. In the industry main sector, taxing can't help to reduce emissions effectively, but transfers among sectors are not usually very possible on the other hand. Thus, in the short term, shrinking domestic production in the high emitting sectors and importing from the countries that produce with low-carbon technologies, is the most effective policy. In the long term, those low carbon technologies must be transferred from those countries.

Increasing efficiency in the agriculture sector can reduce emissions at high rates at low costs to the economy as shown in the Multiplier Analysis, but, taxing can't be a reasonable action at all. Managing wastes more properly and taxing waste production both in industries and final consumption policies are efficient as proposed by Multiplier Analysis and CGE analysis, respectively.

When a conclusion is drawn from the results of the SDA; efficiency increasing policies in production processes of the waste, electricity from coal and electricity from natural gas sectors, and decreasing total final demand shares and per capita consumption amounts of agriculture, mineral, highway transportation, electricity from coal and electricity from natural gas sectors were the two policies proposed. Efficiency policies proposed in waste and electricity producing sectors were proposed in Multiplier Analysis and CGE analysis, and it was supported with the former finding of the SDA. It must be emphasized that the biggest opportunity for reducing emissions were in the consumption side of the economy in contradiction to NCCAP and INCD documents. Even though the sectors to be dealt with priority were similar with the Multiplier Analysis and CGE analysis, these results indicate that it is necessary to work more on reducing per capita consumption.

The policies proposed by the two analyses can’t achieve the 21% target. The author generated her own policies adhering to the NCCAP and INDC policies and because of this, different climate change mitigation policy tools were not employed, such as Emissions Trading System. High demand changes in Multiplier Analysis and tax rates that shrank the economy greatly in CGE analysis could not help to reach the target, and because of this, more forceful policies are required.

In conclusion, as reaching the INDC target seems impossible for Turkey, the INDC target and the document itself should be revised in 2020 in accordance with the Paris Agreement which foresees an update of NDCs every five years. As each Party will undergo a technical expert review during the period, the document should also be supported by a series of analyses that determining mitigation target and actions to be taken. This will also help Turkey to be eligible to receive international support for its financial, technology and capacity-building needs. Another failure in the INDC would not only make Turkey more vulnerable to this seemingly inevitable change, but also can completely undermine any opportunity it has to shape the process.

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APPENDIX A

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APPENDIX B

APPENDIX C

NCCAP Simulations												
NCCAP document				Author								
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	PURPOSE E1. Reducing energy intensity	OBJECTIVE E1.1. Reduce primary energy intensity at 10% by 2015 as a result of implemented and planned policies and measures	All	Yes	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of primary energy sectors (coal mining, petroleum,natural gas extraction, coke,refined petroleum).	NCCAP01	-0.09	na	na	na	-0.05	-0.06
		OBJECTIVE E1.2. Develop the capacity for energy efficiency by 2015	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE E1.3. Support R&D activities on energy efficiency	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE E1.4. Increase the amount of incentives given by Renewable Energy General Directorate for energy efficiency applications by 100% until 2015	All	Yes	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of all electricity producing sectors.	NCCAP02	-0.63	na	na	na	-0.83	-1.79

NCCAP Simulations (continues)												
NCCAP document				Author								
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	PURPOSE E2. Increase the share of clean energy in energy production and use	OBJECTIVE E2.1. Ensure that the share of renewable energy in electricity production is increased	E 2.1.1.1. Utilizing entire technical and economic potential for hydroelectric energy on basin-basis, in consideration of economic, environmental and social conditions until 2023.	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from coal electricity sector to hydro electricity sector at a rate of 16.3% of total exogenous electricity final demand (1 925 550 thousand tl). (Technical and economic hydroelectric energy potential planned to be used in 2023 is 356 216 and 140 billion kWh respectively. This means 97 billion kWh must be in use in 2015. This is a shock increasing hydro electricity share from 24.2% to 40.5% in total electricity production.)	NCCAP03	-0.82	0.00	0.00	0.00	-2.18	-4.92
			Others	No	-	-	-	-	-	-	-	-
		OBJECTIVE E2.2 Develop capacity by 2015 so as to increase utilization of renewable energy resources	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE E2.3 Ensure technological development by 2020 for energy production from renewable energy resources	All	No	-	-	-	-	-	-	-	-

