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Macroeconomic Impacts of Net Zero Pathway for Turkey[1]

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Abstract

In this paper we are analyzing the impacts of reaching to net zero by 2053 on Turkey's economy. We use a CGE model that is calibrated to 2018 Social Accounting Matrix of Turkey. Our scenarios incorporate the results of sectoral analysis from Turkey Country Climate and Development Reports published by the World Bank (2022). We take the results of land use change, energy, transport and buildings sectors and translate them into shocks in the CGE model. Our results suggest that, high levels of electrification of buildings and transport are likely to pose challenges for the net zero pathway of Turkey, although the energy efficiency gains thanks to the mitigation policies are likely to compensate the adverse effects of increasing electricity prices in the short to medium term. Hence Turkey needs to revise the energy sector policies to increase the production capacity of renewables further to ease the transition to a net zero economy. Mitigation policies are generally progressive in the sense that they do not harm poorer households as much as richer households but still the lower income groups would need to be compensated especially in the early years of the transition. Increase in government revenues thanks to a carbon tax and removing subsidies on fossil fuels would create enough fiscal space for social protection programs required for a just transition. Last, a well-managed transition to a net zero economy offers significant growth benefits for Turkey.

Keywords: Climate Change mitigation, Turkey, Carbon Pricing, Computable General Equilibrium

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Introduction

Turkey recently ratified the Paris agreement and committed to reduce net GHG emissions to zero by 2053. In this paper we are analyzing the impacts of reaching to net zero by 2053 on Turkey's economy. We use a CGE model that is calibrated to 2018 Social Accounting Matrix of Turkey which is built using 2012 IO tables, 2018 household and labor surveys as well as GTAP energy and emission databases. Our scenarios incorporate the results of sectoral analysis from Turkey Country Climate and Development Reports published by the World Bank (2022). We take the results of land use change, energy, transport and buildings sectors and translate them into shocks in the CGE model through relevant CES function's share parameters using twist parameters (e.g. electrification of transport sector increases the share parameter of electricity in the transport sector's energy nest), energy efficiency gains (e.g. retrofitting buildings increase the efficiency of energy use by households and services for heating purposes), power mix (e.g. energy activities' productivity adjusts to replicate the power mix of an Energy Planning Model's ambitious mitigation scenario), and productivity and production subsidies given to forest services sector which increases carbon sequestration thanks to better forest management.

Our results suggest that, high levels of electrification of buildings and transport are likely to pose challenges for the net zero pathway of Turkey, although the energy efficiency gains thanks to the mitigation policies are likely to compensate the adverse effects of increasing electricity prices in the short to medium term. Hence Turkey needs to revise the energy sector policies to increase the production capacity of renewables further to ease the transition to a net zero economy. Mitigation policies are generally progressive in the sense that they do not harm poorer households as much as richer households but still the lower income groups would need to be compensated especially in the early years of the transition. Increase in government revenues thanks to a carbon tax and removing subsidies on fossil fuels would create enough fiscal space for social protection programs required for a just transition. Last, a well-managed transition to a net zero economy offers significant growth benefits for Turkey.

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This paper aims to present a detailed analysis of the macroeconomic modelling results for the Turkey Country Climate and Development (CCDR) report. Turkey CCDR aims to explore the policy options to combine Turkey's urgent economic and development priorities with its commitment to climate action. CCDR seeks to achieve this by a multisectoral approach where land use, transport, power and building sectors are analyzed using sector level models. Sectoral models assess the pathway to reach the net zero target in 2053. Then MANAGE model is used to analyze the macroeconomic impacts of all sector level policies together.

The sector models highlight the contribution of specific mitigation measures to the net zero pathway and the costs associated. The MANAGE model takes those as given and analyses the impacts on growth and other macroeconomic variables as well as household welfare and employment at sector level. The focus of the macroeconomic analysis is to draw attention to the trade-offs that mitigation policies would entail. Analyzing those trade-offs would provide valuable insights on the challenges and opportunities that a transition to a net zero economy would bring about.

In what follows we present the modelling framework, scenarios run based on the sectoral analysis and results.

Model

The CGE model used in this study is based on the MANAGE model which is developed in house at the World Bank. MANAGE is a single country CGE model that relies on neoclassical structural modeling approach. Most of the model assumptions follows the standard CGE literature. An extended documentation and user guide for the model can be found in can der Mensbrugghe (2019). In what follows we will briefly explain the main features of the MANAGE model.

