EUROPE AND CENTRAL ASIA

TÜRKIYE CCDR

Background Note 6

Macroeconomic modelling

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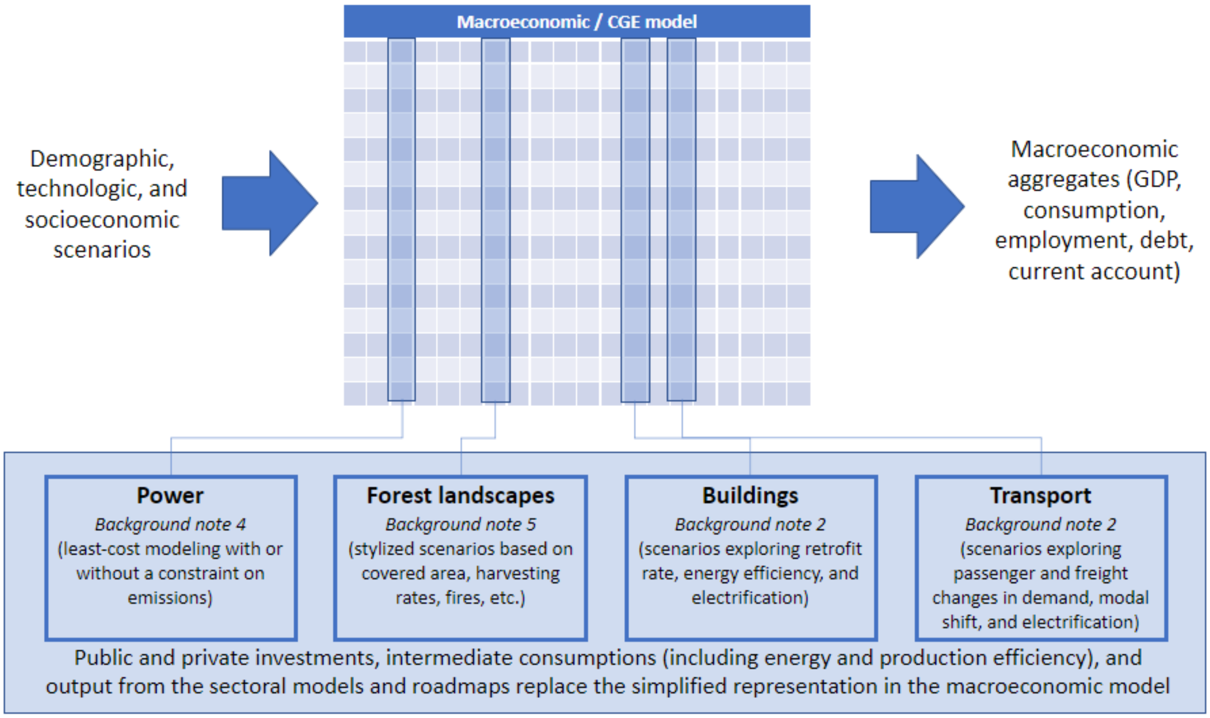
Introduction

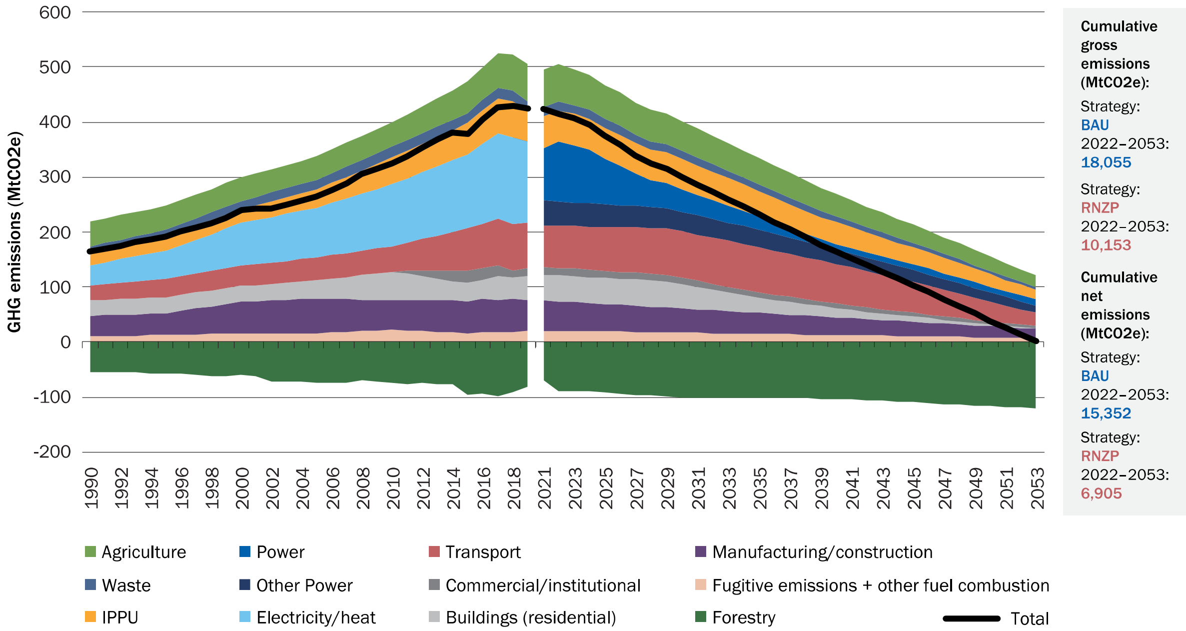
This background note aims to provide details on the macroeconomic modelling approach and results for the Turkey Country Climate and Development (CCDR) report. The Turkey CCDR explores the policy options to combine Turkey's economic and development priorities with its commitment to climate action. The Turkey CCDR seeks to achieve this in two iterative stages. First by adopting a multisectoral approach where the power, transport, buildings, and forest landscapes sectors are analyzed using sector level models. The sectoral models explore various pathway to reaching Turkey's net zero emissions target in 2053. To bring the sectoral analyses together, two macroeconomic models, the MANAGE CGE model (part 1) and the MFMod macrostructural model (part 2), are used to analyze the macroeconomic impacts of the sector level policies. This note explains how the economic modelling in the report integrated the sector-level analyses—which include detailed representation of assets and technologies and some sectoral interactions but exclude macroeconomic or inter-sectoral feedback—with the macroeconomic analyses which captures inter-sectoral relationships and general equilibrium effects albeit with simplified representations of production systems and technologies (Figure 1).