NCCAP Simulations (continues)												
NCCAP document				Author								
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	PURPOSE E3. Limit GHG emissions originating from use of coal in electricity production, by using clean coal technologies and taking efficiency-increasing measures	OBJECTIVE E3.1. Increase the average cycle efficiencies of existing coal-fired thermal power plants until 2023	All	No	-		-	-	-	-	-	-
	PURPOSE E4. Reduce losses and illicit use in electricity distribution	OBJECTIVE E4.1. Reduce nationwide electricity distribution losses to 8% by 2023	All	Yes	INCREASING EFFICIENCY TYPE SHOCK: A decrease shock in all electricity sectors at a rate of 2.18% (8%*3/11).	NCCAP04	-0.14	na	na	na	-0.18	-0.39

NCCAP Simulations (continues)													
NCCAP document				Author									
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
INDUSTRY	PURPOSE S1. Increase energy efficiency in the industry sector	OBJECTIVE S1.1. Making legal arrangements for energy efficiency and limitation of greenhouse gas emissions	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE S1.2 Limiting GHG emissions originating from energy usage (including electrical energy share) in the industry sector	All	No	-	-	-	-	-	-	-	-
	PURPOSE S2. Decrease the CO_2 equivalent intensity per GDP produced in the industrial sector until 2023	OBJECTIVE S2.1. Developing the financial and technical infrastructure for limitation of GHG emissions	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE S2.2. Develop and use new technologies for limitation of GHG emissions in the industry sector until 2023	All	No	-	-	-	-	-	-	-	-
	PURPOSE S3. Strengthen the capacity of the industry sector for combating climate change	OBJECTIVE S3.1. Building the information infrastructure for limitation of GHG emissions in the industry sector until 2015	All	No	-	-	-	-	-	-	-	-

NCCAP Simulations (continues)												
NCCAP document				Author								
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
TRANSPORTATION	PURPOSE U1.Developing an intermodal transport system and ensuring balanced utilization of transport modes in freight and passenger transport	OBJECTIVE U1.1. Increasing the share of railroads in freight transportation (which was 5% in 2009) to 15% and in passenger transportation (which was 2% in 2009) to 10% by 2023	All	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to railway transport at a rate of 10% of total highway transport (5 899 214).	NCCAP05	-0.22	-0.05	-0.01	0.00	0.00	0.00
		OBJECTIVE U1.2. Increasing the share of seaways in cabotage freight transportation (which was 2.66% in ton-km in 2009) to 10%, and in passenger transportation (which was 0.37% in passenger-km in 2009) to 4% as of 2023	All	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to water transport at a rate of 10% of total highway transport (5 899 214).	NCCAP06	-0.30	0.08	0.02	0.01	0.00	0.02
		OBJECTIVE U1.3. Decreasing the share of highways in freight transportation (which was 80.63% in ton-km in 2009) below 60%, and in passenger transport (which was 89.59 in passenger-km in 2009) to 72% as of 2023	All	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from highway transport to railway transport at a rate of 20% of total highway transport (11 798 428).	NCCAP07	-0.44	-0.09	-0.02	0.00	0.00	-0.01
		OBJECTIVE U1.4. Preparing and putting in practice the "Transportation Master Plan" until 2023	All	No	-	-	-	-	-	-	-	-

NCCAP Simulations (continues)													
NCCAP document				Author									
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
TRANSPORTATION	PURPOSE U2: Restructuring urban transportation in line with sustainable transport principles	OBJECTIVE U2.1. Limiting emission increase rate of individual vehicles in intracity transport	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE U2.2. Developing the necessary legislation, institutional structure and guidance documents until the end of 2023 for implementation of sustainable transport planning in cities	All	No	-	-	-	-	-	-	-	-
	PURPOSE U3: Dissemination of the use of alternative fuels and clean vehicle technologies in the transport sector	OBJECTIVE U3.1. Making legal arrangements and building capacity to increase use of alternative fuels and clean vehicles until 2023	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE U3.2. Taking local measures to encourage use of alternative fuel and clean vehicles in urban transport until 2023	All	No	-	-	-	-	-	-	-	-
	PURPOSE U4. Increasing efficiency in energy consumption of transportation sector	OBJECTIVE U4.1. Limiting the energy consumption in transport until 2023	All	No	-	-	-	-	-	-	-	-
	PURPOSE U5. Developing the information infrastructure in the transport sector	OBJECTIVE U5.1. Building a well-organized, reliable and sustainable information infrastructure with transport and travel data including GHG emission data, until the end of 2016	All	No	-	-	-	-	-	-	-	-