Production activities in MANAGE model are profit maximizers under constant returns to scale technologies. They use labor, capital, land and intermediate inputs to produce commodities and services (which we will refer as commodities from here on) for domestic and international markets. The production function is a nested one with constant elasticity of substitution production function in value added nests and a Leontief technology at intermediate input nest. The CES production function allows for substitution of factors in a specific nest while Leontief technology assumes a fixed ration between them. Thus, using a nested production structure allows using different substitution elasticities among factors.

In the top nest, value-added and an aggregate non-energy intermediate inputs are combined, following a Leontief production technology. This creates a link between sectors as output of a sector is an input for others. At the second level, the composite intermediate input is obtained by combining all non-energy intermediate inputs with a Leontief technology. The value-added composite aggregates capital composite factor and other factors of production (labor and land). The last nest combines energy

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and capital with a CES production function, making them substitutable. Demand for factors and intermediate inputs as well as the output level is determined according to the production nest.

One of the novelties of the MANAGE model is ability of production activities to determine the energy intensity of production endogenously based on the energy prices. This distinction is important when analyzing carbon pricing policies. Introducing carbon pricing is likely to raise the cost of energy which in this framework would incentivizing substituting capital with energy. The intuition behind this mechanism is that firms are likely to invest in energy efficient technologies to use less energy and hence substitute capital with energy. MANAGE model also has a vintage capital structure where old and new capital are treated differently in terms of substitutability with energy. New capital is substitutable with energy while old capital is near complement. That is the vintage capital structure captures the semi-putty/putty relations across inputs with more elastic long-run behavior as compared to the short-run.

Energy production in this version of the MANAGE model distinguishes 5 types of electricity generation activities: Coal, Gas, Oil, Hydro and Renewables. The electricity generation mix is endogenously determined based on the relative cost of each generation activity. Alternatively, the model allows targeting a specific energy generation mix through adjusting the investment in each type of generation (e.g. increasing investment in renewables to follow a renewable energy target).

All markets in the model are perfectly competitive implying that prices are equal to marginal costs in the equilibrium. Thus, firms compete with each production activity compete with others in the factor markets to hire labor and capital. There are three four types of labor (skilled female, unskilled female, skilled male and unskilled male), one capital and on land in the model. Labor and land supply are determined by a supply function that is sensitive to average wage and land price respectively. Labor supply is also segmented across sector groups. Hence movement of labor across those sector groups are limited. This is achieved by introducing a CET function which drives the supply of labor to the sector groups based on relative wages across sector groups and an elasticity of substitution. Hence, workers cannot move across sectors. This allows model to mimic the labor market rigidities.

Capital supply is determined as a result of capital accumulation process where shrinking activities release capital which is added to "new" capital stock. New capital is fully mobile across sectors. This allows to mimic some rigidities in the capital market as movement of capital from a declining sector to an expanding sector is limited. Rate of return on capital is same in expanding sectors while declining sectors have a lower rate of return.

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The model consists of a ten representative household types according to income deciles. Households are the owners of factors of production. They supply labor depending on the real wages: higher wages induce more labor supply. That means we ignore the wealth effect on labor supply which would require reducing the labor supply for very high levels of real wage rate. Income sources other than factor income for households are income and transfers from government and rest of the world. Households spend their income on consumption, savings and direct taxes. The distribution of consumption across commodities is determined by two level utility function. At the first level, a Constant Difference in Elasticities (CDE) utility function determines the consumption of aggregated commodities. The use of CDE allows better representation of income effects on household demand by allowing consumption shares to change as income and prices change (Hertel 2001) unlike other functional forms like Linear Expenditure System (LES) or Constant Elasticity of Substitution (CES) demand functions which assumes that expenditure shares are independent from the household income and are constant. The aggregate groups are food, manufacturing, energy, services and transport. So, the first level utility function distributes household consumption spending across those broader categories. Then a second level CES nest distributes the spending on each aggregate consumption among commodities in that group. For example, energy group consists of coal, refined petroleum, coke, electricity and natural gas.