Figure 1. Integration of sector-level and macroeconomic analyses



The CCDR is built around a Resilient Net Zero Scenario (RNZP), constructed from various sectoral roadmaps, with detailed roadmaps developed for the power sector, transport, buildings, and Forrest landscapes, and more simplified roadmaps for industry and agriculture (Figure 2). For each of the sectors, the analysis provides estimates of the investment needs in the RNZP scenario, as well as estimates of various costs and benefits (e.g., reduction in fuel consumption from the power and transport systems). These investments, costs, and benefits are then fed into macroeconomic models to explore the feasibility of the RNZP and its implication on growth and other macroeconomic variables as well as household welfare and employment at the sectoral level. The focus of the macroeconomic analyses is to draw attention to the economic trade-offs that mitigation policies could entail. Analyzing those trade-offs provides valuable insights on the potential challenges and opportunities of the transition to a net zero economy.

Figure 2. Historical emissions (left) and RNZP scenario (right)



Part 1: Computable General Equilibrium Modeling

The CGE model used in this study is based on the MANAGE model which is developed by 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 van der Mensbrugghe (2020)[1.] In what follows we will briefly explain the main features of the MANAGE model.

Production activities in the MANAGE model are profit maximizers under constant returns to scale technologies. They use labor, capital, land, and intermediate inputs to produce goods and services (which we will refer as goods from here on) for domestic and international markets. The production

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[1] van der Mensbrugghe, Dominique, 2020. The Mitigation, Adapation and New Technologies Applied General Equilibrium (MANAGE) Model, Version 2.0g. GTAP Technical Paper, TP/20/xx. Center for Global Trade Analysis, Purdue University West Lafayette, IN

function is a nested one with constant elasticity of substitution (CES) 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 ratio 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 input are combined, following a Leontief production technology. This creates a link between sectors as output of one sector can be an input for others. At the second nest, the composite intermediate input is obtained by combining all non-energy intermediate inputs with a Leontief technology. The value-added composite aggregates the capital composite factor and other factors of production (labor and land). The last nest combines energy 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. The 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 a 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 others in the factor markets to hire labor and capital. There are four types of labor (skilled female, unskilled female, skilled male and unskilled male), one capital and one 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 Constant elasticity of transformation (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 freely 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 mimics 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.

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 a 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 assume 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[2]. Both specifications assume that domestic 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 and household savings are endogenous. In effect, the 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

[2] This model considers 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.

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 includes seven power activities that produce a homogenous electricity commodity: Coal, gas, nuclear, hydroelectricity, wind, solar and other. The 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 a small share in power supply based on the average cost structure of nuclear power activities in the GTAP power database.

Scenarios and inclusion of the sectoral roadmaps into the model

We run the RNZP scenarios using the MANAGE CGE model. We calibrate the parameters and elasticities of the CGE model to reproduce the emission reductions determined in the sectoral analysis. We also introduce into the CGE the attendant investment and other costs required to achieve those emission reductions:

Energy: The CGE power mix is calibrated to the results of the RNZP scenario from the least-cost power system modeling (see Background Note 4). We allow productivities of different power generation activities to adjust to reproduce the sectoral model pathway. 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. We assume that only 75% of investments for green transition would be added to the capital stock.

Transport: We target in the CGE the emission reductions reported in the RNZP scenario by the transport model (see Background Note 2, Part 2) 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 to 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 (see Background Note 2, Part 3). 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. The investment demand is assumed to be mostly for the construction sector. As in the energy scenario we conservatively assume that the some of the investments in building sector would transform the existing building stock and hence that part of investment would not expand the capital stock nor increase productive capacity of the whole economy. We thus again assume that 75% of the investments would be added to the capital stock.

Forest landscapes: We target the increase in capacity of forests to sequestrate carbon following the findings of the forest landscapes analysis (see Background Note 5). This is achieved by subsidizing the forest services sector which supplies services for better management of the forests. Hence, unlike other scenarios the forest scenario does not change investments but rather imposes the costs of green transition through increased subsidies that are paid by government. This is consistent with the sectoral analysis, in which investment needs in the sector are relatively small at the macro level. In other words, in the CGE model we assume that intensity of carbon sequestration of forests can be increased thanks to better forest management which is measured in the model as increasing supply of forest services from the existing capital stock in the forestry sector.

To achieve net zero emissions in 2053, the commitment made by Turkey in 2021, the RNZP scenario combines the sector scenarios with a carbon tax that starts from USD 11 in 2022 and gradually reaches USD 211 dollar by 2040. The carbon tax level is selected to keep the government tax revenue equal to the baseline levels in spite of the reduction in consumption of fossil fuels caused by the increase in their prices as well as energy efficiency gains described above. Since refined petroleum products are heavily taxed in Turkey, government loses a 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, ensuring a neutral impact on public finance.