NCCAP Simulations (continues)													
NCCAP document				Author									
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
WASTE	PURPOSE A1. Ensure Effective Waste Management	OBJECTIVE A1.1. Reduce the quantity of biodegradable wastes admitted to landfill sites, by 75% in weight till 2015, by 50% till 2018 and by 35% till 2025	All	Yes	INCREASING EFIICIENCY TYPE SHOCK: A 10% decrease in all waste amount. (Objective A1.1. does not give a clear goal. Waste statistics of Turkish Statistical Institute does not give sufficient detail about waste types.)	NCCAP08	-0.05	na	na	na	-0.02	-0.02
		OBJECTIVE A1.2. Establish integrated solid waste disposal facilities across the country, and dispose 100% of municipal wastes in these facilities, until the end of 2023	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE A1.3. Finalize Packaging Waste Management Plans	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE A1.4. Establish the recycling facilities foreseen within the scope of the Solid Waste Master Plan with the EU-aligned Integrated Waste Management approach	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE A1.5. Termination of uncontrolled disposal of wastes 100% by 2023	All	No	-	-	-	-	-	-	-	-

NCCAP Simulations (continues)													
NCCAP document				Author									
Sector	Purpose	Objective	Action	Measurability	Policy for 2015	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
AGRICULTURE	PURPOSE T1. Increase the sink capacity of the agriculture sector	OBJECTIVE T1.1. Determine and increase the quantity of carbon stock captured in the soil	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE T1.2. Identifying and increasing topsoil and subsoil biomass			-	-	-	-	-	-	-	-
	PURPOSE T2. Limitation of greenhouse gas emissions from agriculture sector	OBJECTIVE T2.1. Identify the potential GHG emissions limitation in agriculture sector	All	No	-	-	-	-	-	-	-	-
		OBJECTIVE T2.2. Decrease the increase rate of GHG emissions originating from vegetal and animal production			-	-	-	-	-	-	-	-
	PURPOSE T3. Develop information infrastructure and capacity in the agriculture sector	OBJECTIVE T3.1. Build the information infrastructure that will meet the needs of the agriculture sector in adapting to and combating climate change	All	No	-	-	-	-	-	-	-	-

INDC simulations										
INDC document		Author								
Sector	Plans and policies to be implemented	Measurability	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Increasing capacity of production of electricity from solar power to 10 GW until 2030	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from coal electricity sector to renewable electricity sector at a rate of 14.3% of total exogenous electricity final demand (1 685 201 thousand tl). (Total electricity power installed in 2030 is estimated to be 149,821 MW (5.5% growth per year), and renewable electricity share is aimed to be 26,000 MW. This is a shock increasing renewable electricity share from 3.1% to 17.4% in total electricity production.)	INDC01	-0.72	0.00	0.00	0.00	-1.91	-4.30
	Increasing capacity of production of electricity from wind power to 16 GW until 2030	Yes								
	Tapping the whole hydroelectric potential	Yes	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts first from coal electricity, then petroleum electricity, then natural gas electricity sectors to hydro electricity sector at a rate of 32.4% of total exogenous electricity final demand. (3 819 585 thousand tl). (Total electricity production in 2030 is estimated to be 628.9 billion kWh (5.5% growth per year), and technical and economic hydroelectric energy potential is 356 billion kWh. This is a shock increasing hydro electricity share from 24.2% to 56.6% in total electricity production.)	INDC02	-1.54	0.00	0.00	0.00	-3.79	-8.55
	Commissioning of a nuclear power plant until 2030	No	-	-	-	-	-	-	-	-
	Reducing electricity transmission and distribution losses to 15 percent at 2030	Yes	INCREASING EFFICIENCY TYPE SHOCK: A decrease shock in all electricity sectors at a rate of 15%.	INDC03	-0.94	na	na	na	-1.25	-2.68
	Rehabilitation of public electricity generation power plants	No	-	-	-	-	-	-	-	-
	Establishment of micro-generation, co-generation systems and production on site at electricity production	No	-	-	-	-	-	-	-	-

