Multifunctional Analysis of Regions through Input-Output (MARIO) for energy transition policies analysis: the case of Italian private passengersâ€™ transport sector.

Topic: Input-output analysis for policy making I (Chair: Francesco Tonini, Polytechnic University of Milan)

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The global energy sector plays a dominant role in CO2 emissions and it is responsible for almost three-quarters of the total. It is therefore evident that an energy system that does not contemplate a radical transition will not be able to meet future challenges. Europe's objective of pursuing a policy towards a lower carbon energy system was formalized in 2015 with the Paris Agreement. In the most recent years, the commitment was fully embraced with the launch of the Green Deal, an ambitious plan to reduce its emissions by at least 55% by 2030 and to make Europe the first carbon-neutral continent by 2050. The huge technological shift that is forecasted for various sectors to support the transition brings along several risks and threats associated with newly opened supply chains. The complexities of current sustainability challenges, therefore, call for analytical models and tools to properly evaluate transitional policies from a Life Cycle Assessment perspective. The analysis of current existing literature highlights the lack of adequate open-modelling tools that can comprehensively provide a framework to implement transparent, automatic, and easily reproducible shock and footprint analyses for policies and products.
For this reason, Multifunctional Analysis of Regions through Input-Output (MARIO) has been developed and openly published on GitHub. MARIO is a Python package for handling Input-Output (IO) tables and models which aims at providing a simple & intuitive Application Programming Interface for common IO tasks. MARIO supports automatic parsing of different structured tables such as EXIOBASE, EORA, EUROSTAT, and ad-hoc built tables in different formats. Furthermore, MARIO allows for smooth handling of database aggregation, modification, and extension. Finally, ad hoc defined MARIO functions provide IO analysts with a wide set of instruments related to production or consumption-based visualization of results in different scenarios. As bench test of the newly developed MARIO framework a real case study application for the private passenger transport sector is performed.
Transport sector is one of the main contributors to EU CO2 emissions together with power and industry sectors accounting for 22%, 26%, and 22% of the total 2020 carbon emissions respectively. Part of the reason is attributable to the role played by road transport which, with 820 Mton CO2eq produced annually, is responsible for 72% of the total emissions. Up to 60% of such emissions are related to passenger vehicles alone. To limit private passengersâ€™ transport sector emissions, BEV and FCEV technologies are the most promising solutions in substituting internal combustion engine vehicle fleets. BEV and FCEV prospected large-scale deployment makes it necessary to assess the systemic implications, both economic and environmental, arising from the introduction of their respective supply chains. The objective of this application is therefore to analyse in detail the effects of a shift of the traditional car fleet to the new mobility technologies with specific reference to the Italian context. The operational impact of driving the vehicles is assessed together with the respective manufacturing process as well as the infrastructural investments needed to create the conditions for their diffusion. Two scenarios are outlined assuming a 60% penetration of BEVs or FCEVs alternatively in the Italian car fleet.
The adoption of the MARIO framework based on EXIOBASE data allowed an extensive characterization of the interventions considered, outlining in detail the production processes of cars and their main components and making it possible to analyse the implications deriving from the introduction of the new supply chains. The indicators used to quantify the impact of car substitution

have been chosen to represent the economic, environmental, and social dimensions. According to the obtained results, FCEV technology emerges as the most favourable both in terms of its potential to reduce GHG emissions and in GDP increase for the country. Both technological solutions demonstrate how the displacement of traditional fuels is far more beneficial in comparison to the environmental burden of new vehicle manufacturing. Results show FCEV technology triggers higher GDP growth and high-skilled employment within the Italian economy rather than BEVs, whose supply chain delineates a greater reliance on foreign activities, particularly for what concerns the exploitation of mining hubs for batteries production. The study thus demonstrates the potential of MARIO framework to comprehensively analyse multiple aspects deriving from decarbonization processes at national level. Further MARIO development is planned to properly consider the dynamic transition processes that could occur during the modelling horizon, as the occurrence of different economic conditions and stages of technological development.