In the macroeconomic RNZP runs, 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 (which will lead to slightly different results at the sectoral level, when macroeconomic, such as inter-sector, effects are accounted for).

Emissions in the sectors that are not subject to dedicated sector modelling (agriculture, manufacturing, IPPU, waste and fugitives) constitute roughly 40 percent of total emissions excluding LULUCF and are assumed to decline by 66% following the RNZP emissions reduction. These reductions are triggered by the growing carbon price level which would increase incentives to reduce emission intensive inputs (e.g., fossil fuels, fertilizers etc.) as well as increasing investments in emission saving technologies. Reduction in emission intensive inputs is endogenously driven by the increase in relative prices of those inputs. Reductions due to technological change is assumed to be residual in the sense that reductions that cannot be achieved by increasing carbon price would be achieved by emission saving technological change. The cost of emission saving technologies is, then, assumed to be equal to the upper bound of expected cost of Carbon Capture and Sequestration (assumed here to be around $120/tCO2e)[3] or the carbon tax level in the corresponding year; whichever is lower. The assumption relies on the fact that firms would invest in emission saving technologies as long as the per tonne cost is equal to 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 ton of CO2 emissions and CCS costs $120 per tonne, the firm would use CCS rather than investing in more emission efficient furnaces etc.).[4]

The investment requirements reported by each sector are added to the total investments assuming that domestic savings would adjust to fund them. This is achieved by fixing the domestic investment levels to the sum of (i) baseline investment levels and (ii) the investment requirements reported by the sectoral analyses. As domestic 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 domestic consumption and higher domestic savings by both households and firms. This necessarily

[3] We ran several sensitivity analyses for the assumed upper bound of cost of CCS, but macroeconomic results and main messages did not change significantly as long as the cost is kept at reasonable levels, e.g. above $40 and below $175.

[4] The cost of CCS ($120 per tonne CO2e) is an upper estimate based on Bataille, C. 2019. "Physical and policy pathways to net-zero emissions industry". *Wiley interdisciplinary reviews: Climate Change*. 12(1). http://dx.doi.org/10.1002/wcc.633.

means lower returns from capital as firm savings increase and hence the amount of capital income transferred to the households is reduced.

Scenarios, sensitivity analysis, and model's assumptions

We run a set of sensitivity analyses on top of the RNZP 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 market 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 RNZP 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.

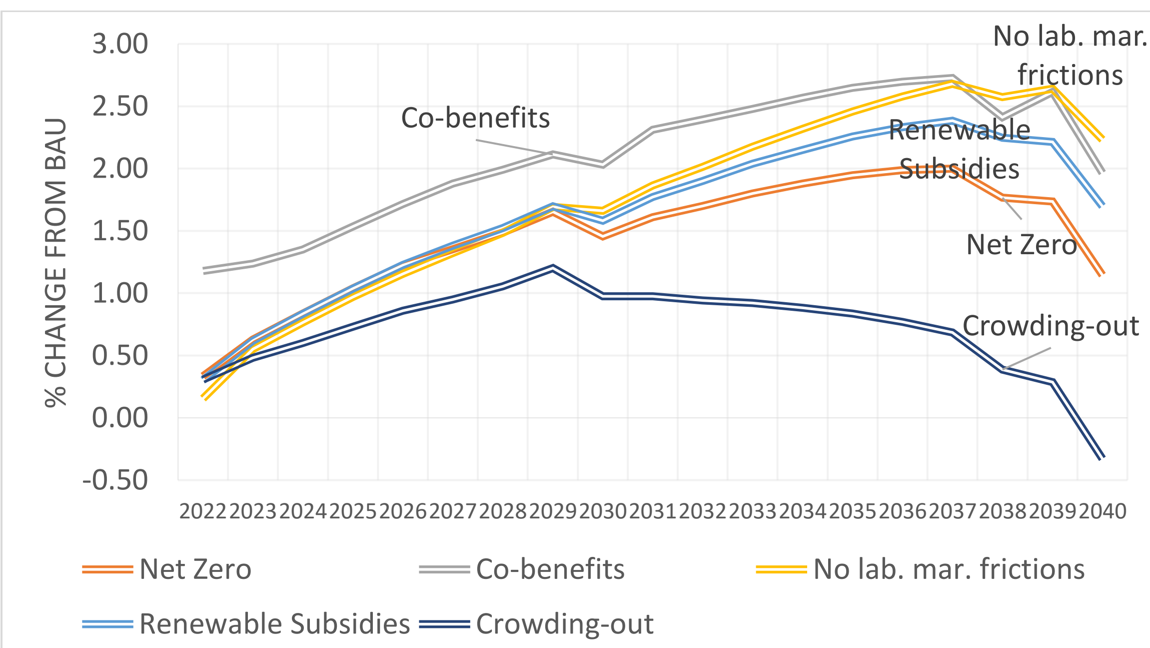
Cost of emission saving technological change: Since investment cost of technological change depends on several assumptions, we run two scenarios with higher and lower cost for the emission saving technological change in the sectors that are not subject to specific sector modelling (i.e., agriculture, 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 the BAU we assume that the additional investments needed for the green transition are exogenous and accommodated by an increase in domestic savings. 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 extent 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 compared to the baseline level, investment increases only to the extent that government savings increase due to increasing government revenues from the carbon tax. The rest of the required funding for the sectoral investments would be at the expense of investments in other sectors (e.g., power sector investments would reduce investments in other sectors, causing a crowding out of public and private investments).