INDC simulations (continues)										
INDC document		Author								
Sector	Plans and policies to be implemented	Measurability	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
INDUSTRY	Reducing emission intensity with the implementation of National Strategy and Action Plan on Energy Efficiency	No	(There is not any policy related to emission intensity in the National Action Plan on Energy Efficiency document published in 2016, after INDC submission)	-	-	-	-	-	-	-
	Increasing energy efficiency in industrial installations and providing financial support to energy efficiency projects	No	-	-	-	-	-	-	-	-
	Making studies to increase use of waste as an alternative fuel at the appropriate sectors	No	-	-	-	-	-	-	-	-
TRANSPORTATION	Ensuring balanced utilization of transport modes in freight and passenger transport by reducing the share of road transport and increasing the share of maritime and rail transport	No	-	-	-	-	-	-	-	-
	Enhancing combined transport	No	-	-	-	-	-	-	-	-
	Implementing sustainable transport approaches in urban areas	No	-	-	-	-	-	-	-	-
	Promoting alternative fuels and clean vehicles	No	-	-	-	-	-	-	-	-
	Reducing fuel consumption and emissions of road transport with National Intelligent Transport Systems Strategy Document (2014-2023) and its Action Plan (2014-2016)	No	(There are two policies in the National Intelligent Transport Systems Strategy Document (2014-2023) and its Action Plan (2014-2016), but they are not measurable at all.)	-	-	-	-	-	-	-
	Realizing high speed railway projects	No	-	-	-	-	-	-	-	-
	Increasing urban railway systems	No	-	-	-	-	-	-	-	-
	Achieving fuel savings by tunnel projects	No	-	-	-	-	-	-	-	-
	Scraping of old vehicles from traffic	No	-	-	-	-	-	-	-	-

	Implementing green port and green airport projects to ensure energy efficiency	No	-	-	-	-	-	-	-	-
	Implementing special consumption tax exemptions for maritime transport	No	-	-	-	-	-	-	-	-

INDC simulations (continues)										
INDC document		Author								
Sector	Plans and policies to be implemented	Measurability	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
WASTE	Sending solid wastes to managed landfill sites	No	-	-	-	-	-	-	-	-
	Reuse, recycle and use of other processes to recover secondary raw materials, to utilize as energy source or to remove wastes	No	-	-	-	-	-	-	-	-
	Recovering energy from waste by using processes such as material recycling of wastes, bio-drying, bio-methanization, composting, advanced thermal processes or incineration	No	-	-	-	-	-	-	-	-
	Recovery of methane gas from landfill gas from managed and unmanaged landfill sites	No	-	-	-	-	-	-	-	-
	Utilization of industrial wastes as an alternative raw material or alternative fuel in other industrial sectors, through industrial symbiosis approach	No	-	-	-	-	-	-	-	-
	Conducting relevant studies to utilize wastes generated from breeding farms and poultry farms	No	-	-	-	-	-	-	-	-
	Rehabilitation of unmanaged waste sites and ensuring wastes to be deposited at managed landfill sites	No	-	-	-	-	-	-	-	-
AGRICULTURE	Fuel savings by land consolidation in agricultural areas	No	-	-	-	-	-	-	-	-
	Rehabilitation of grazing lands	No	-	-	-	-	-	-	-	-
	Controlling the use of fertilizers and implementing modern agricultural practices	No	-	-	-	-	-	-	-	-
	Supporting the minimum tillage methods	No	-	-	-	-	-	-	-	-

Emission decreasing simulations										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Reduce primary energy intensity	Raising efficiency in primary energy use can decrease primary energy demand.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in primary energy sectors (coal mining, petroleum,natural gas extraction, coke,refined petroleum).	EMIS01	-0.09	na	na	na	-0.05	-0.06
	Raise efficiency in electricity use	The policy can be achieved by raising efficiency in electricity use.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts of all electricity producing sectors.	EMIS02	-0.63	na	na	na	-0.83	-1.79
	Utilize entire technical and economic potential for hydroelectric energy	A transfer shock in exogenous final demand accounts first from coal electricity, then petroleum electricity, then natural gas electricity sectors to hydro electricity sector at a rate of 32.4% of total. (3 819 585 thousand tl). (Total electricity production in 2030 is estimated to be 628.9 billion kWh (5.5% growth per year), and technical (216 billion kWh) and economic (140 billion kWh) hydroelectric energy potential is 356 billion kWh. This is a shock increasing hydro electricity share from 24.2% to 56.6% in total electricity production.)	TRANSFERRING VOLUME TYPE SHOCK: A transfer shock in exogenous final demand accounts from coal, then petroleum, and then natural gas electricity sectors (most emitting) to hydro electricity sector, at a rate of 32.4% of total exogenous electricity final demand.	EMIS03	-1.54	0.00	0.00	0.00	-3.79	-8.55

