

Green Investment in Italy: Macroeconomic, Fiscal, Distributional and Environmental Effects in an IO-SFC Model

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Abstract

Italy's climate commitments imply a substantial reallocation of investment towards low-carbon energy at a time when fiscal space, income distribution and external dependence remain important macroeconomic constraints. This paper uses an empirically calibrated input-output stock-flow consistent (IO-SFC) model to examine how targeted support for renewable-energy producers propagates through production, public finances, distribution, the external accounts and greenhouse gas (GHG) emissions. The framework links 163 industries to six institutional sectors and combines detailed input-output relations with stock-flow consistent financial accounts. We compare two ways of financing the same green-investment effort: public borrowing and a levy on non-renewable energy producers. Both policies raise renewable investment and shift the energy mix, but their wider effects differ. Borrowing produces the stronger expansion in investment and activity, alongside larger fiscal and external imbalances and a marked decline in the wage share. Levy financing yields a smaller expansion but milder fiscal, distributive and external effects, together with a clearer and more persistent fall in emissions. The simulations therefore indicate that the consequences of green investment depend not only on its scale and sectoral destination, but also on the financing mechanism through which it is implemented.

Keywords: green investment; IO-SFC; Italy; fiscal policy; income distribution; greenhouse-gas emissions

1. Introduction

There is increasing theoretical and empirical evidence that the green transition entails a broad set of interconnected macroeconomic, fiscal, distributive, and environmental effects (D'Alessandro *et al.*, 2020; Monasterolo and Raberto, 2018; Jackson and Jackson, 2025; Pettena and Raberto, 2025; Veronese Passarella, 2025a and 2025b). Large investment programmes simultaneously affect aggregate demand, the composition of production, public finances, income distribution and the external position. These interactions are especially important when the transition is implemented in an economy characterised by high public debt, weak wage dynamics and a sizeable dependence on imported energy and strategic inputs.

From this perspective, Italy provides an especially useful setting in which to study these interactions. The 2024 Integrated National Energy and Climate Plan (PNIEC) places the country within the European climate-neutrality framework and envisages a substantial acceleration of renewable-energy deployment. Relative to the current policy path, the PNIEC estimates cumulative additional investment needs of EUR 174.4 billion over 2024-2030 (Governo Italiano, 2024). At the same time, public debt in Italy remains high by European standards, while the productive system is strongly interconnected with the rest of the European economy. Moreover, weak productivity and wage dynamics make the distributive incidence of transition policies a central part of their social sustainability. The energy system also remains exposed to imported fossil fuels and to imported industrial inputs required for the transition (Canelli *et al.*, 2024). A policy that improves the energy mix can therefore have macroeconomic, fiscal and distributive effects that extend far beyond the energy sector.

Building on this literature, the contribution of this paper is to focus explicitly on the financing of the green transition. While existing studies have shown that transition policies can generate important macroeconomic, distributive and environmental effects, comparatively less attention has been paid to how alternative financing arrangements may shape those effects. This paper examines that question by comparing two forms of targeted support for renewable-energy producers: one financed through higher public borrowing and the other through a levy on non-renewable energy producers. The analysis assesses how these alternative financing regimes affect economic activity, public finances, income distribution, the external position and greenhouse gas (GHG) emissions. The central question is therefore not only whether green investment can support the transition towards renewable energy,

but how alternative financing arrangements shape its broader macroeconomic, fiscal, distributional and environmental consequences.

To address this question, the paper develops an empirically calibrated input-output stock-flow consistent (IO-SFC) model of the Italian economy. The model combines a 163-industry input-output structure with a comprehensive set of monetary and financial accounts for households, non-financial firms, banks, the government, the central bank and the foreign sector. Households are divided between workers and rentiers, allowing the simulations to capture distributional effects alongside changes in aggregate demand, while the environmental block records greenhouse gas (GHG) emissions and distinguishes between twelve electricity-producing industries. This framework makes it possible to simultaneously trace the sectoral, macroeconomic, fiscal, distributive, and environmental effects generated by alternative ways of financing green investment.

The remainder of the paper is organised as follows. Section 2 situates the analysis within the ecological macroeconomic and IO-SFC literature. Section 3 presents the main features of the model and its empirical calibration. Section 4 describes the alternative policy and financing scenarios. Section 5 presents the simulation results, while Section 6 discusses their main economic and environmental implications. Section 7 concludes.