Results

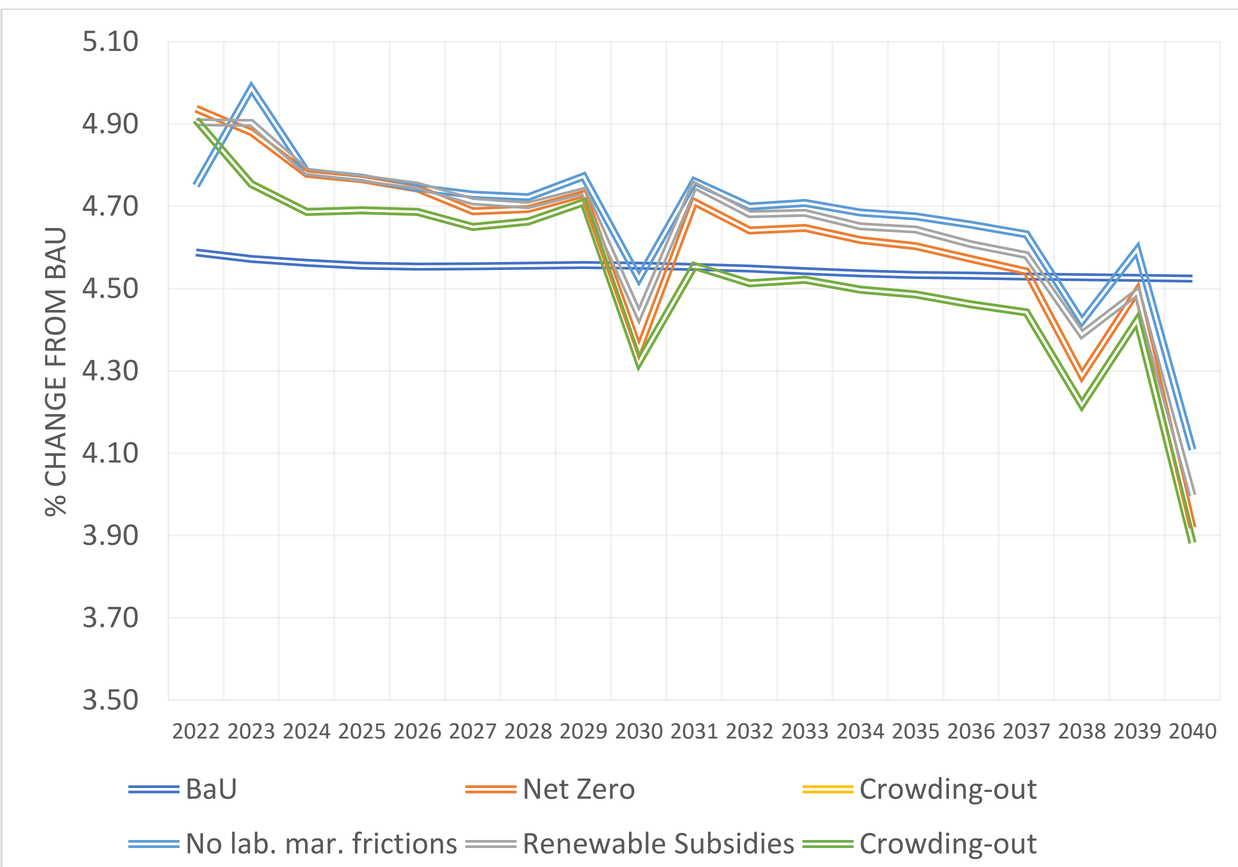
The RNZP scenario would contribute to economic growth in Turkey—especially when mitigation co-benefits are considered, and labor market frictions are addressed. Increases in energy efficiency in transport and building sectors is the driver of the growth benefits in the short to medium term. After 2030, 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 3: Transitioning to RNZP would bring growth benefits in the short and medium term especially if labor market frictions are addressed (growth differences in percentage points relative to the business as usual)