Government does not have a behavioral assumption and is completely neutral. It collects taxes, receives transfers from rest of the world and domestic agents and then spends them on saving, government consumption and investment, transfers to rest of the world. Government can borrow from domestic institutions or from rest of the world but must pay interest on debt in following periods. All tax rates are fixed at base year levels. The volumes of government current and investment spending are also fixed. This implies that government savings (primary balance) is endogenous and adjust to clear the government balance. The gap between government investment demand and public saving is satisfied through foreign and domestic borrowing. Alternative government closures can be considered for the simulations of fiscal reforms. For example, there can be a target for the government budget balance and a ‘swing’ fiscal instrument, such as personal income taxes, adjusts to achieve the target.

Rest of the world (ROW) exports from and imports to Turkey according to Constant Elasticity of Transformation and Armington specification respectively[4]. Both specifications assume that domestic

[4] This model does consider however only one trade partner, the Rest of the World. However the model code is flexible enough so that additional trading partners can be added in a two level nested structure. See model documentation for more details.

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commodities are not perfect substitutes with traded commodities. Thus, imports and exports are determined based on the difference between domestic prices and world prices which are assumed to be fixed in line the small open economy assumption. ROW also makes transfers to domestic agents and receives transfers from them. These transfers are assumed to be constant share of GDP. Last, ROW account invests in Turkey, which corresponds to F/X flows for investment purposes (e.g. FDI, short term capital movements etc.)

The model follows a savings-driven closure where aggregate investment is flexible and equals to the available volume of saving. Foreign saving is exogenous and fixed as a share of GDP, while government saving and household savings are endogenous. In effect, rate of return on capital adjusts to equalize investment to the saving. Hence, the model has the crowding out effect where government investment displaces private investment.

The model dynamics follows the neo-classical growth framework (Solow-Swan growth model) implying that the long-run growth rate of the economy is determined by three main factors: capital accumulation, labor supply growth, and increases in productivity. The stock of capital is endogenous, while the latter two are exogenously determined. The capital stock in each period is the sum of depreciated capital from the previous period and new investments. For each type of labor, the maximum stock of labor available in each period grows exogenously based on population projections by age cohort and cohort-specific participation rates. The technical progress specific to sector and production factors are calibrated to replicate the GDP growth in the baseline and equals to that calibrated level in simulations.

The model is calibrated to replicate the 2018 Social Accounting Matrix (SAM) for Turkey, which is constructed for this study. The SAM is based on 2018 macro-aggregates, 2012 input-output (IO) table and household surveys. It comprises of 38 sectors and commodities, 6 factors of production (capital, land, skilled and unskilled labor disaggregated by gender, ten household types by income deciles. The SAM also distinguishes between public and private investment demand.

The SAM consist of seven power activities that produce a homogenous electricity commodity: Coal, gas, nuclear, hydroelectricity, wind, solar and other. Single power sector in the original IO table is split based on GTAP power database with ad-hoc adjustments for the Turkish power balance tables. Nuclear power is introduced with an insignificant share in power supply based on the average cost structure of nuclear power activities in the GTAP power database.

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Scenarios

We run sector and Net Zero Pathway (NZP) scenarios using the MANAGE model. Sector scenarios for energy, transport, forestry and buildings depend on the results of the analytical work in corresponding sections on those sectors. In sector scenarios we calibrate the parameters and elasticities of the CGE model to reproduce the emission reductions reported in sectoral analysis. We also introduce the investment and other costs required to achieve those emission reductions:

- **Energy**: CGE models power mix is calibrated to the results of the Energy Planning Model's 90 percent emission reduction scenario. We allow productivities of different power generation activities to adjust. We introduce the investment requirements in the model as an exogenous shock. The additional investments are paid by increased public and private savings which in turn reduces total consumption in economy. However, we do not add all of energy sector investments to the capital stock to take into account the fact that energy transition would require retiring some of the fossil fuel based power plants earlier.
- **Transport**: We target the emission reductions reported by the transport model and adjust the share of electricity and fossil fuels in the total energy demand of road transport sector and consumption of households. This is equivalent of electrification in the transport sector. Second, we increase the energy efficiency of fossil use in the transport sector to reflect the efficiency gains of modernizing the fleet and switching to more efficient modes of transport such as railways. Investment requirements for the transition in transport sector is introduced to the model in the same way as energy scenarios.
- **Buildings:** We follow the same approach as transport for buildings. Until 2030, we only allow energy efficiency gains in service sectors and households to adjust to reach the reported emission levels. After 2030, we adjust the share of electricity in intermediate demand of service sectors and in household consumption. In buildings scenario, the investment demand is assumed to be mostly for construction sector. As in the case of energy scenario we assume that the some of the investments in building sector would transform the existing building stock and hence would not expand the capital stock and hence increase productive capacity of the whole economy.
- **Forestry:** We target the increase in capacity of forests to sequestrate carbon following the findings of the land use section. This is achieved by subsidizing the forest services sector which supplies services for better management of the forests. Hence, unlike other scenarios forest