2. Macroeconomic Approaches to the Green Transition: The Case for IO-SFC Modelling

The analysis of the green transition raises fundamental questions about the type of macroeconomic framework required to study it. Mainstream climate-economy analysis has been dominated by Integrated Assessment Models (IAMs), but their theoretical structure has been subject to substantial criticism. Among the main limitations identified in the literature are the simplified treatment of climate damages, the representation of energy-economy feedbacks, the limited integration of monetary and financial dynamics and the potential underestimation of transition and mitigation costs (Gambhir *et al.*, 2019; Lontzek *et al.*, 2015; Keen *et al.*, 2021; Keppo *et al.*, 2021; Köberle *et al.*, 2021). These limitations are particularly important when the object of analysis is not simply the technological substitution of one energy source for another, but a transition unfolding through production, investment, finance, income distribution and sectoral interdependence. Non-mainstream ecological macroeconomic approaches provide a more suitable starting point for analysing these processes because they explicitly recognise the monetary, financial, distributive and structural

character of a modern economy and the feedbacks that connect these dimensions to environmental change.

Non-mainstream ecological macroeconomics starts from a different conception of the economy. Rather than treating the economic system as moving around an equilibrium determined independently of monetary and financial relations, it emphasises historical time, fundamental uncertainty, path dependence and the role of institutions in shaping economic outcomes. In the macroeconomic tradition adopted here, production and employment are demand-led, while money and finance are integral to the functioning of the economy rather than neutral mechanisms operating alongside the real system. Income distribution, balance-sheet positions and financial commitments therefore influence expenditure, investment and accumulation, while structural change unfolds through sectoral interdependencies and cumulative processes over time. These features make non-mainstream ecological macroeconomic approaches particularly well suited to analysing the green transition, where technological change, investment, financing, distribution and environmental outcomes evolve jointly rather than as separable dimensions of the adjustment process (Fontana and Sawyer, 2016; Rezai and Stiglitz, 2016; Hafner *et al.*, 2020).

Within this broader non-mainstream tradition, stock-flow consistent modelling provides a particularly suitable framework for this purpose. SFC models impose a coherent accounting structure in which sectoral budget constraints, transactions and changes in balance-sheet positions are jointly reconciled, and every financial asset is matched by a corresponding liability (Godley and Lavoie, 2007; Nikiforos and Zezza, 2017; Carnevali *et al.*, 2019). Ecological extensions of SFC models use this accounting discipline to connect monetary and financial dynamics with energy use and emissions (Dafermos *et al.*, 2017; Dafermos and Nikolaidi, 2022; Carnevali *et al.*, 2021, 2023). This makes it possible to analyse climate policy alongside public debt, private balance sheets and financial flows, rather than treating finance as an external add-on to the real economy.

A limitation of many SFC models is, however, that their industrial structure remains highly aggregated. Input-output (IO) analysis provides the complementary advantage of tracing intermediate-input requirements and cross-industry propagation in much greater detail (Miller and Blair, 2021). Hybrid IO-SFC models combine these strengths: the IO block captures sectoral interdependence, while the SFC block preserves macro-financial closure and balance-sheet consistency (Hardt and O'Neill, 2017; Fevereiro *et al.*, 2025). Early contributions include Berg *et al.* (2015) and Naqvi (2015), while more recent applications have examined circular-economy policies,

carbon taxation and energy-transition dynamics (Di Domenico *et al.*, 2023; Jackson and Jackson, 2025; Pettena and Raberto, 2025; Thomsen *et al.*, 2025a, 2025b).

Building on the conceptual and methodological foundations provided by Veronese Passarella (2025a) and his related work on the interaction between monetary relations, financing structures and macroeconomic dynamics (Veronese Passarella, 2025b), the present paper develops further and applies this approach to address a specific policy question: whether alternative financing arrangements for targeted renewable-energy investment alter the macroeconomic, fiscal, distributive and environmental outcomes of the green transition. The contribution is therefore not simply to examine the effects of green investment, but to make the financing mechanism itself part of the transition experiment. By comparing two financing regimes within the same multisectoral structure and for the same underlying green-investment intervention, the analysis isolates the role played by financing in shaping the transition.