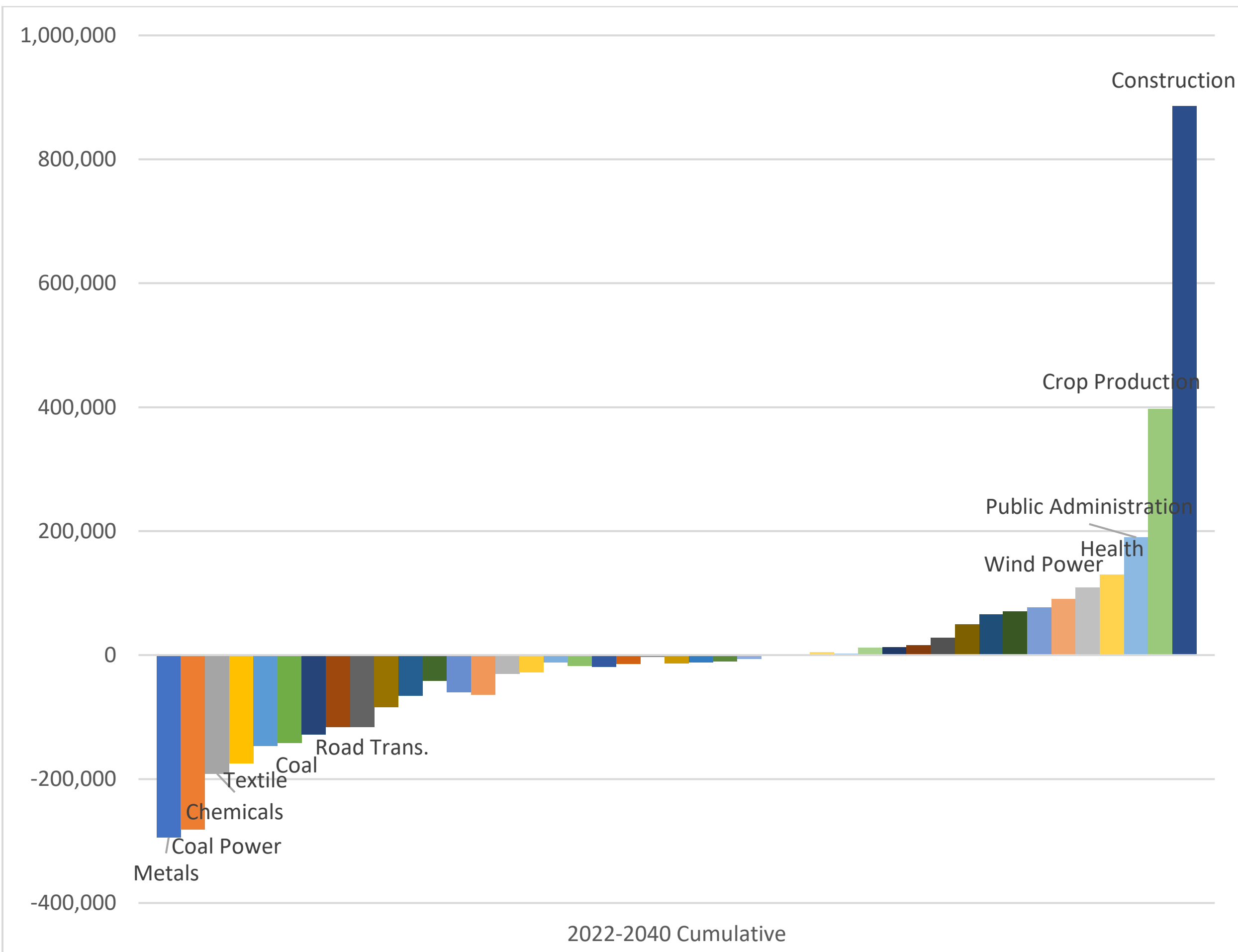
Increasing electricity prices might pose a challenge for the growth in the longer term. As electrification of buildings and transport surges the demand for electricity and attendant prices start to increase significantly and economic growth slows down to the extent that year on year growth falls back to the 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.

Figure 4: GDP growth is generally above the baseline until 2037 but can be reduced significantly afterward due to higher electricity prices



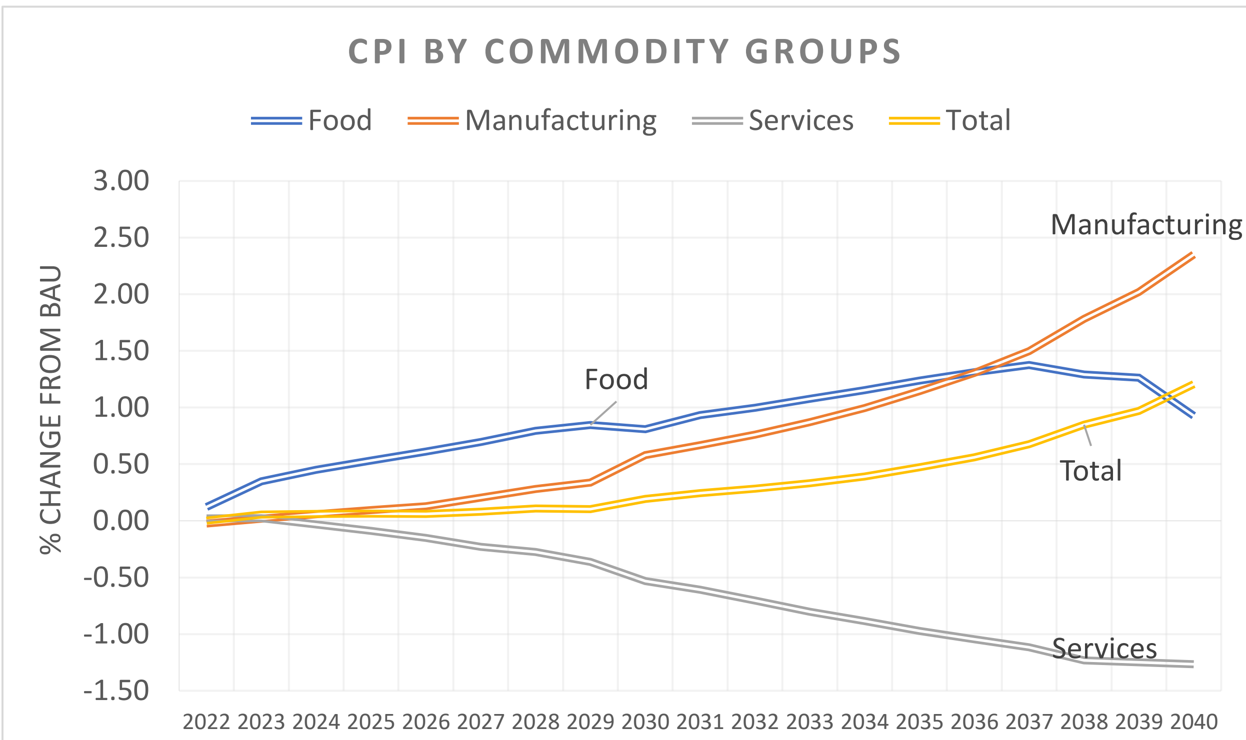
The RNZP would raise and reduce jobs between 2022 and 2040, but overall generate up to 70 thousand jobs over in cumulative net terms - mostly in construction, agriculture and renewable power sectors as well as upstream sectors supporting them. The job gains are higher in earlier years, e.g., as much 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 5: The RNZP would significantly reallocate labor force across sectors creating losing and winning sectors



