The Coalition of Finance Ministers for Climate Action

The importance of inter-model comparisons to inform robust decision-making: the example of the Italian Ministry of Economy and Finance

Italy—Ministry of Economy and Finance

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Overview and key results

This contribution details an application focused on the economic impact of mitigation policies. Specifically, it considers an emission mitigation plan and investigates its implications on macro-variables, comparing the dynamic properties of the Italian Regional and Environmental Computable General Equilibrium of the Department of Finance (IRENCGE-DF) model (a computational general equilibrium [CGE] model) with those of the General Equilibrium Environmental Model (GEEM—a dynamic stochastic general equilibrium [DSGE] model). The main transmission channels in the two models are analyzed, and a comparative assessment of the magnitude and the persistence of the effects is carried out to disentangle the channels through which the policy action propagates. It is shown that, despite substantial differences between the two models, the responses of the key variables to a mitigation plan are qualitatively similar. However, quantitative disparities are observed between the two models, owing primarily to the forward-looking behavior mechanism and New Keynesian elements (such as imperfect competition and price-setting frictions) incorporated into the GEEM, as well as the breakdown of variables in several sectors and distributional components in the IRENCGE-DF model.

The Ministry of Economy and Finance study examines a mitigation policy implemented through a gradual increase in the carbon tax able to generate a 35% reduction in emissions within six years. Specifically, the policy scenario (POL) assumes a 35% reduction by 2030 compared with the baseline (BAS), achieving a target of 305 $MtCO_2e$ greenhouse gas emissions. Note that this contribution does not deal with specific policy provisions that have been implemented or that the Italian Government is about to implement. Indeed, the scenario is solely intended to be illustrative of the analytical potential of the two models. Accordingly, the simulation hypotheses concerning the credibility, design, and size of the shocks are to some extent arbitrary. Also, this mitigation scenario does not include recycling policies. As a result, the fiscal revenues generated by the higher carbon tax revenues are entirely used to reduce public debt.

The IRENCGE-DF model

Selected results are presented from simulations using the interlinked models for the BAS and POL scenarios. The BAS scenario serves as a counterfactual and, in this context, represents a hypothetical setup where it is assumed no environmental policy is undertaken in Italy.[1] This implies that greenhouse gas emissions increase between 2020 and 2030 at a rate of approximately 2% per year, rising from the COVID-19 pandemic low level of 381 $MtCO_2e$ to around 469 $MtCO_2e$ in 2030 (excluding land use, land use change and forestry [LULUCF]). In the IRENCGE-DF model, greenhouse gas emissions are calibrated to historical levels up to 2021. Then, they vary according to the different scenario hypotheses.

The POL scenario encompasses an ambitious target introduced through the imposition of a carbon price across all sectors of the economy, including the residential and transportation sectors. Turning to the results of IRENCGE-DF, in neoclassical general equilibrium models, taxes are distortionary, and the welfare loss caused by the tax can vary depending on the elasticity of supply and demand with respect to prices. Given the significant abatement effort required to decarbonize the economy from a high-emissions scenario such as the one envisaged in this study, the impact on consumption is significant and equal to –3.5% in 2030 (see Table 1). In terms of GDP, the loss is around –2.1% in 2030.

Welfare impacts, differentiated across household deciles and measured by comparing the Equivalent Variation,[2] are reported in Figure 1. The effect is negative for all households but differs in terms of its

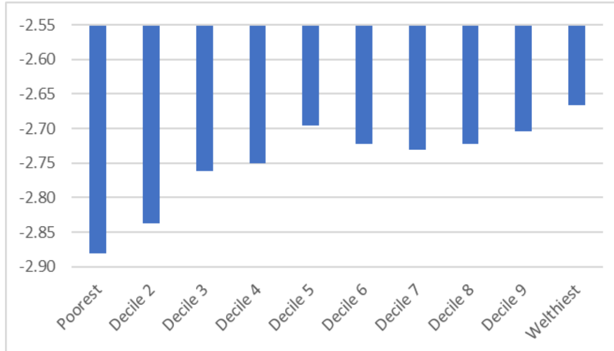
1 Although current EU legislation on climate mitigation requires all Member States to curb greenhouse gas emissions to certain levels.
2 The Equivalent Variation (EV) measures the change in welfare or utility of a consumer resulting from a change in prices, income, or other economic conditions. It is used to evaluate consumer welfare as it represents the amount of money a consumer would be willing to pay (or need to be compensated for) to achieve the same level of utility after a change occurs. If positive, it denotes a welfare improvement (or the opposite, if negative).

magnitude across deciles, with poorer households bearing a disproportionate impact of climate regulation, mostly because energy products constitute a larger share of their income.

