

Lessons and methods from three model linking analysis

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As countries make progress in implementing policies towards their climate change mitigation targets, one of the key questions that arises is how effective current policies are in reducing greenhouse gas (GHG) emissions. The OECD's Inclusive Forum on Carbon Mitigation Approaches (IFCMA) aims to answer this question by a modelling assessment of the impacts of current and legislated mitigation-relevant policies on GHG emissions et economic outcomes. This involves developing a standardised and granular database on mitigation policy design—the IFCMA Climate Policy Database (OECD,2025) and building on these data to conduct model-based quantitative analyses that estimate the impacts of this “real world” policies. To develop a robust methodology for a broad set of countries three modelling exercises were conducted for very different countries: Chile, Nigeria and Switzerland.

To measure the effects of current “real world” policies on emissions, the modelling framework is coupling a common dynamic CGE model (the OECD ENV-Linkages model) to different sectoral models for the three countries. This method combines the granularity and technology details of sectoral models with the breadth of an economy-wide model.

The value added of this modelling approach is to provide quantitative assessment of the current policy actions on emissions using an ex-ante analytical approach (i.e. modelling) and not with ex-post empirical analysis.

To test the modelling approach, the pilot studies cover a diverse portfolio of policies and sectors. Each of the pilots focuses on a subset of sectors that are key for considered country in their emission reductions plans. The sectoral scope of the exercise has also been agreed upon with the national authorities and tailored towards the needs of each country. For Switzerland, the sectors analysed were Buildings, Transport and Industry; for Chile, Power Generation and Transport; and, for Nigeria, Transport and Agriculture, Forestry, and Other Land Use (AFOLU). The policies to be assessed were chosen from the IFCMA Climate Policy Database supported by expert judgement in consultation with the respective authorities and include up to ten key climate(-relevant) mitigation policies per country.

This paper therefore presents first the methods of coupling the sectoral models to the CGE model. Then the paper provides some lessons about common modelling results, including an evaluation of the effectiveness of the selected real-world policies currently implemented in the countries considered as well as their implication for public finances. Finally, the paper reviews the strengths and weakness of each of the three models-coupling exercises done, and what should be improved for extending the future work to a broader set of countries.

Introduction

As countries make progress in implementing policies towards their climate change mitigation targets, one of the key questions that arises is how effective current policies are in reducing greenhouse gas (GHG) emissions. The OECD's Inclusive Forum on Carbon Mitigation Approaches (IFCMA) aims to answer this question by assessing the impacts of current and legislated mitigation and mitigation-relevant policies on GHG emissions. This involves developing a standardised and granular database on mitigation policy design—the IFCMA Climate Policy Database (OECD, 2024^[1])—and building on these data to conduct model-based quantitative analyses that estimate the impact of policies on GHG emissions. To develop a robust methodology for both climate policy database and the modelling analysis, the IFCMA conducted pilot studies for Chile, Nigeria and Switzerland before scaling up the work to a broader set of member countries.

The IFCMA modelling analysis relies on linking sectoral and economy-wide models to assess the impact of selected policies on emissions. Each pilot study focuses on specific sectors identified in consultation with national governments, and taking into consideration their expected contribution to emission reductions. They used different sectoral models depending on the country and the sectors examined. This has allowed the Secretariat to explore different methodologies and assess the suitability of the various sectoral models for capturing the effect of policies on emissions in a range of member countries. Each of the sectoral models has been linked with the same OECD in-house economy-wide model—the ENV-Linkages model.

This note presents the main insights from the modelling analyses conducted for the three pilot studies and draws lessons for scaling up this work to other IFCMA member countries. The note is structured as follows: Section 2 outlines the modelling strategy for the evaluation of current policies, including the novelty and value-add of the exercise. Section 3 includes methodological lessons drawn from the pilot studies. Section 4 identifies the takeaways from the modelling results of the pilot studies. This includes pilot-specific takeaways as well as more general considerations. Finally, Section 5 provides an overview of the proposal for scaling-up the modelling exercise.

The modelling strategy for evaluating current policies

The IFCMA modelling approach evaluates how effective current policies are in mitigating emissions

To measure the effects of current policies on emissions, the modelling framework combines the granularity and technology details of sectoral models with the breadth of an economy-wide model through a soft-linking setup. Sectoral models are biophysical or engineering models (e.g., an energy-system or a land-use model) that record *direct impacts* of policies on technology choices and input substitution (see further details about these effects in Box 2). In contrast, economy-wide models, such as Computable General Equilibrium (CGE) models, include fewer technological details but provide a comprehensive representation of economic flows, covering all economic sectors and ensuring macroeconomic consistency. These economy-wide models are therefore able to quantify *indirect* economic effects, such as those on prices or demand for goods not directly targeted by the policies.

Linking the models through a one-way soft link ensures a detailed and consistent assessment while maintaining flexibility and feasibility.¹ This modular approach allows for greater sectoral detail while preserving the strengths of each model. Conducting a one-way model linking exercise ensures consistency across models and generates robust insights into system interactions without the added challenges of fully integrated modelling. In short, the model linking approach works as follows: the sectoral model is run first, and its outcomes (i.e. *direct impacts*) are fed into the economy-wide model that complement them with the economy-wide impacts (*indirect impacts*).² While both models are run sequentially and separately, the historical data, the implemented policies, and the baseline projections and assumptions are carefully harmonised across both models.