The transition would also put pressure on inflation as food and manufacturing prices would rise. Service sector prices would fall as services are generally less emission intensive and shifting to electricity both for transport and heating shields them from the price impacts of the carbon tax. However, that is not enough to compensate the adverse impact of food and manufacturing sectors on overall price levels. The increase is especially present in the longer run as the increasing carbon price starts to push cost up on the supply side, and the increase in electricity prices passes through to headline prices

Figure 6: CPI by commodity groups



The impact of the green transition on Government revenues critically depends on the level of carbon tax. As liquid fuels are already heavily taxed and constitutes a significant source of income for government, the reduction in fossil fuel use in the 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 transition and adverse effects of the transition, notably retraining and or unemployment compensation.

In summary, investments are needed in balancing electricity supply and demand during the transition to mitigate price rises that hinder economic activity and employment. the CGE results suggest that while rising electricity demand and attendant prices from electrification of buildings and transport are compensated for in the early transition by energy efficiency, challenges will arise in the longer term.. Hence Turkey needs to revise 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 growth benefits for Turkey.

Part 2: The impact of investments on macro aggregates, trade, and current account

The RNZP includes roughly USD 313 bn in cumulative nominal investments over the next two decades, which would be additional to the business as usual investments needed to build infrastructure and support Turkey's growth and development objectives. In parallel, these RNZP-related investments are estimated to generate significant fuel savings in the order of 21% of GDP, cumulatively. These investment needs are run through the CGE in Part 1, and through a macro-structural consistency framework in Part 2. The investments identified for the green transition in the introduction of this note and their implications on energy consumption and imports, have implications for public finance and public debt, and the trade balance and current account. In Part 2, we complement the work with the CGE by focusing on these effects with in a partial equilibrium framework using the macrostructural model MFMod.[5]

[5] Burns, A., Campagne, B. P. M., Jooste, C., Stephan, D. A., & Bui, T. T. (2019). The World Bank MacroFiscal Model Technical Description (Policy Research working paper No. 8965). Retrieved from http://documents.worldbank.org/curated/en/294311565103938951/The-World-Bank-MacroFiscal-Model-Technical-Description

Figure 7: Annual and cumulative Investment needs relative to GDP

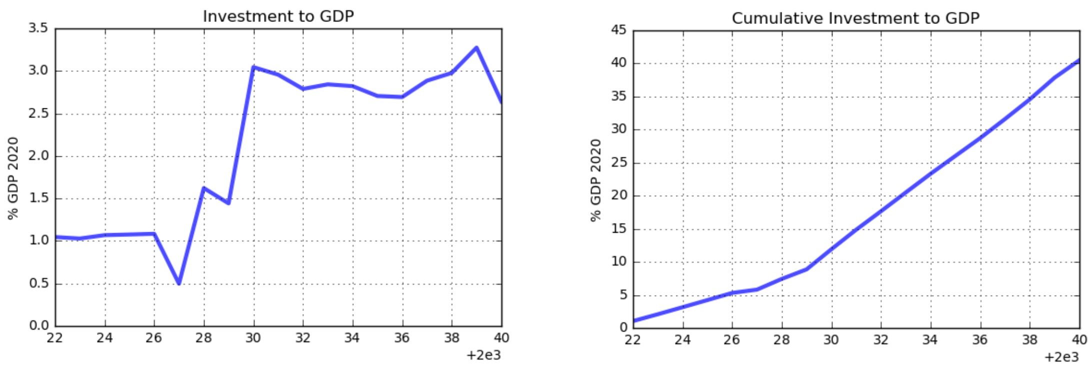
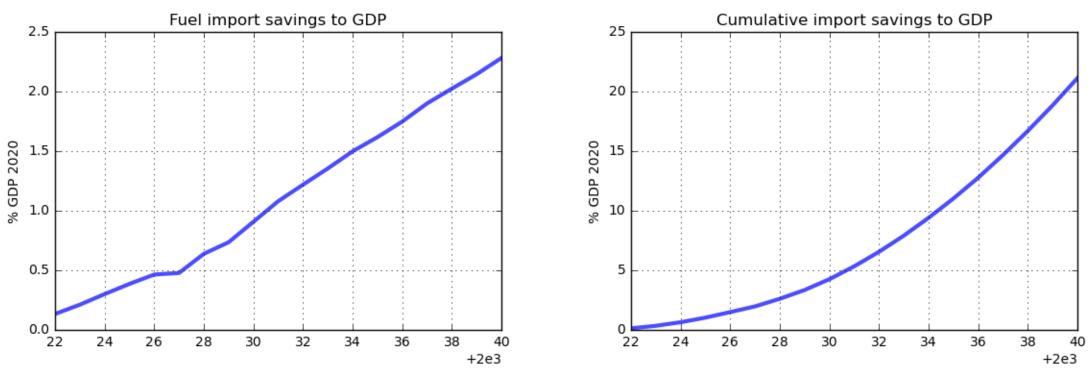


Figure 8: Annual and cumulative Fuel import savings relative to GDP



Methodology

The modeling setup takes the investment amounts as given, following the estimates done at the sectoral level (see background notes 2, 4, and 5). The simulations assume that the government contributes 50% towards these investments while the remainder is provided by the private sector based on economic reforms that raise the return on, and hence incentivize, these investments. The model also takes the economy wide fuel savings from the CGE model as an input, complementing the trade impacts determined in the model itself.