Emission decreasing simulations (continues)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Increase efficiency in coal, petroleum and natural gas electricity production with co-generation technology	Co-generation can decrease demand for electricity beside decreasing cost of producing electricity.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in coal, petroleum and natural gas electricity production.	EMIS04	-0.53	na	na	na	-0.71	-1.53
	Reduce losses and illicit use in electricity distribution	Reducing losses can decrease total electricity demand.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous final demand accounts in all electricity producing sectors.	EMIS05	-0.63	na	na	na	-0.83	-1.79
	Increase the share of clean energy in electricity production	Coal electricity production is the most emitting sector with 1873 kg CO_2 eq. per thousand TL.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from coal electricity to renewable electricity.	EMIS06	-0.14	0.00	0.00	0.00	-0.38	-0.85
		Petroleum electricity is emitting 1435 kg CO_2 eq. per thousand TL.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from petroleum electricity to renewable electricity.	EMIS07	-0.003	0.000	0.000	0.000	0.000	0.000
		Natural gas electricity is emitting 1041 kg CO_2 eq. per thousand TL.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from natural gas electricity to renewable electricity.	EMIS08	-0.12	0.00	0.00	0.00	0.00	0.00

Emission decreasing simulations (continues)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
INDUSTRY	Decrease CO_2 equivalent intensity per GDP produced in the industrial sectors	Mineral sector has the highest emission coefficient (1084) among other industry sectors and it has 0.77% share in total gross output in the economy. Transferring demand from mineral to an aggregate sector with a zero emission coefficient value, service, can help to decrease emission sourcing from domestic production. Turkey can import products of this sector.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from mineral sector to service sector.	EMIS09	-0.18	0.03	0.02	0.00	-0.01	-0.02
TRANSPORTATION	Decrease CO_2 equivalent intensity per freight and passenger transport by utilization of transport modes more balancedly	Railway transportation emission coefficient is less than highway transportation's coefficient.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from highway transportation to railway transportation.	EMIS10	-0.22	-0.05	-0.01	0.00	0.00	0.00
		Water transportation emission coefficient is less than highway transportation's coefficient.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous accounts from highway transportation to water transportation.	EMIS11	-0.30	0.08	0.02	0.02	0.00	0.02
	Direct people to public transportation and increase efficiency by applying sustainable transport solutions in highway transportation	Inciting people to use more public transport and decreasing personal vehicle demand by the way; putting sustainable transport solutions (tunnel construction, intelligent transport systems, scraping of old vehicles from traffic, easing transfers among modes, etc.) into practice can decrease highway transportation.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in highway transportation.	EMIS12	-0.90	na	na	na	-0.41	-0.50

Emission decreasing simulations (continues)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
WASTE	Manage waste sector more efficiently	Changing consumer behaviours, enhancing recycling, separating biodegradable waste and reducing its amount admitted to landfill sites, incentives to industries for use of biodegradable packaging are viable policies to implement.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in waste sector.	EMIS13	-0.05	na	na	na	-0.02	-0.02
AGRICULTURE	Increase efficiency	Fuel savings by land consolidation, avoiding excess use of fertilizers, implementing modern agricultural practices are viable policies to implement.	INCREASING EFFICIENCY TYPE SHOCK: A 10% decrease shock in exogenous accounts in agriculture sector.	EMIS14	-0.76	na	na	na	-0.38	-0.45

Developmental simulations (output multiplier)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Increase efficiency in electricity use	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output. Increased output can be bought by government or can be exported.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of all electricity producing sectors.	OUT01	na	0.10	0.12	0.16	na	na
INDUSTRY	Direct economy to high output sectors	Although substitutability among the goods of the sectors is very low or zero; domestic demands in the sectors that outputs are decreased are assumed to be met by import, supply excesses in the sectors that outputs are increased are assumed to be absorbed by rest of world, by export. Transfer amounts are determined over exogenous final demand amounts of chemistry, metal, industry sectors. This total is transferred to service, mineral, and food sectors according to their shares.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from chemistry, metal, industry sectors to service, mineral, food sectors.	OUT02	0.68	2.23	2.00	0.78	-0.26	0.94
	Increase efficiency in high output sectors	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of food, mineral, service sectors.	OUT03	na	6.47	6.22	5.30	na	na
AGRICULTURE	Increase efficiency	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of agriculture sector	OUT04	na	0.38	0.61	0.50	na	na