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scenario does not change investments but rather imposes the costs of green transition through increased subsidies that are paid by government. In the model we assume that intensity of carbon sequestration of the forests can be increased thanks to better forest management which is measured in the model as increasing supply of forest services.

NZP scenario combines the sector scenarios with a carbon tax that starts from USD 11 in 2022 and gradually reaches to USD 211 dollar. Carbon tax level is selected to keep the government tax revenue equal to the baseline levels. Since refined petroleum products are heavily taxed in Turkey, government loses significant amount of tax revenues as consumption of refined petroleum products decline significantly due to the green transition. So, we select a carbon tax level that is high enough to compensate for such loss.

In NZP scenario we take the calibrated parameters in sector scenarios as given. That is, we no longer target sector level emission reductions but rather rely on the parameter values that are calculated by the model in the sector scenarios. In other words, we run the scenarios in two steps: First to calibrate the model to replicate the results of sectoral analysis and then to put those calibrated parameters together in the general equilibrium setting.

Emissions in the sectors that are not modelled in other chapters are assumed to decline by 66% following the NZP emission reduction. The cost of such decline is assumed to be the lower of $120 or carbon tax levels in the corresponding year. The assumptions relies on the fact that firms would invest in emission saving technologies as long as its per tonne cost is equal or lower than the carbon tax but also there would be a limit to such cost as technologies like Carbon Capture and Sequestration would be the upper limit (e.g. if a sector needs to invest $140 per avoided emissions and CCS costs $120 per tonne, the firm would use CCS rather than investing in more emission efficient furnaces etc.)

The investment requirements reported by each sector is added to the total investments assuming that savings would adjusts to fund them. This is achieved by fixing the investment levels to the sum of baseline investment levels and the investment requirements reported by sector analysis. As investments are fixed we allow savings to increase to ensure the investment-saving balance. This implies that the cost of transition is passed to consumers in the form of lower consumption and higher savings and lower returns from capital as firm savings also increase and hence the amount of capital income transferred to the households is reduced.

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We run five sensitivity analysis on top of the NZP scenario:

- **Air pollution Co-benefits**: A vast literature suggests that reductions in air pollution increase the labor productivity. We capture this in the model by linking the labor productivity to air pollution levels. The international literature suggests that a one percent decline in PM2.5 concentration would increase labor productivity by 0.3 percent. In this scenario we assume that this relationship is effective both in the baseline and the scenario. As mitigation policies reduce the air pollution, labor productivity starts to increase compared to baseline.
- **Labor marker frictions:** The CGE model assumes an imperfect labor market where movement of labor across sectors is limited. In this scenario we assume perfect mobility to show the impact of labor market frictions on the effectiveness of mitigation policies and short term welfare costs of the transition.
- **Higher and Lower Carbon tax:** We run two scenarios with lower and higher carbon price that are equivalent to twice and half of the carbon price level in NZ scenario to test the sensitivity of results to the selected carbon tax.
- **Renewable Subsidies:** We run a scenario where government subsidizes renewable energy production to keep the electricity prices constant to see the contribution of lowering electricity prices to growth.
- **Cost of Emission saving Technological Change:** Since investment cost of technological change depends on several assumptions, we tun two scenarios with higher and lower cost for the emission saving technological change in the sectors that are not modelled in other chapters (i.e., agriculture, manufacturing, IPPU, waste and fugitives).
- **High Crowding out:** The sum of investments required for the transition are significant and it is not guaranteed that it would all be financed by the increase in domestic savings. Hence we run a sensitivity analysis by changing the assumption on how investments are funded. In this scenario we assume that investments are endogenous and saving rates are fixed. Hence, sectoral investment requirements would be financed by domestic savings to the extend that public and private savings increase. As private savings are a function of household and enterprise income which do not increase significantly or even decline, investment increases only to the extend that government savings increase due to increasing government revenues from the carbon tax. Rest of the required funding for the sectoral investments would be at the expense of investments in