The World Bank's macrostructural model, MFMod is used in quantifying the economy-wide impacts of the energy efficient infrastructure investment. The customized standalone model for Turkey extends the investment channels along the several dimensions. (1) Capital stock is differentiated by public and private contributions and (2) capital stock is differentiated between infrastructure and non-infrastructure capital [6], (3) the time horizon is extended to 2040.

In the model, investment decisions are based on the difference between returns and the cost of capital. Specifically, the dynamic investment equation is a function of past investment decisions (to reflect the "sticky" nature of asset decisions) and the marginal Tobin's Q ratio, which reflects the return vs. the cost of capital. In the long-run, the investment to capital ratio is a function of long-run economic growth plus the rate of capital depreciation. The private sector infrastructure equation is written as:

$$\frac{I_t}{K_{t-1}} = \beta \frac{I_{t-1}}{K_{t-2}} + (1-\beta)\left[\frac{\Delta \ln(A_t)}{\alpha} + \Delta \ln(WPOP_t) + \delta_t\right] + \gamma\left(\frac{MPK_t}{UCC_t}\right) + \varepsilon_t$$

The investment to capital ratio $\left(\frac{I_t}{K_{t-1}}\right)$ is a function of previous investment decisions. In the long-run this ratio converges to long-term growth (TFP adjusted for the labor share in income plus growth in working-age population) and the capital depreciation rate. In the short-run, investments increase if the marginal product of capital (MPK_t) is higher than the cost of capital (UCC_t). The error term is independent and identically distributed ($\varepsilon_t \sim i.i.d$). Thus, any measure that raises expected growth in the long run will generate higher investment. The real cost of capital is a function of the short-term interest rate (proxied by the average interest rate on government debt (r_t^B)) and adjusted for corporate income taxes (τ_t^{CIT}):

$$UCC_t = \frac{P_t^I}{P_t^Y}\left(\frac{r_t^B + \delta - E_t\pi_t}{1-\tau_t^{CIT}}\right)$$

While public sector choices in the model are discretionary, private investment choices are behavioral based on firm-level optimization. As a result, there are multiple ways of representing the increase in the private sector investments, and the policies or public interventions in place to incentivize those investments. Here, to explore the implication of higher investments, two scenarios are used with different (and contrasted) assumptions on how the private sector incentives generate the investment amounts:

1. **TFP Scenario.** An increase in total factor productivity (A) from FDI flows and investment climate reforms (these are taken as a given). In the TFP scenario, an improvement in productivity in infrastructure will generate the necessary investment amounts required to reduce emissions.

[6] In Hallegatte, Jooste, McIsaac (2022) use a modified version of the model to explore the vulnerability to floods and earthquakes. http://hdl.handle.net/10986/37060

The TFP boost need not come at an economic cost (i.e., better rule or law, better institutions, a reduction in entry barriers are not always expensive), even though it may also include investments. This efficiency boost will also lower marginal costs, which benefit producers directly, but also consumers through lower end-user prices. Higher aggregate demand (from investment, lower costs) will imply an increase in imports. However, note that this import rise is offset by a reduction in fuel imports due to the “efficiency” factor of the new investments.

2. **Fiscal incentive scenario.** Government transfers to the private sector, where transfers are financed by raising additional revenues through a carbon tax calibrated on the CGE simulations presented in the first section of this paper. The economic transmission mechanisms are different in the case of raising funds via a carbon tax and then transferring those revenues as a subsidy to the private sector. The carbon tax drives a wedge between fossil fuel and renewable energy demand. It is assumed that the carbon price is passed onto the end-user, which implies a rise in aggregate prices in the short run. The government collects revenues from the carbon, which is then transferred to the private sector via a subsidy in energy efficiency infrastructure investment. The subsidy lowers the cost of capital for this type of investment relative to the return to capital.

Another important assumption concerns the productivity of the new investment. The question is whether the investments necessary for the RNZP are producing economic value in addition to emissions reductions, or only emissions reductions. Some of these investments are additional because they correspond to an additional cost to produce the same service. For instance, buildings can be more expensive because of electrified heat and better insulation. But at the same time, these investments have significant benefits beyond emission reductions and energy efficiency. In the building example, better insulated buildings tend to be more comfortable, provide better health (because of better ventilation and less indoor pollution), and in the case of the Turkey RNZP, the investments also allow for higher resilience to heat waves and earthquakes.

To provide the most conservative estimates, the simulations in this note assume that these investments provide energy efficiency gains, but do not generate new capital stock, but rather reflects adjustments to the existing stock of capital. In other words, all co-benefits are ignored, except energy efficiency. In the model, to ensure that capital stock does not rise, the infrastructure investment is offset by reducing non-infrastructure capital investment (for both public and private investment). However, the efficiency component of capital should also be considered when analyzing the output responses of this investment. The economic production function is a Cobb-Douglas technology:

$$Y_t = A_t F(N_t, u_t^K K_{t-1})$$

While the efficient investment spending does not add to the existing stock of capital (K_t), it does modify its efficiency (u_t^K), and hence may increase output in the medium to long run horizon. Furthermore, second round effects will imply changes to both factor prices, which will have implications for labor too. To reflect the crowding out effect (for capital to remain constant) requires an increase in the cost of capital for other types of investments.