Table 1. Macroeconomic effects (% change with respect to the baseline)

	Cons.	Priv. invest.	GDP	Employment	Gini index
2025	−1.3	−0.7	−0.7	−0.4	0.07
2026	−1.7	−0.9	−0.9	−0.6	0.08
2027	−2.1	−1.1	−1.2	−0.7	0.10
2028	−2.6	−1.4	−1.5	−0.8	0.11
2029	−3.0	−1.6	−1.7	−0.9	0.12
2030	−3.5	−1.9	−2.1	−1.1	0.13

Figure 1. Household welfare (% change with respect to the baseline)



Source: Internal analysis, from the IRENCGE-DF model

Continuing with the analysis of income distribution, the Gini index serves as a widely recognized measure of income inequality, increasing as disparities between wealthier and less affluent segments widen. The observed increase in the Gini index (+0.13% relative to the baseline in 2030) aligns with findings from other assessments of household welfare. This increase confirms that stringent climate policies, such as carbon taxes or emissions regulations, can exacerbate income inequality by imposing disproportionate economic burdens on lower-income groups.

Turning to the impact on economic sectors (Figure 2), it is evident that fossil fuel and energy-intensive industries experience the most substantial reductions in output. This suggests a significant shift in economic activity away from these sectors due to market dynamics relating to climate policies. Regarding the electricity mix (Figure 3), there are notable changes in 2030 compared with the BAS scenario. Specifically, solar, wind, and other renewable sources show an almost twofold increase in their contribution to the electricity generation mix.

Figure 2. Sectoral production (% change with respect to the baseline)

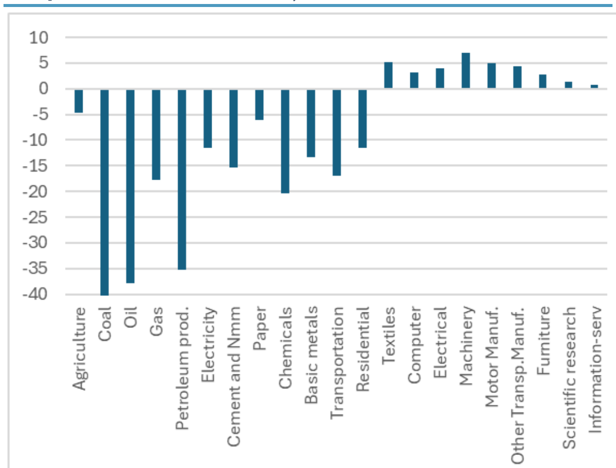
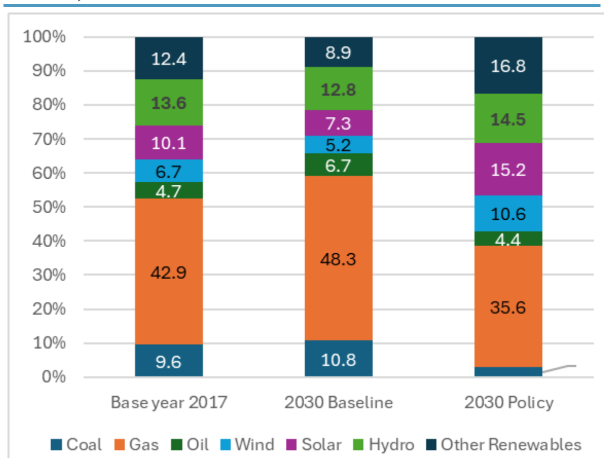


Figure 3. Electricity supply mix in 2030 (% share)



Source: Internal analysis

Finally, it is noteworthy that certain less carbon-intensive sectors benefit slightly from climate policies. Specifically, sectors such as textiles, machinery equipment production, and electrical equipment production experience notable increases.

The characteristics of the BAS may partially overestimate the reduction in GDP and consumption of the POL, as well as its regressive impact. This is explained by the fact that the BAS in this application is purely illustrative since it assumes no environmental policy is currently in place in the country, which is clearly not the case. In addition, no strong assumptions have been made about either the evolution of energy efficiency, using the autonomous energy efficiency improvement (AEEI) parameters of the model or the electrification of important sectors. This results in unrealistic future projections, such as a decrease in the share of renewable energy (RE) within the BAS scenario, which does not align with current trends and expectations. This application is therefore mainly useful to illustrate the type of output a CGE model can produce.