3. Model and empirical calibration

3.1 Economic and financial structure

The model is implemented in discrete annual time in R and solved simultaneously in each period. The simulation horizon covers thirty periods, with each period representing one year. Its accounting structure distinguishes six institutional sectors: households, non-financial firms, commercial banks, the government, the central bank and the foreign sector. Households are further separated into workers and rentiers, allowing differences in labour income, distributed profits, interest income, wealth and portfolio composition to feed into consumption, saving and distributional outcomes.

Production is organised around 163 industries. Final demand, comprising household consumption, fixed investment, government expenditure and exports, determines gross output through the Leontief input-output structure. Industry-level employment follows output and labour coefficients subject to adjustment frictions. Prices are determined by production costs, mark-ups, imported-input costs and capital depreciation, while mark-ups respond to the relation between actual and potential output. Investment is determined at industry level through a gradual adjustment of capital towards a target capital-output ratio. Fiscal support can shift firms' target capital stocks and thereby alter the sectoral allocation of accumulation.

The financial block reconciles sectoral financing requirements and portfolio positions through loans, deposits, securities and other financial assets and liabilities. Banks accommodate loan demand, hold reserves and government securities, and obtain central-bank advances when necessary. Government deficits generate new public liabilities, while the central bank accommodates the residual position. Household portfolio allocation follows a Tobin-type structure, and the foreign block links exports, imports, securities positions and the current account. This architecture allows the same policy shock to affect aggregate demand, public and private debt, income distribution and external balances within a mutually consistent accounting framework. Table 1 below summarises the main blocks of the IO-SFC framework and their respective roles in the model.

Table 1. Main blocks of the IO-SFC framework

Block	Role in the model
Production	163 industries; input-output requirements; final demand; gross output and value added
Prices and income	Industry costs, mark-ups, wage income, profits and sector-specific price indices
Households	Workers and rentiers; consumption, saving, personal credit and portfolio allocation
Firms and monetary and financial sector	Industry investment, capital stocks, loans, profits, securities and banking balance sheets
Public sector	Taxes, government expenditure, deficit, government debt and central-bank holdings
Foreign sector	Exports, imports, current account, foreign securities and exchange-rate channel
Energy and emissions	Twelve electricity industries, energy production, GHG intensities and total emissions

3.2 Data and environmental accounting

Initial macroeconomic stocks and flows are calibrated to the Italian economy in 2021 using Eurostat data. The industry structure is taken primarily from EXIOBASE 3. The 2021 tables provide domestic and imported intermediate-input coefficients, final-demand shares, employment, wages and mark-ups, while GHG emission intensities are derived from the 2019 accounts in order to avoid distortions associated with the exceptional reduction in emissions during the Covid period (Stadler *et al.*, 2018, 2025). Capital depreciation information is drawn from EUKLEMS (Bontadini *et al.*, 2023), while electricity-intensity coefficients are constructed from IEA Monthly Electricity Statistics. Parameters that are not directly observed are calibrated to reproduce the 2021 Italian macroeconomic configuration and a stable benchmark path, with remaining parameters and exogenous variables drawing on Canelli *et al.* (2022).

The electricity block distinguishes coal, gas, hydro, wind, petroleum-based generation, biomass and waste, solar photovoltaic, geothermal and other sources, with inactive categories retained for nuclear, solar thermal and marine generation. A common electricity price is applied across generation sources, while physical electricity production is recovered using source-specific energy-intensity coefficients. GHG emissions are calculated by applying industry-specific emission coefficients to output and aggregating across industries. The resulting framework can therefore distinguish between changes in the composition of energy supply and changes in the overall scale of production.

The calibration should be interpreted as a policy-simulation benchmark rather than as a forecasting model. The objective is to compare internally consistent counterfactual paths under different financing arrangements, not to predict the exact future path of the Italian economy. The baseline is therefore deliberately stable, making the policy effects easier to identify as deviations from the calibrated reference trajectory.

4. Financing Green Investment: Policy Experiments

The experiments are motivated by the additional investment effort identified in the Italian PNIEC. The intervention is represented as selective support for renewable-energy producers, accompanied by a gradual change in the composition of intermediate energy use. Relative to the benchmark, renewable intermediate consumption increases by 15 per cent and non-renewable intermediate consumption declines by approximately 9 per cent, leaving total energy requirements broadly unchanged while altering the energy mix. The cumulative scale of support is calibrated to EUR 174.4 billion and phased over the simulation period to the end of 2030.