The value added of the IFCMA approach is to provide quantitative assessment of the current policy actions on emissions using an ex-ante analytical approach (i.e. modelling) and not with ex-post empirical analysis. *Ex-post* empirical analysis, while strongly rooted in historical data, still requires certain conditions to be met to allow an econometric model to have sufficient explanatory power³. These requirements include having sufficiently long data time series, and a need for a policy to cause a clear impact on a measured variable (e.g. emissions) independent of other developments (this approach is for example successfully

¹ More explanations on the different models and the linking approach can be found in a previous IFCMA publication (OECD, 2024^[9]) or in (Delzeit et al., 2020^[13])

² The method chosen for the one-way soft linking follows Schreiber et al. (2025^[12]) closely.

³ A previous OECD report (Pisu et al., 2023^[11]) presents a broader overview of methodological options for assessing and comparing climate change mitigation policies across countries, including a discussion on the advantages and limitations of ex-ante modelling and empirical methods in estimating the effectiveness of different policy instruments.

applied in Stechemesser et al. (2024^[2]). These requirements rule out the evaluation of very recent policies or more ancient but gradually implemented policies (e.g. coal-power phase out legislation). The IFCMA's work under the Climate Policy Effectiveness Network (CPEN) further examines and synthesises the available ex-post evidence on mitigation policy impact (OECD, 2025^[3]).

Well-designed *ex-ante* modelling does not face the same data limitations as *ex-post* approaches and could provide better insights on the functioning of policies. Because *ex-ante* modelling is based on a structural representation of technological and economic relationships, it helps understand how a policy works, how it interacts with other measures, and to identify the various channels that drive its impact. Another advantage of the modelling approach is to allow for policy counterfactuals and their assessments. This, for example, enables testing the impact of one current policy (e.g., an emission-standard on vehicles) in the absence of another existing policy (e.g. an excise tax on fuels) and to then isolate the specific impact of one policy from their interactions with other policies.

To test the modelling approach, the pilot studies cover a diverse portfolio of policies and sectors. Each of the pilots focuses on a subset of sectors that are key for considered country in their emission reductions plans. The sectoral scope of the exercise has also been agreed upon with the national authorities and tailored towards the needs of each country. For Switzerland, the sectors analysed were Buildings, Transport and Industry; for Chile, Power Generation and Transport; and, for Nigeria, Transport and Agriculture, Forestry, and Other Land Use (AFOLU). The policies to be assessed were chosen from the IFCMA Climate Policy Database supported by expert judgement in consultation with the respective authorities and include up to ten key climate(-relevant) mitigation policies per country.

A growing number of IFCMA member countries have recognised that linking sectoral and economy-wide models is a robust approach to assess the effectiveness of granular energy and climate policies. The Informal Focus Group meeting series showcased several national initiatives that underline this trend (see Box 1). These examples, while not exhaustive, reflect a broader movement toward integrated modelling as a foundation for robust quantitative assessment of countries' policies.

Unlike most of these national initiatives, the modelling framework used for the IFCMA economy-wide analysis relies on a global model rather than a single-country model. By using the global OECD ENV-Linkages model (Chateau, Dellink and Lanzi, 2014^[4]), all pilot studies—and later a wider set of IFCMA member countries—rely on the same macroeconomic framework. The bottom-up (sectoral) models nevertheless varied by pilot. These were chosen to allow for an accurate analysis of the focus sectors and policies in each

country. An energy system model was used for Switzerland (JRC-EU-TIMES⁴) and Chile (PMR model⁵), while for Nigeria both an energy system model (LEAP⁶) and a forestry model (G4M⁷) were used. This enabled the Secretariat to assess the suitability of the different modelling tools for the IFCMA and to draw lessons on the effects that can be captured with each model.

Box 1. Examples of similar modelling approaches in IFCMA member countries

During the virtual Informal Focus Group (IFG) meetings hosted over the course of 2024-25, multiple countries have presented their national initiatives on linking sectoral and economy-wide models. Some of these examples are listed below.

- Denmark's GreenREFORM platform integrates a Computable General Equilibrium (CGE) model with multiple sectoral sub-models. Managed by the DREAM Group, these tools are actively used by the Danish Ministry of Finance to support policy analysis.
- The United States' Environmental Protection Agency (EPA) has presented a hybrid modelling approach that links a detailed electricity sector model (IPM) with the CGE model SAGE.
- Italy has developed a collaboration between its Ministry of Economy and Finance and the Italian Energy Agency to connect a CGE model with a TIMES energy system model, aiming to estimate the economic and emissions impacts of climate policies.
- Costa Rica has linked its sectoral energy and transport model (OSeMOSYS-CR, developed by the University of Costa Rica) with the CLEWs economy-wide model, managed by the Central Bank of Costa Rica. This integration supports comprehensive assessments of energy and transport strategies.
- The Climate Change Commission in New-Zealand is linking the ENZ model (that is a suite of 4 sectoral models) and the C-PLAN CGE model, which supports evidence-based decision-making by offering flexible scenario adjustments and aligning with national climate reporting.

Outside of the IFGs seminars some additional initiatives may be worth to be mentioned including:

- The CEEP-IT project from Belgium's Federal Planning Bureau, linking the GREU, single-country CGE model for Belgium, GREU with a TIMES model.
- The Korean modelling effort of Yonsei University, supported by the KEI institute and the Korean Ministry of Environment, linking a suite of sectoral bottom-up model, including an Energy System Optimization Models, with a global top-down economic model.
- For its updated draft of its Nationally Determined Contribution (NDC) in 2021 the South African Department of Forestry, Fisheries and the Environment (DFFE) made use of technical analysis

⁴ JRC-EU-TIMES model (Nijs and Ruiz, 2019^[10]) version managed and developed by the Paul Scherrer Institute (PSI).

⁵ A description of the the Chilean PMR model is provided in Benavides et al. (2021^[14]).