Employment increasing simulations (employment multiplier)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Increase efficiency in electricity production	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output. Increased output can be bought by government or can be exported.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of all electricity producing sectors.	EMP01	na	0.10	0.12	0.16	na	na
INDUSTRY	Direct economy to high output sectors	Although substitution between goods of the sectors subject to transfer is very low or zero; domestic demands in the sectors of which outputs are decreased are assumed to be met by import, supply excesses in the sectors of which outputs are increased are assumed to absorbed by rest of world, by export. Transfer amounts are determined over exogenous final demand amounts of chemistry and metal sectors. This total is transferred to service, mineral, industry, and food sectors according to their shares.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from chemistry, metal sectors to service, mineral, food, industry sectors.	EMP02	0.08	0.34	0.32	0.16	-0.28	0.15
	Increase efficiency in high output sectors	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of food, mineral, service, and industry sectors.	EMP03	na	9.23	9.00	8.42	na	na
AGRICULTURE	Increase efficiency	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of agriculture sector.	EMP04	na	0.38	0.61	0.50	na	na

GDP increasing simulations (value added multiplier)										
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)	Change in hard coal use (%)	Change in lignite use (%)
ENERGY	Increase efficiency in electricity production	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output. Increased output can be bought by government or can be exported.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of all electricity producing sectors.	GDP01	na	0.10	0.12	0.16	na	na
INDUSTRY	Direct economy to high output sectors	Although substitutability among the goods of the sectors is very low or zero; domestic demands in the sectors that outputs are decreased are assumed to be met by import, supply excesses in the sectors that outputs are increased are assumed to be absorbed by rest of world, by export. Transfer amounts are determined over exogenous final demand amounts of chemistry, metal, industry sectors. This total is transferred to service, mineral, and food sectors according to their shares.	TRANSFERRING VOLUME TYPE SHOCK: A 10% transfer shock in exogenous final demand accounts from chemistry, metal, industry sectors to service, mineral, food sectors.	GDP02	0.68	2.23	2.00	0.78	-0.26	0.94
	Increase efficiency in high output sectors	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of food, mineral, service sectors.	GDP03	na	6.47	6.22	5.30	na	na
AGRICULTURE	Increase efficiency	Raising efficiency can be realized by improvement in technology: using same amount of input but obtaining more output.	INCREASING EFFICIENCY TYPE SHOCK: A 10% increase shock in exogenous final demand accounts of agriculture sector.	GDP04	na	0.38	0.61	0.50	na	na

Alternative tax policies - CGE								
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)
ENERGY	Reduce primary energy intensity	Taxation of primary energy sources at various stages of the economy can help producers and consumers use less of these resources. These taxes change economic structure to a less emitting one.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in primary energy sectors (coal mining, petroleum,natural gas extraction, coke,refined petroleum).	ALT01	-0.539	-0.819	-0.882	-0.218
	Reduce electricity intensity in production and consumption	Taxation of electricity without resource discrimination at various stages of the economy can help users to decrease their demand for electricity. They can find ways to substitute electricity with other intermediate inputs or change their consumption behavior due to high taxes. These taxes change economic structure to a less emitting one.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in all electricity producing sectors.	ALT02	-2.070	-0.813	-0.840	-0.283
	Utilize hydroelectric energy potential more	Taxation of electricity from fossil energy sources and subsidizing hydroelectricity can allow a transfer to hydroelectricity which is accepted among renewable energy sources. This policy creates a structural change in the economy.	Place a 10% intermediate input use tax (τitp) on electricity producing sectors from coal, petroleum, and natural gas; give a 10% subsidy to electricity production from hydro energy.	ALT03	-0.639	-0.402	-0.401	-0.098