4.1 Borrowing-financed support

In the first experiment, the government finances support to renewable producers through additional borrowing. The policy raises the target capital stock in supported industries and generates an investment-led increase in demand. The subsidy multiplier is set at 0.9. Because the public sector absorbs the financing requirement, the experiment allows the expansionary effects of green investment to operate without an offsetting contemporaneous levy on the non-renewable sector.

4.2 Levy-financed support

The second experiment maintains the same scale of support to renewable producers but finances it through a levy on non-renewable energy producers. All other assumptions are held constant,

including the compositional shift in intermediate energy use. The contractionary effect on the industries subject to the levy is represented by a multiplier of -0.5. The policy therefore combines an incentive to expand renewable capacity with a direct negative impulse to non-renewable production. The comparison with the borrowing-financed experiment isolates how the different financing structure changes the aggregate, fiscal, distributive and environmental outcomes.

5. Results

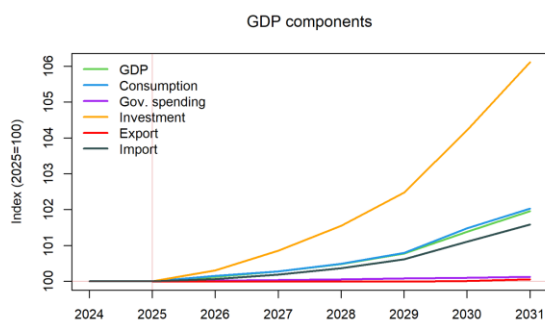
5.1 Borrowing-financed green investment

The borrowing-financed experiment produces a clear investment-led expansion. Fixed investment rises substantially relative to the baseline and pulls GDP and consumption upward. The expansion also raises output and employment in a broad set of industries through input-output linkages. Renewable investment and production increase, and the renewable share of electricity production rises over the policy horizon.

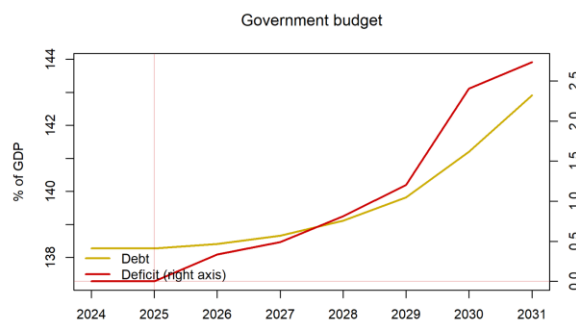
The stronger activity response comes with macroeconomic costs. The government deficit widens and the public-debt ratio rises. Higher domestic demand is accompanied by an increase in imports and a progressive deterioration of the trade balance. The wage share declines visibly, indicating that labour income does not keep pace with the overall expansion. In this experiment, therefore, the larger aggregate demand effect is associated with weaker fiscal, external and distributive outcomes.

Borrowing-financed renewable support

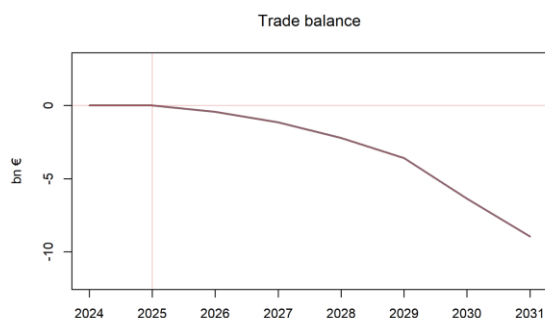
(a) GDP components



(b) Government budget



(c) Trade balance



(d) Wage share

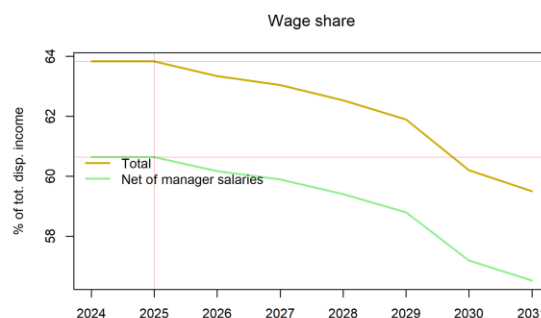


Figure 1. Selected macroeconomic, fiscal, external and distributional outcomes under borrowing-financed renewable support.

Source: authors' simulations based on the calibrated model.