⁶ For the Long-range Energy Alternatives Planning System (LEAP) see: https://iamparis.eu/detailed_model_doc/38

⁷ Here is an overview of the Global Forest Model (G4M): <https://iiasa.ac.at/models-tools-data/g4m>

using the University of Cape Town's linked South Africa TIMES (SATIM) and South Africa General Equilibrium (SAGE) models.⁸

Source: [Informal Focus Groups Module 2 \(M2\)](#).

The modelling analysis aims to estimate the impact of current real-world policies across countries

While integrated modelling approaches are commonly adopted, they are mainly used to conduct scenario-based analysis of future mitigation strategies and not to evaluate current policies, as proposed by IFCMA. For example, the World Bank Country Climate and Development Reports (CCDRs) use of this state-of-the-art model-based approach to

⁸ See <https://www.climatecommission.org.za/publications/south-africas-ndc-targets-for-2025-and-2030> for more information.

identify effective mitigation and adaptation strategies for the future for about 70 low- and middle-income economies (Abalo et al., 2025^[5]), but do not consider at all to assess the impact of current policies.

The strong connection between the detailed IFCMA Climate Policy Database and the modelling of policy impacts ensures that the analysis remains closely aligned with real-world policy experiences. The modelling exercise is based on the use of the granular and up-to-date policy information that is gathered under the Climate Policy Database for current and legislated policies for both mitigation and mitigation-relevant policies. The database plays a critical role in developing accurate reference scenarios and informing modelling choices. By providing detailed input data on policy intensity, coverage, and design, it enhances the realism and reliability of both sectoral and general equilibrium models. This ensures that policy scenarios are grounded in actual policy characteristics and improves their relevance for decision-making.

The accuracy of the quantitative assessment conducted under the modelling framework during the pilots has been significantly strengthened by the active involvement of domestic experts and policymakers. Their feedback and guidance significantly enhanced the quality and relevance of the modelling by incorporating insights into local conditions and technical details of current policies. By accounting for country-specific circumstances, the modelling results become more realistic and better tailored to national contexts. Some policy types—such as subnational measures—can be difficult to capture in detail, and domestic expertise is key to identify the most appropriate modelling strategies.

Methodological lessons

Modelling set-up

The pilot studies confirmed that the proposed modelling methodology is both appropriate and effective for assessing the impact of current climate mitigation policies on GHG emissions. The sectoral models proved to be capable of dealing with policy details relevant for insights into avoiding emissions in specific parts of the economy (e.g. technological detail, detail on the forest or agricultural sector etc.), while the economy-wide model proved to capture macroeconomic impacts absent in the sectoral model that were relevant for estimating the emission impacts (examples are provided in OECD (2025 (forthcoming)^[6])).

The pilot studies highlighted that the ease of linking CGE models with sectoral models strongly depends on the type and structure of the sectoral models. An overview is provided in **Error! Reference source not found.** below. The linking process is generally more straightforward when sectoral models that are relatively focused or modular—such as those used in the pilots for Chile and Nigeria—compared to cases where the sectoral model encompassed a broader range of sectors, as is the case for the EU-JRC-TIMES model in the Swiss pilot. This modular configuration simplifies the calibration and the linking of models, but at the cost of energy system interactions across sectors. More generally, the balance, in the sectoral model, between model-endogenous behaviour and exogenous scenario assumptions plays an important role in determining both the linking approach and how to interpret sectoral model results. For example, models such as LEAP (used in the Nigeria pilot) rely more heavily on scenario inputs and expert judgment. This affects how sectoral results can be used in an economy-wide model, and thus influences the overall linking process and the resulting policy insights.

Data inputs and harmonisation

The IFCMA Climate Policy Database is a necessary starting point for implementing policies into the modelling tools. Still, the pilots showed that in certain instances additional data collection is needed to inform the modelling of policy scenarios. Across the different pilots, it has been necessary to collect additional data regarding certain policy details, or for near future developments of the policy instruments (e.g. extension of the coverage of building efficiency codes across cantons in Switzerland) or for interpretation of policy instruments by other authorities. In certain cases, it has also been necessary to make several assumptions due to unavailability of data (for example, sub-national data). To ensure consistency, efforts have been made to co-ordinate the identification of data sources across

the Climate Policy Database and modeling teams at the OECD, the sectoral modelling partners, and the national authorities. For instance, in the case of Nigeria, the data about fossil fuel subsidies gathered from the IFCMA Climate Policy Database had to be disaggregated to translate subsidies to yearly price impacts for households to match the model's structure. The national sectoral modelling partner and general-equilibrium modelling team identified additional data sources to disaggregate the data, in co-ordination with national authorities, ensuring coherence with the initial data from the climate policy database and benefitting from validation by national authorities. The modelling effort therefore, in return, contributes to the development of the policy database.

The harmonisation process across both types of models is a prerequisite to conduct a robust model linking exercise but is time-consuming. To combine a sectoral bottom-up model and a top-down economy-wide model, data inputs in both models must be aligned to ensure consistency throughout the exercise. In addition, the baseline and policy scenario assumptions must be harmonised across both models. This process ensures that the analysis is robust even though it may be time consuming. Once the exercise is conducted, when using a sectoral model that covers a large number of countries (e.g. the EU-JRC-TIMES model), streamlining this process will allow to save time when modelling additional countries.

Time horizon and policy scope

Assessing the impact of current and legislated climate policies requires careful consideration of the time horizon and this, in turn, affects some modelling choices. Policy effects can evolve over time as technologies advance and cleaner options become more affordable, yet evaluating policies introduced many years ago remains challenging. Such analyses require detailed historical information on policy implementation and models capable of representing the energy system as they existed in the past—something many models are not designed to do, as they typically focus on present or future conditions. The modelling strategy implies to remove current policies from a reference scenario to assess their individual impact. It also entails a significant upfront effort to establish the reference scenario, since any adjustment to assumptions for one policy requires updating and rerunning all policy scenarios. Once this foundation has been put in place, however, subsequent policy analyses can be conducted more efficiently.