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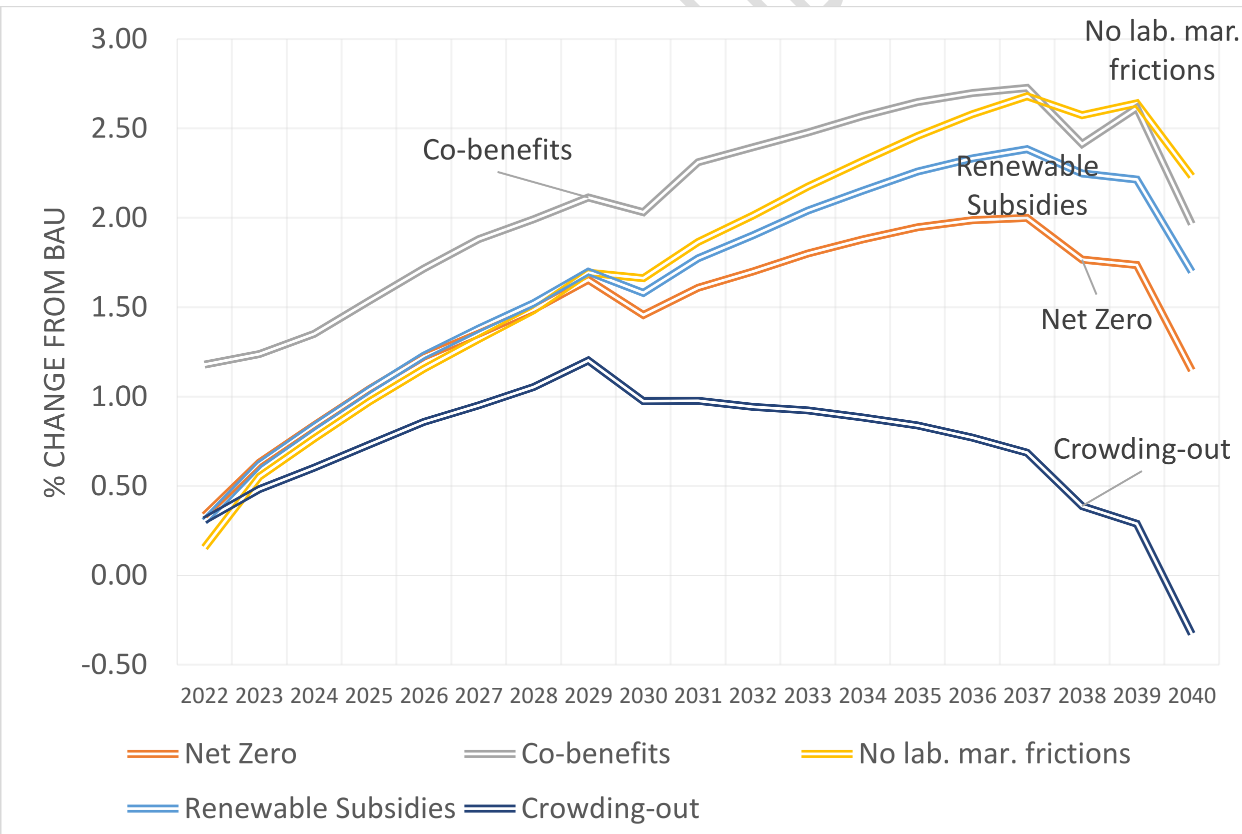
other sectors. E.g. power sector investments would reduce investments in other sectors, causing a crowding out effect.

Results

NZP would contribute to economic growth in Turkey; especially when mitigation co-benefits are considered, and labor market frictions are addressed. Increase in energy efficiency in transport and building sectors is the driver of the growth benefits in the short to medium term. After 2030, the significant increase in investments due to electrification in buildings further increases growth benefits. The growth benefits of the transition are boosted when co-benefits through air pollution reduction are taken into account or frictions in labor markets are removed making it easier for people in the most affected sectors to find jobs in the growing sectors such as renewable energy.