Alternative tax policies - CGE (continues)								
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)
ENERGY	Increase efficiency in coal, petroleum and natural gas electricity production with co-generation technology	Taxing electricity production from fossil fuels can help producers to abandon old technologies and adopt co-generation technologies. Government knocks taking taxes off after establishment of these technologies.	Place 10% intermediate input use taxes (τitp) on fossil electricity producing sectors, coal, petroleum, and natural gas.	ALT04	-0.964	-0.618	-0.615	-0.149
	Increase the share of clean energy in electricity production	Coal electricity production is the most emitting sector with 1873 kg CO_2 eq. per thousand TL.	Place a 10% intermediate input use tax (τitp) on coal electricity production and give a 10% subsidy to renewable electricity production.	ALT05	-0.331	-0.205	-0.204	-0.050
		Petroleum electricity is emitting 1435 kg CO_2 eq. per thousand TL.	Place a 10% intermediate input use tax (τitp) on petroleum electricity production and give a 10% subsidy to renewable electricity production.	ALT06	0.031	0.019	0.019	0.005
		Natural gas electricity is emitting 1041 kg CO_2 eq. per thousand TL.	Place a 10% intermediate input use tax (τitp) on natural gas electricity production and give a 10% subsidy to renewable electricity production.	ALT07	-0.532	-0.333	-0.332	-0.081

Alternative tax policies - CGE (continues)								
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)
INDUSTRY	Decrease CO_2 equivalent intensity per GDP produced in the industrial sectors	Mineral sector has the highest emission coefficient (1084) among other industry sectors and it has 0.77% share in total gross output in the economy. Taxing mineral use as intermediate input can help to decrease emissions.	Place a 10% intermediate input use tax (τitp) on mineral sector.	ALT08	-0.157	-0.542	-0.502	-0.042
TRANSPORTATION	Decrease CO_2 equivalent intensity per freight and passenger transport by utilization of transport modes more balancedly	Railway transportation emission coefficient is less than highway transportation's coefficient.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation and give 10% subsidies on the same points in railway transportation.	ALT9	-0.329	-0.493	-0.854	-0.061
		Water transportation emission coefficient is less than highway transportation's coefficient.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation and give 10% subsidies on the same points in water transportation.	ALT10	-0.326	-0.403	-0.756	-0.054
	Direct people to public transportation and increase efficiency by applying sustainable transport solutions in highway transportation	To decrease emissions from highway transportation, tax rates can be increased. Increased prices direct people to use more public transport and decrease personal vehicle demand. Producers also tries to be more efficient in planning their highway transportations, such as using intelligent transport systems, preferring new and low emitting vehicles instead of old vehicles.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in highway transportation.	ALT11	-0.330	-0.494	-0.856	-0.061

Alternative tax policies - CGE (continues)								
Sector	Aim of policy to be implemented	Explanation	Policy for 2030	Shock number	Change of total greenhouse gas inventory (%)	Change in employment (%)	Change in gdp (%)	Change in output (%)
WASTE	Manage waste sector more efficiently	Placing taxes on waste production can help decreasing emissions from waste. All producers pay tax for each TL waste that they produce (This time, τitp from each sector to waste is taxed). Household and other consumers also pay taxes (τitc, τitp, τitg) for their waste. These taxes cause waste amount to decrease, thus, to emit less. This can be possible with change in consumer behaviors, enhanced recycling, revaluation of biodegradable waste as to prevent its admission to landfill sites and increase use of biodegradable packaging.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in waste.	ALT12	-0.107	-0.204	-0.218	-0.025
AGRICULTURE	Increase efficiency in agricultural production	Taxes applied to agricultural production can cause structural changes in production process, e.g. consolidation of land to save fuel, avoiding excess use of fertilizers, implementing modern agricultural practices. Applying taxes on consumption can increase this effect.	Place 10% taxes on intermediate input (τitp), household consumption (τitc), government expenditure (τitg), and investment (τiti) in agriculture.	ALT13	-0.035	-0.008	-0.673	0.033

VITA

Ayla Alkan was born in Antalya in 1981. She graduated from Industrial Engineering program at Yıldız Technical University in 2004, took her master's degree from Industrial Engineering program at Galatasaray University in 2010, and have been a PhD student in Economics program at Izmir University of Economics since 2010.

She worked as an engineer in a private logistics company, Ekol Logistics, between 2004-2008. She started to work as a research assistant in the Faculty of Engineering at Izmir University of Economics in 2009, after two years, she started to work in the Faculty of Business and worked until 2017. She worked as a part-time lecturer at Izmir University of Economics during the fall semester in 2017-2018 academic year.

She has two research articles in peer-reviewed journals (one is indexed in Web of Science Core Collection), and three and two proceedings presented and printed in international and national scientific meetings, respectively. Research fields of her are optimization, metaheuristics, project management, engineering economics, sustainability, computable general equilibrium, input-output modeling, and climate change economics.