The pilot studies demonstrated that the chosen modelling framework can capture the GHG emission impacts of a wide range of policies in great detail. The sets of policies included both economic and regulatory policies in very diverse country settings and sectors, demonstrating that the chosen approach would be able to capture the diverse policy landscape of IFCMA member countries. Nevertheless, the policies that can be modelled

also depend on the chosen sectoral models. For instance, in the current set-up, certain mitigation(-relevant) policies may be difficult to capture, such as “speed limits”. Modelling these policies remains possible but would require using other types of models, such as general equilibrium models of urban areas (see e.g. Tikoudis et al. (2022^[7]) and OECD (2020^[8]), relying on the MOLES model).

Completeness and model development

The pilot studies revealed that some development of the economy-wide model is needed to better represent policies that influence long-lived assets, such as buildings and vehicles. The Swiss pilot showed that certain “stock-related” policies—such as the Building Energy Codes—are more difficult to capture accurately with the current model structure. Implementing such policies requires the model to distinguish between different types of investments. This distinction—which is not yet explicitly present in the current version of ENV-Linkages—made it more challenging to include in the sectoral model effects of policies that target the building stock in the CGE framework. Addressing this limitation would require targeted model enhancements and additional resources. It would however significantly improve the ability to represent the increasingly relevant policies that affect energy efficiency and technology turnover in long-lived assets.

The pilot studies highlighted that the modelling framework, when complemented by additional tools, deliver insights on variables beyond the emission and economic impacts of policies. For example, assessing the distributional impacts of policies would provide valuable insights into how different household groups are affected. Some policies can influence households with varying carbon footprints in different ways, whether directly, or indirectly through their effects on government budgets. Understanding how policy instruments can affect agents differently may affect the overall change in emissions. Moreover, and more importantly, integrating tools that could capture such distributional effects would strengthen the analysis by supporting more equitable and effective policy design.

Table 1. Sectoral modelling frameworks used in IFCMA pilots

Pilot	Sectors	Main policies	Sectoral models type	Key Advantages/Disadvantages
Chile	Transport Power	Technology standard Carbon Tax Technology ban Fossil-fuel Excise Tax	PMR Energy Model: Power system optimization module + Transport optimization module Country-specific model	Endogenous energy variables for quantities, as well as capital costs can be passed to CGE. Some price effects dealt with exogenous to the model. Segmented energy system: transport and power systems are not connected: no indirect energy-market effects, but easier to calibrate policies in the CGE.
Nigeria	Transport (Buildings)	Fossil-fuel Excise subsidy Forest management	Energy demand simulation model (LEAP)	Endogenous energy variables for quantities can be passed to the CGE. Segmented models for forestry

	Forestry		Forestry Model Country specific models	and energy systems, they are not connected: No indirect energy-market effects, but easier to calibrate policies in the CGE. Forestry model does not provide economic input.
Switzerland	Transport Buildings Industry and Power	Technology standard ETS Performance standard Carbon Tax Fossil-fuel Excise Tax	EU-JRC-TIMES MODEL Full energy system optimization model Regional model for 27 EU countries	Endogenous energy variables, both prices and quantities, as well as capital costs can be passed to CGE. Full energy system: full direct prices effects, endogenous effect of interconnected national energy markets. Provides richer impacts but makes calibration of policy in CGE more complex.

Source: Authors

Box 2. Types of emission impacts that can be assessed by different types of models

Linking sectoral and economy-wide models offers a way of combining the granularity of sectoral modelling and the ability of economy-wide models to assess indirect economic effects of climate policy on emissions (OECD, 2024^[9]).

Direct impacts evaluated by the sectoral models

Sectoral models, or so-called “bottom-up” models, have a granular representation of specific sectors, for example detailed energy technology choices in an energy system model. However, to remain manageable, these model often work in a partial equilibrium set-up where final demand for a sector’s services is assumed to be similar across two scenarios and when prices of sector/commodities not cover by the model are set to exogenous (see for example Nijs and Ruiz (2019^[10])). Between sectoral models there are degrees of difference in the extent to which they represent technological choices and energy markets endogenously. For example, the JRC-EU-TIMES model used in the Swiss pilot, has a fully integrated energy system with partial economic decision making and interactions between power generation, transport systems, buildings and industry, and including international markets for energy carriers. On the other end of the spectrum are sectoral models which merely function as calculators of total demand or supply in a given sector and of the corresponding GHG emissions related to the technological choices in a sector, possibly with some limited optimal allocation of means (e.g. power generation technologies) to fulfil demand, with other technological choices depending on scenario assumptions (LEAP models, as used in the Nigerian pilot, study tend to be on this end of the spectrum). Lastly, the coverage of models in terms of sub-sectors and technological options often varies with the amount of historical effort that has been put in the development of these models, meaning that these kinds of models often become richer in information and better when they are used and developed further over time.

In sectoral models, differences in technological choices resulting from removing a policy are a consequence of differences in investment decisions and in choices of the optimal level of use of available technologies. These changes are driven by the model’s objective to seek the least-cost energy system within given constraints. When a pricing policy is applied, certain technologies become more attractive than others. When a regulation is applied, certain imperatives or constraints on the use of specific technologies translate directly to changes in the level of their use.

Indirect (or “general equilibrium”) impacts added by the economy-wide (i.e. CGE) model

Economy-wide models, such as the OECD’s ENV-Linkages model used in these pilot studies, on the other hand focus on the responsiveness of demand and supply to price-adjustments that clear all markets and

insures a consistent national and global accounting framework. However, technological choices tend to be characterised by a simplified representation through smooth production and consumption functions for each sector or agent.