Incorporating a more realistic reference scenario that includes existing mitigation measures and anticipated energy efficiency improvements results in a reduced economic impact. Under this scenario, the cost of achieving the same emissions reduction target is projected to decrease, leading to a GDP impact of around –0.6% by 2030. This reflects the potential economic benefits of current policies and technological advancements in reducing the overall cost of emissions mitigation. In terms of policy considerations, CGE models are best suited to compare the performance of different policy mixes in terms of their effectiveness, efficiency, and equity. As an example, assuming a POL2 scenario in which the introduction of the carbon tax is included in a more comprehensive policy mix where the increase in the stringency of climate policies is accompanied by other complementary policies, such as those aimed at compensating vulnerable groups and sectors or at reducing the costs of the transition, POL2 may perform better than POL in terms of efficiency and equity. An analysis carried out simulating scenarios in which the increase in carbon tax is accompanied by revenue recycling (e.g., the use of additional revenues from carbon tax to reduce other taxes, provide cash transfers, or enhance the use of renewable energy in production) shows a smaller reduction in GDP and a decrease in the Gini index compared with the non-revenue-recycling scenarios.

GEEM

In the GEEM model the greening policy is mapped onto the model by imposing an increase in the carbon tax so as to achieve the final emissions goal, i.e., a cumulative reduction of emissions by 35% over six years. Table 2 reports the results of this mitigation policy.

Table 2. Emissions mitigation of –35% in six years (with carbon tax) estimated by GEEM

Year	GDP	Consumption	Consumption (Ricardian)	Consumption (non-Ricardian)	Investment	Hours	Wages
2025	−1.96	−1.91	−1.85	−2.59	−1.94	−0.82	−1.81
2026	−2.90	−3.30	−3.00	−6.38	−1.98	−1.76	−4.10
2027	−3.39	−3.83	−3.32	−9.16	−2.03	−2.30	−5.74
2028	−3.64	−4.13	−3.43	−11.29	−2.06	−2.57	−6.95
2029	−3.74	−4.33	−3.48	−13.09	−2.06	−2.66	−7.90
2030	−3.74	−4.51	−3.50	−14.90	−2.04	−2.64	−8.71

Note: All the variables are expressed as percentage deviations from steady state values. Source: Internal analysis

The introduction of a carbon tax induces a persistent and negative effect on output (GDP), consumption, and labor, respectively, on the order of –3.74%, –4.51% and –2.64% in 2030. Nonetheless, in transition the magnitude of these effects is greater than that observed for the IRENCGE-DF model. The different transitory dynamics are due specifically to the fact that the channel through which the mitigation policy propagates is different, owing to the presence of agents' expectations and to the existence of large real and nominal adjustment costs. On the one hand, households and firms have perfect foresight: by adjusting their behavior according to the policy changes, they fully anticipate the effects of the policy changes. On the other hand, the presence of large real and nominal adjustment costs makes the transition more difficult. This, together with limited possibilities to substitute away from fossil sources of energy over the time span examined, results in larger negative effects on output and consumption.[3]

The reduced level of economic activity, in turn, yields, through general equilibrium effects, fewer hours, which translates into lower wages. Nonetheless, non-negligible distributional effects across households are also observed, since non-Ricardian households experience a significant drop in their consumption (−14.90 after six years), while the reduction is fairly moderate for Ricardian households (−3.50 after six years). Intuitively, non-Ricardian households are more exposed to the changing economic conditions and suffer from the diminished level of economic activity induced by the mitigation scheme. This result, pointing to the distributional aspects of this policy intervention, is in accordance with the IRENCGE-DF model results (see Figure 1). Furthermore, when the shift toward major abatement is fully underway, investment still remains below the baseline value by around 2.04%.

In this context, it is important to highlight that the medium- and long-run costs associated with mitigation policies can be substantially alleviated by recycling the revenues generated by carbon pricing. In general, recycling carbon revenues with tax reductions alleviates the fiscal pressure on the budgets of the more vulnerable households.

Communication

The application reported in this contribution is for illustrative purposes only. However, the findings resulting from the use of the modeling tools are usually destined for internal institutional use.

Conclusions

The above exercise demonstrates that the two models (IRENCGE-DF and GEEM) can complement each other and provide valuable insights to policymakers. The CGE model, with its detailed representation of the economy's sectoral interactions and the impact of policy changes on different industries, allows a comprehensive analysis of the distributional effects of environmental policies. On the other hand, the DSGE model, which can incorporate macroeconomic fluctuations and forward-looking behavior, provides a dynamic framework to assess the short- and long-term impacts of these policies on overall economic stability and growth. By integrating the strengths of both models, one can gain a more robust understanding of how climate mitigation strategies can be designed and implemented. This combined approach helps policymakers to evaluate the trade-offs and synergies between different policy options, ultimately supporting more informed and effective decision-making.

3 The model may underestimate the potential for technological innovation and the adoption of cleaner technologies that could facilitate substitution away from fossil fuels. Furthermore, the mitigation scenario does not consider the implementation of complementary policies that could mitigate the negative impacts, such as subsidies for renewable energy, investment in energy efficiency, or R&D incentives for green technology.