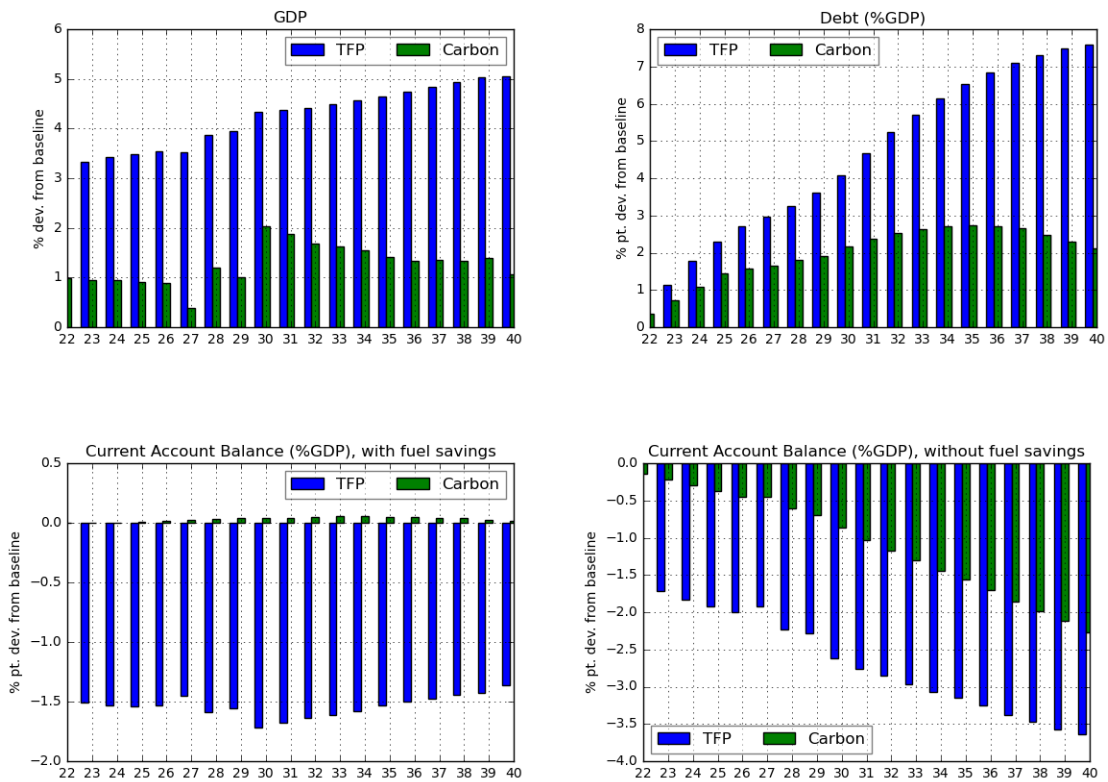
In this simulation, it is assumed that private sector non-infrastructure investments are crowded out. This assumption is the most pessimistic in terms of impact on economic growth.

Results

This simulation shows that the TFP scenario boosts GDP substantially. While aggregate capital stock from the investment remains fixed, the TFP impact generates aggregate economic benefits by making existing factors of production more efficient. The TFP scenario has a rapid increase of public debts (50% of infrastructure investments are financed by the government). The increase in public debt in this scenario starts from a low debt to GDP baseline. The crowding out effects are thus lower than would have been if debt to GDP is high. The TFP increase also lowers marginal costs, which reduces inflation (and consequently monetary policy) pressures. In this case, the fiscal space coupled with lower marginal costs and more efficient public investment has strong economic spillovers. The increase in aggregate demand generates an increase in imports. The current account balance deteriorates consequently. However, without the fuel saving impact, the current account balance would have worsened materially more (counterfactual bottom right panel in Figure 9).

In the fiscal incentive scenario, the carbon tax financing of subsidies works through a different channel. The economic benefits in terms of GDP are much reduced as the carbon tax directly affects households at all levels. The carbon tax will suppress aggregate demand, even though it leads to less emissions. The carbon tax is recycled via subsidies for the private sector to invest in the sectors identified in the RNZP sectoral roadmaps. The increase in investment offsets the household losses from the tax. Debt still rises in this scenario, but primarily through the government own discretionary infrastructure expenditures. When combined with the fuel savings, this scenario leads to a small current account surplus.

Figure 9: Simulation results



Conclusions

Based on the analyses presented here using the carbon tax scenario rather than the TFP scenario, we expect the RNZP to increase GDP growth and employment, even without considering benefits from avoided climate change impacts, thanks to large investments, energy efficiency, technological upgrading, and reduced fuel costs. Turkey's GDP grows faster in the RNZP, in which sectoral roadmaps are combined with economywide interventions, including carbon pricing, with appropriate recycling. However, this growth benefit would be lower if carbon pricing revenues are not recycled in a way that supports private sector investment and additional investments in the RNZP crowd out other investments. Growth benefits are also markedly lower after 2035, as decarbonization of the power system gradually leads to higher electricity prices. While the additional investments needed are significant, their overall impacts on the fiscal and external balances are relatively small. The analysis shows that additional investments raise capital and related imports, but savings in oil and gas imports offset these in the current account balance. Also, public debt levels rise by 1 to 3 percentage points of GDP compared with a baseline scenario, as government revenues from carbon tax help offset borrowing for investment needs. This provides an indication of the space the government has should it choose to save less and instead take on a larger share of the total investment needed in capital and innovation to support the transition. Macroeconomic stability is essential to preserving this fiscal space. In terms of the external balance, the negative effect of larger investments on the current account balance are offset by reductions in oil and gas imports in the RNZP, compared with the baseline scenario. Lowering oil and gas imports would also reduce exposure to energy supply and price instability from geopolitical risks.