In the IFCMA modelling framework, the economy wide modelling is implementing the same policies than in the sectoral model. Moreover, the “direct impact” of policies from the sectoral models (on their corresponding covered sector), are aligned in the economy wide. Therefore, the difference in impacts between the two models is quantifying the “general equilibrium” (GE) effects or “indirect impacts”. For sake of simplicity, GE impacts are categorized between i) behavioural changes in fundamental energy demand drivers, that contrarily to sectoral models are not invariant across scenarios, ii) macro-economic impacts, iii) indirect effects on output and demand of non-targeted sectors through relative prices changes and income effects, and finally, iv) changes in international trade patterns. For the selected policies in pilot countries the following GE effects will add to the “direct impacts”:

- Changes in production level: policies that increase unit cost of production for some goods will depress the corresponding production (e.g. increase of energy costs for fossil-intensive sectors under tax policies). Similarly, some regulation policies may impact the levels of production that are considered as invariant in sectoral models (e.g. car manufacturing production). In same spirit some policies affect competitiveness of exporting industries with respect to tier countries and therefore impact their production.
- Consumer behavioural changes: some policies impact the fundamental drivers of household end-use energy service demands (e.g. car road travel, needs for residential space heating...).
- Price-rebound effects: any policies that dampen the demand for a commodity will in turn imply a price rebound effect that offset partly the direct negative impact. Indeed, firm’s supply behaviour accommodates lower demand partly with reducing supply and partly with reducing selling price (e.g. for fossil-intensive sectors under carbon pricing policies).
- Income and macroeconomic impacts: some fiscal tools are important component of government budget revenues and therefore the neutral balance-budget rule will have non-negligible impacts on household purchasing power and expenditures level (e.g. excise tax or subsidies on fuel consumption).

Combined, these indirect effects can exert a large influence over the total effect of policy measures on greenhouse gas emissions and are therefore important to capture.

Source: Authors

Takeaways from the modelling results of the pilot studies

The modelling approach allows for a comprehensive description of policies impacts on all sectors and activities

The *direct impacts* of policies on emissions, primarily quantified by sectoral modelling, reflect detailed changes in technology (or land use), and explains a large share of emission impacts. Firms, households, and landowners are generally assumed to choose

economically optimal solutions for specific aspects of their behaviour, such as energy use, transport, or land management. For instance, in Switzerland, in response to the CO₂ levy, building owners tend to prefer electrical process heating over thermal solutions (an example is provided in Figure 1 Illustration of sectoral model detail: trends in commercial sector space heating capacities for the CO₂ levy of the Swiss pilot (2020 = 100)). Moreover, sectoral models explicitly represent how agents' technology choices are constrained by existing regulations, such as standards imposing vehicle efficiency rates studied Swiss and Chilean pilots.⁹

The pilot exercises show that the use of information from sectoral models is critical to evaluate the impact of regulatory instruments.¹⁰ Sectoral models are fundamental to describe the channels of policy incidence of regulatory instruments which rely on specific standards for technologies (e.g. CO₂ emissions per km, or buildings' energy performances), notably due to the diverse ways in which they interact with the existing stock of equipment or infrastructure (e.g. buildings or vehicles): An illustration is provided in Box 3. While regulations specify change in emission or fuel efficiency standards for new vehicles, their translation to emission changes depends on many factors. Furthermore, it shows irregular patterns, which can be only captured by a sectoral model. CGE models can only mimic the economic impacts of regulations but not the underlying mechanism.

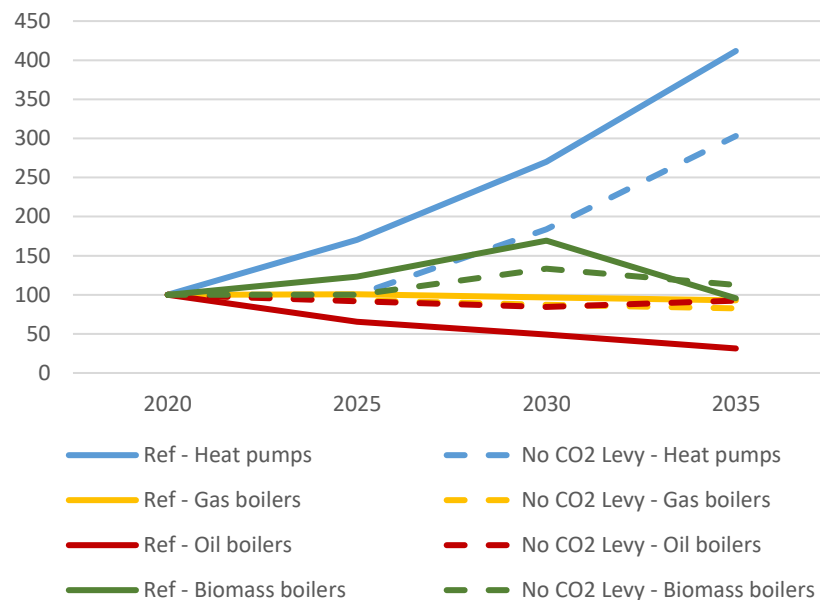
The pilot studies show that integrating indirect economic impacts of policies can significantly change the estimated magnitude of quantitative assessments, compared to analyses that focus solely on *direct effects*. Sizeable impacts on, and feedback from, firm or household budgets, market prices, value added, and incomes tend to be ignored in sectoral models, while they are central to a CGE modelling analysis. These impacts reflect changes in economic conditions, such as impacts on production and demand levels (i.e. “fundamental drivers of energy demand”), in response to price changes or income effects. The Swiss pilot shows that considering these indirect effects could, for some of the policies, increase or decrease the emission reduction by more than 20% (with respect to the cases where only *direct effects* are recorded)¹¹.