Figure 1: Transitioning to NZP would bring growth benefits in the short and medium term especially if labor market frictions are addressed



Increasing electricity prices might pose a challenge for the growth in the longer term. As electrification of buildings and transport surges the demand for electricity price starts to increase significantly and economic growth slows down to the extent that year on year growth falls back to baseline average of 4.5% or even below after 2037 when the demand from electrification surges. Another factor driving electricity prices up is the slow response of power supply to the demand. As the shift from fossil fuels to renewables become more ambitious, most of the new renewable capacity only makes up for the reduced power generation from the fossil fuels and limits the expansion of supply. Scaling up power supply by supporting growth of renewable energy production would reduce the pressure on electricity prices significantly. Removing the barriers in front of the expansion of renewable energy such as labor market frictions and subsidizing renewable energy production would stop the reduction in economic growth.

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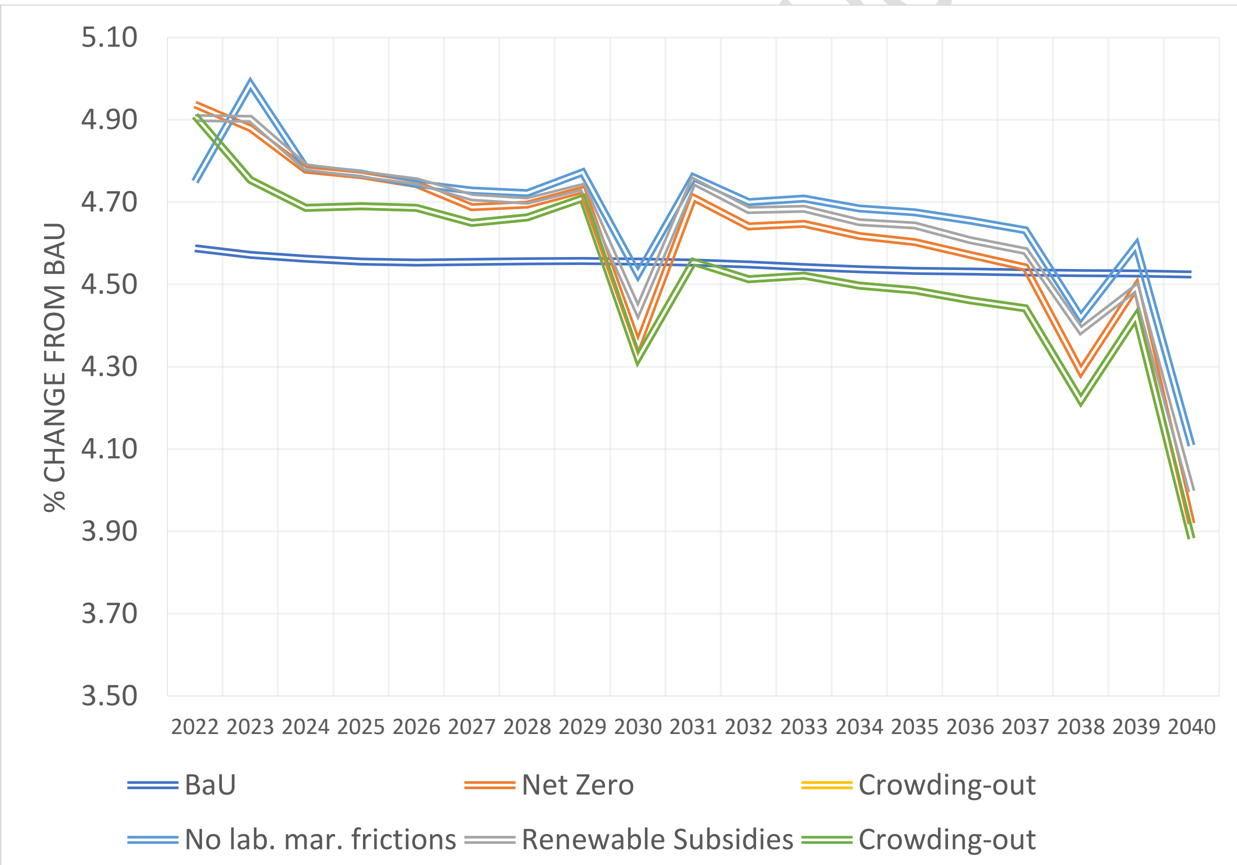
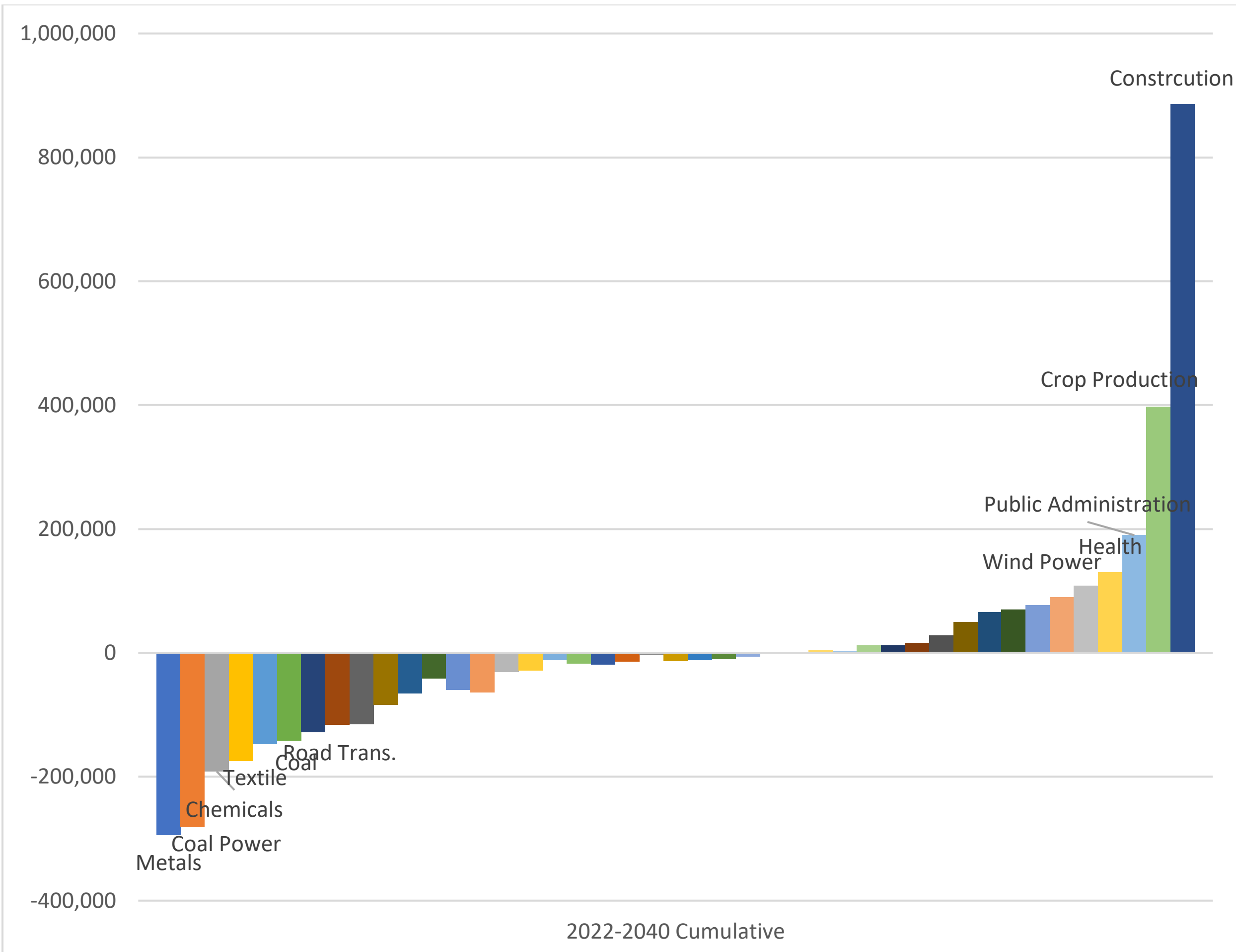
Figure 2: GDP growth is generally above the baseline until 2037 but can be reduced significantly afterward due to higher electricity prices