⁹ The sectoral analysis and preliminary results of economy-wide analysis for the Chile pilot have been completed, but the results have not yet been published. An IFCMA Informal Focus Group to be held in early 2026 will present them in detail.

¹⁰ Following the policy instrument typology for the IFCMA Climate Policy Database (OECD, 2024^[11]), “regulatory instruments” include fuel economy standards, mandates about specific technology or energy mix, ban of technology and other kinds of similar instruments.

¹¹ A detailed discussion of the change in emission impacts when analysing the policies and policy impacts of the sectoral model in the economywide model is provided in the Swiss pilot report IFCMA(2025)/11 ^([6]).

Figure 1 Illustration of sectoral model detail: trends in commercial sector space heating capacities for the CO₂ levy of the Swiss pilot (2020 = 100)



Source: EU-JRC-TIMES model

The nature and relative importance of the different channels of transmission differs by policy

The sign and magnitude of *indirect economic impacts* differ by type of policy and the sectors covered. For example, an excise tax on fuel consumption tends to reduce **the demand** for transportation services; while the indirect impact of carbon pricing on manufacturing sectors, will tends to reduce **their supply** (i.e. their level of production). This is illustrated by the implementation of the Mineral Oil Tax in Switzerland, in which the price increase of the CO₂ Levy leads to changes in final demand for transportation by internal combustion engine vehicles (car sharing, reduced use of car or switching to other modes of transportation). This latter *indirect effect* may double the reduction of emission compared to an evaluation only based on the *direct impact* (shift away from internal combustion engine towards electric vehicles). However, in the case of the Swiss Emission Trading System (ETS), the main *indirect impact* is to reduce the production level of the chemical industry (by increasing the cost of energy use for this sector). Finally, for the power sector policies in Chile the main indirect impact is the change in electricity demand resulting from price impacts of technology switching in power generation (i.e., the *direct impact*).

The broader the fiscal base of a policy instrument, such as excise taxes on fuels or carbon prices under ETS, the stronger its macroeconomic effects. These effects can, in

turn, influence the fiscal incidence of the policy—such as through changes in level of consumption. Some fiscal policies cover a large amount of energy expenditures (i.e., the tax base) and thus constitute a substantial part of total government revenues. Therefore, these policies, once implemented, have non-negligible income effects that can reinforce (or offset) the direct price effects. For instance, excise taxes on fossil fuel use in transport in Chile and Switzerland, show price-effects reducing the consumption of fuels for transport. But, if the collected tax is not directly redistributed back to households an additional income effect will also reduce the consumption of all goods. For the reform of fossil-fuel subsidies in Nigeria the effects are exactly the opposite. For these types of broad fiscal policies, the economy-wide model is necessary to track all changes in government budget and to assess the corresponding macro-economic impacts.

Some policies, such as vehicle taxes, may intuitively have a large “emission” base but can still have negligible effect on emissions. There are two main reasons for such an outcome. First, certain policy instruments do not effectively influence technology choice. Second, some policy instruments have an insufficient magnitude to provide meaningful incentives. For example, the motor vehicle taxes in both Switzerland and Chile did not seem to significantly influence household choices between different vehicle (engine) types, nor did they have a meaningful impact on the level of vehicle use (kilometres driven). As a result, they did not noticeably change fuel consumption and related GHG emissions. Furthermore, the relatively low levels of the carbon tax implemented in Chile or the subsidies to building renovation in Switzerland make these two policies limit the impact of these policies even if in practice they are targeting “elastic” activities. Finally, afforestation policies in Nigeria can potentially have a strong effect, as they could theoretically cover most of the country’s land area, but they tend to be applied only to a limited number of areas, and therefore have only a small effect on emissions.

Furthermore, some policies, such as emission standards and excise taxes on fuel in Switzerland, are found to reinforce each other. This means that the combined impact of policies is higher than the sum of the individual impact of each policy if they were to be implemented on their own. A notable example in which a pricing policy and a regulation reinforcing each other is interaction of the Swiss Mineral oil tax in combination with the vehicle CO₂ emissions standard. While these policies clearly overlap, as they both target private car use, their combined impact on emissions turns out to be higher than what would be estimated for each policy individually. This is due to the fact that the vehicle emissions standard reduces emissions of new cars owned by Swiss households, while the mineral oil tax reduces the use of inefficient gasoline and diesel cars and provides a stimulus to replace them by newer cars. Similar results are found for the transport policies considered for the Nigerian pilot.

In contrast, for some policies, such as the coal phase-out regulation and the carbon tax in Chile, the overlap turns out to be inefficient. The Chilean carbon tax for stationary thermal power generation installations is estimated to have negligible impacts on emissions because most of the emissions covered by this tax are also subject to the coal-fired power generation retirement agreements. These retirement agreements are binding, and the low level of the carbon tax (5 USD/tonne of CO₂) does not motivate a faster retirement of the coal power plants.

International developments which affect the effectiveness of domestic policy not only concern technological ones, but also foreign climate-relevant policies. In the case of Switzerland, there is a considerable impact of European Union (EU) legislation even when it does not apply to Switzerland. For example, the EU Directive on renewables indirectly puts a downward pressure on the future price of emission permits under the EU-ETS and it therefore reduces the effectiveness of the ETS for Switzerland.

Country specificities condition the magnitude of policy impacts

The pilot studies highlight that country-specific economic structures play an important role in shaping policy effectiveness. Conclusions about the effect of a given policy instrument in one country can therefore not be directly translated to countries with different economic structures. For example, in the Swiss pilot the detailed coverage of European industry sector technologies by the TIMES models showed that it would be more economical for Swiss ETS sectors to import EU -ETS allowances. Indeed, other countries participating to the EU-ETS countries have industries and power generation systems with more low-hanging fruit (cheaper to decarbonize further), which explains why the impact of an important policy such as the ETS was lower in Switzerland than in the total ETS region. Furthermore, as previously explained in Box 3, country characteristics other than economic structure affect the effectiveness of policies too, e.g. the mentioned current stock of equipment (vintages of vehicle fleet or buildings stock age structure). This underlines why structural models, as used in the pilots, with their details on economic or engineering structure are the relevant tools to highlight policy effectiveness since they are calibrated to match country-specific characteristics and economic structures.

Beyond economic structures, differences in residents' behaviour—as well as habits linked to geography, infrastructure or culture—can also help explain why a similar policy may have varying impacts across countries. The example provided before in Box 3, shows that the regulation on CO₂ emissions for vehicles has a much lower impact in Chile than in Switzerland in the medium run. One reason for this effect is that the renewal rate of the vehicle fleet is much lower in Chile than in Switzerland. Another example is that in the Nigerian pilot the modelling of a policy primarily expected to affect transport, namely

removal of subsidies on gasoline, also needed to consider gasoline use in small domestic backup power generators. Due to constraints on power grid availability, the modelling needed to consider increased use of solar PV panels as a substitute.

Box 3. Example of country-specific context affecting policy emission impacts

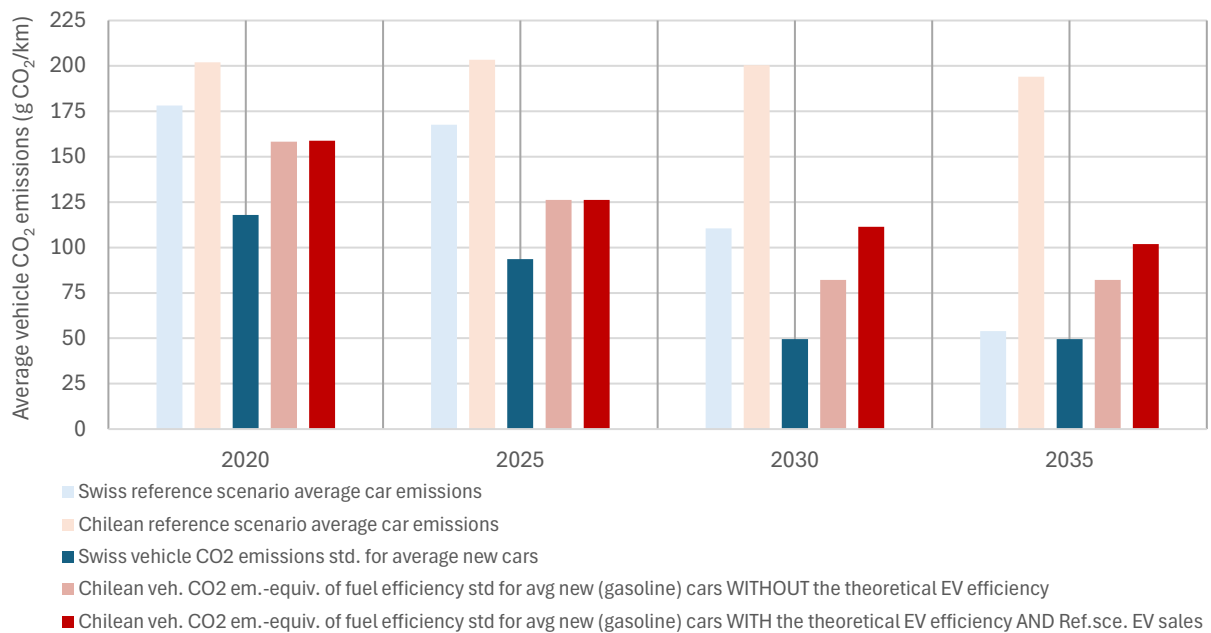
The effectiveness of a vehicle CO₂ emission standard in Switzerland or an equivalent policy like the fuel efficiency standard for light motor vehicles in Chile depends on several factors. These factors complicate a comparison of policies across models. Yet, they also point to cases where the need for the typical level of detail of energy or transport systems models.

Normally a major factor is the renewal rate of the vehicle fleet, which depends on: (i) how fast the vehicle stock grows (related to demography and per capita disposable incomes), (ii) what the vintage structure is of the existing vehicle fleet is, and (iii) how long cars are in use. In the case of Switzerland and Chile shorter average vehicle use lifetimes are assumed for Switzerland (15 years) than for Chile (20 years). However, the total Chilean fleet of passenger cars grows more (44%) than the Swiss fleet (9%) between 2020 and 2035. In this particular example, considering these country-specific dynamics helps understand that ultimately the Swiss standard turns out to be more effective in reducing transport emissions than the Chilean fuel efficiency standard, due to the Swiss standard being stricter than the Chilean one, as illustrated by the dark bars in Figure 2.

This example also illustrates that details of policy implementation can matter: In the Chilean implementation of the vehicle fuel efficiency standard for newly imported vehicles, electric vehicles (EVs) receive a theoretical high efficiency (76 km/L). The consequence is that less efficiency gains are required from non-electric vehicles, when there are more imports of electric vehicles, as is the case in the reference scenario illustrated in the figure below. A standard defined as an emissions standard, like the Swiss standard, therefore appears more effective in the context of a growing EV fleet than a fuel efficiency standard.

Finally, other policies and trends represented in the model play a role as well. In the Swiss pilot a bit more than half of the vehicle emission reductions can be related to other policies, for example a vehicle excise tax and technological trends (like reductions in EV costs and the availability of charging infrastructure).