NZP would generate up to 70 thousand jobs over 2022-2040 mostly in construction, agriculture and renewable power sectors as well as upstream sectors supporting them. The job gains are higher in earlier years, e.g. as much as 270 thousand by 2037 before the most of the job gains are erased by slowing economic activity. Construction jobs would increase significantly because of the increased investment demand by the sectors while increase in agricultural employment is due to competitive advantage the sector gains over being exempt from the carbon tax.

Figure 3: Net zero pathway would significantly reallocate labor force across sectors creating losing and winning sectors



Transition would also put pressure on inflation as food and manufacturing prices would rise. Service sector prices would fall but that is not enough to compensate the adverse impact of food and manufacturing sectors on overall price levels. However, the increase is effective especially in the longer run as increasing carbon price starts to push cost up on the supply side.

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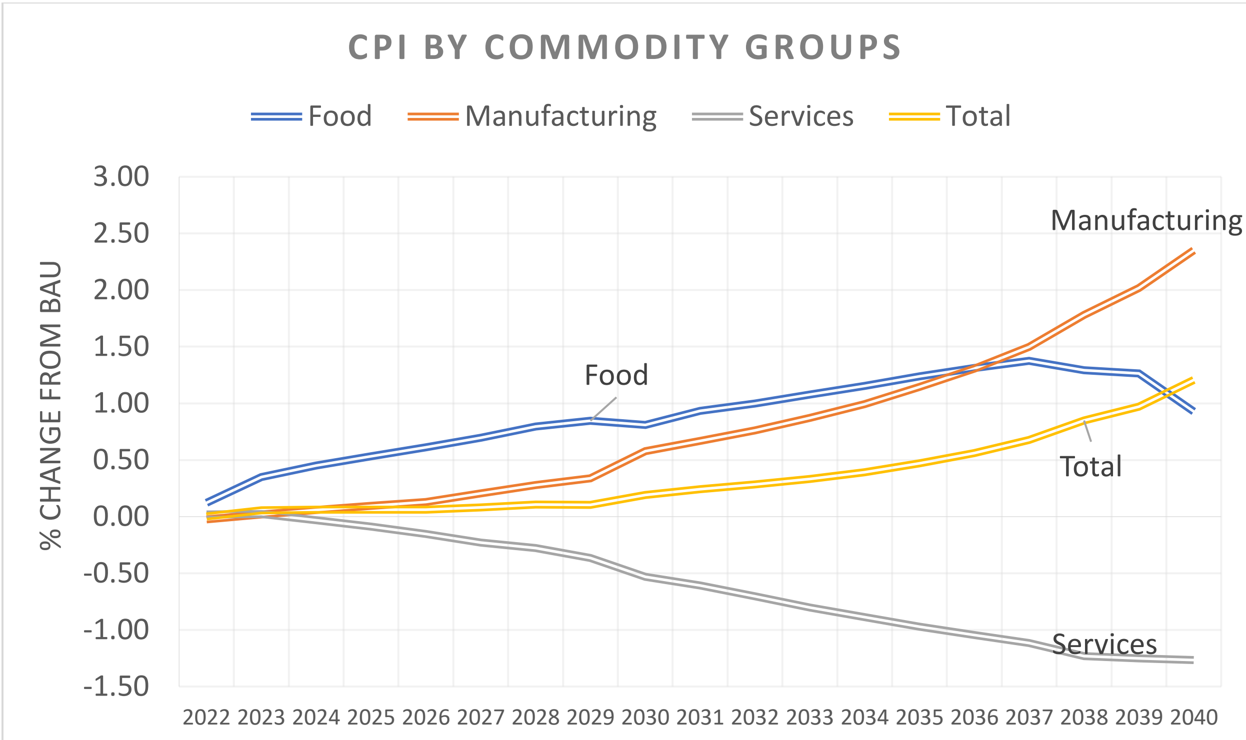

The impact of transition on Government revenues critically depends on the level of carbon tax. As liquid fuels are heavily taxed and constitutes a significant source of income for government, transition implies significant revenue losses for the government. However, an adequate level of carbon tax might compensate for losses in revenues from liquid fuels. **In the sensitivity analysis we found that a $50 carbon tax would compensate for the losses in liquid fuel tax revenues. Although it cannot achieve the net zero pathway.** A carbon tax that reaches $211 in 2040, would generate revenues equal to 2.3% of GDP and hence allow more fiscal space to manage the adverse effects of

CGE results suggest that, high levels of electrification of buildings and transport are likely to pose challenges for the net zero pathway of Turkey, although the energy efficiency gains thanks to the mitigation policies are likely to compensate the adverse effects of increasing electricity prices in the short to medium term. Hence Turkey needs to revise the energy sector policies to increase the production capacity of renewables further to ease the transition to a net zero economy. Mitigation policies are generally progressive in the sense that they do not harm poorer households as much as richer households but still the lower income groups would need to be compensated especially in the early years of the transition. Increase in government revenues thanks to a carbon tax and removing subsidies on fossil fuels would create enough fiscal space for social protection programs

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