Figure 2 Swiss CO₂ emission standard and its equivalence for the Chilean Fuel efficiency standard for light motor vehicles: Comparing reference scenario sectoral modelling results



Source: Authors own calculations based on the IFCMA Climate Policy Database for Switzerland and Chile, and additional information and sectoral modelling results provided by Paul Scherrer Institute (Switzerland) and Centro Energia of University of Santiago de Chile.

Pilot-specific takeaways

Specific circumstances which can be unique to one country could lead to interactions of policy instruments meant for one sector or type of agent with the emissions of other sectors or agents. These interactions not only need to originate in economy-wide price-elastic impacts but can also manifest themselves through interaction via micro-economic behaviour in energy markets. For example, the typical expectation is that if one policy drives up demand for low emission technologies or fuels in one sector, this increases their price and reduces their use in other sectors. While such behaviour is common, an example of a contrary positive effects beyond a targeted sector was found as well, though related to the regulatory context of the country: In this example, the *Swiss ETS* increased demand for biomass in Switzerland, including for biofuels used together with gasoline or diesel in the fuel mix for road transport. As a side-effect and given that also the Swiss CO₂ vehicle emission standard is active, this reinforced the electrification of road transport and further emission reduction, instead of less.

The country interdependencies between commodity markets and energy-related policies, like between European countries, alter the effectiveness of domestic - here Switzerland - policy. The interactions of Swiss policy with the policies of its European partner countries and the degree of integration of the European energy market provide additional factors that influence the effectiveness of the Swiss policies. For instance, because Switzerland shares a common CO₂ vehicle standard with the EU and imports most of its vehicles from EU countries, a withdrawal from this regulation would have a limited domestic impact - since most of imported vehicles would continue to comply with EU efficiency standards. Electricity trade provides another example of these interdependencies: Switzerland's strong integration with neighbouring power markets means that domestic energy and climate policies can be influenced by regional electricity prices and carbon intensity. These examples highlight that the effectiveness of Swiss policies cannot be assessed in isolation, as cross-border market and regulatory linkages play a key role in shaping both costs and emission outcomes, hence the use of multi-regional models for the Swiss pilot.

The Chilean pilot demonstrates that the timing of policy implementation matters for how policies are assessed. Removing a carbon tax while other existing policies remain in place—such as the phase-out of coal-fired power and the expansion of renewable energy—makes it appear less effective in reducing emissions from the power sector than when other these other policies would not have been introduced either (the case of implementing *only* a carbon tax). This outcome emerges from the Chilean pilot, where the simulation assessed the impact of removing policies sequentially, following the chronological order of their implementation. In contrast, the Swiss pilot removed each policy individually from the reference scenario, rather one after the other.

The Nigerian pilot highlights the added difficulties arising from modelling forest-related climate change mitigation policies, especially in a country that is receiver of financial flows in support of forest initiatives. Nigeria is scaling up efforts to preserve its forests and expanding forest coverage. This can have strong benefits for climate change mitigation, besides nature conservation, resilience and other environmental and socio-economic benefits. In most forest-rich global South countries, these efforts are implemented through initiatives that are often financed through development funding, REDD+, carbon credits or other foreign funding. As such, from a modelling viewpoint, it is difficult to attribute the conservation or expansion of forest area to single policies. For the Nigerian pilot, forest initiatives have therefore been pulled together to evaluate altogether their effect on carbon sinks.

Considerations for scaling up the modelling analysis

Collaborating with a small number of experienced sectoral modelling teams, capable of covering a wide range of countries, could keep the modelling process efficient and manageable. This approach would streamline communication, reduce coordination demands and reduce the time needed to set up model-specific data exchanges that are required for model integration and development. Pilot studies have shown that engaging with external modelling experts can be time-consuming. By working with recurrent partners with proven capacity, the process would remain feasible and consistent across regions, ensuring high-quality results, while maintaining a co-ordinated workflow. Beyond the modelling work itself, many supporting tasks—such as administrative procedures and public procurement—can also be resource-intensive. Partnering with a limited number of partners helps to minimise administrative costs.

Building on the experience gained through the pilot studies, continued collaboration with the current modelling teams offers clear efficiency benefits. The Paul Scherrer Institute has already played a key role in successfully implementing one of the pilots and has developed a strong expertise in linking models. With technical connections already established and data exchange procedures well defined, extending the work to additional countries will require significantly fewer resources. Maintaining collaboration with these experienced partners helps reduce start-up costs, ensures methodological consistency, and enables faster and smoother implementation of future analyses. Moreover, the PSI has demonstrated the capacity to support a wide range of IFCMA member countries, including those beyond the EU, scoped in in the Swiss pilot.

In certain specific cases, adopting a country case-study approach may be the most practical and effective option, particularly when no external modelling team currently covers the country in question. This approach allows for targeted analysis that can draw directly on national data, expertise, and policy context. In the case of Nigeria, this approach proved valuable in capturing country-specific dynamics that would have been difficult to reflect using external models alone. While it may require additional effort in data collection and model setup, it also presents an opportunity to strengthen local capacity and generate insights that are closely aligned with national priorities.

Looking ahead, a reasonable and achievable target for scaling up the work would be to conduct similar modelling exercises to those carried out in the pilot phase for around six to eight countries per year, focusing on a set of selected policies and sectors. To facilitate meaningful cross-country comparisons, the sectors covered should be broad enough to capture key policy dynamics, yet focused on those with the highest emissions and where sectoral modelling expertise is available. This targeted approach allows for steady expansion

while preserving the depth and quality of analysis. It would also enable modelling teams to build on existing experience, refine methodologies, and maintain consistency across country applications. Such a gradual scale-up would strike a practical balance between ambition and feasibility. It would support the generation of robust policy insights while keeping the workload and resource requirements manageable.

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