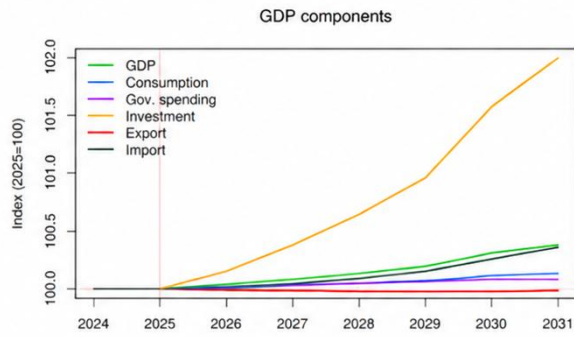
5.2 Levy-financed green investment

Levy financing produces the same directional reallocation towards renewables but a smaller aggregate expansion. Investment still rises, as do GDP and consumption, but the increase is considerably more restrained than under public borrowing. This reflects the fact that support to renewable producers is partly offset by the contractionary effect of the levy on non-renewable producers.

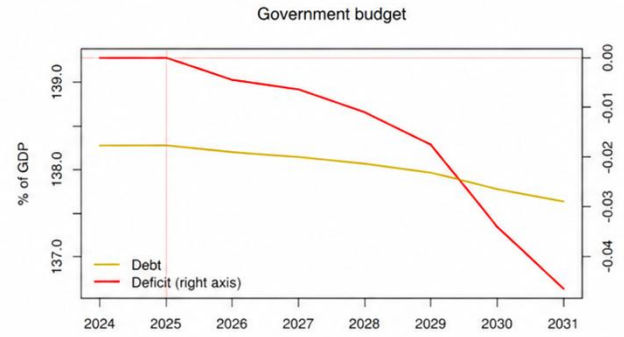
The weaker aggregate demand impulse substantially changes the accompanying balances. The public budget position improves and the public-debt ratio declines slightly rather than increasing. The trade balance still deteriorates, but by much less than in the borrowing-financed case. The wage share also falls only marginally. The levy-financed regime therefore delivers a less expansionary but more contained macroeconomic adjustment.

Levy-financed renewable support

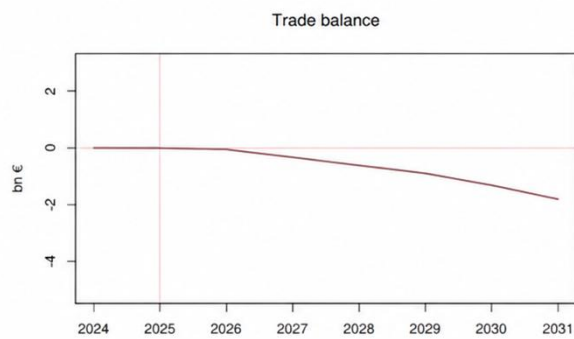
(a) GDP components



(b) Government budget



(c) Trade balance



(d) Wage share

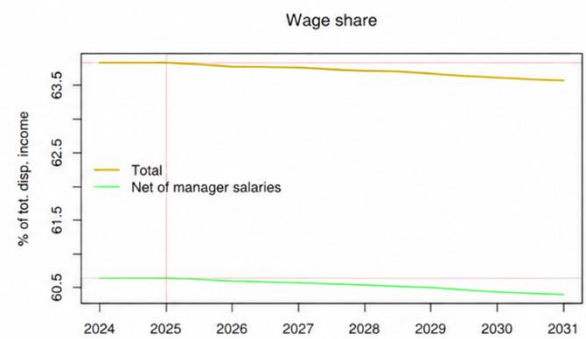


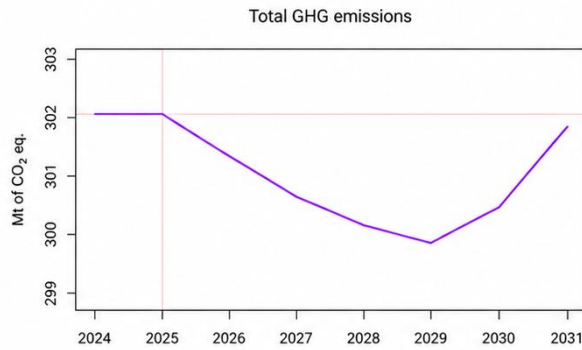
Figure 2. Selected macroeconomic, fiscal, external and distributional outcomes under levy-financed renewable support.
Source: authors' simulations based on the calibrated model.

5.3 Environmental effects of alternative financing regimes

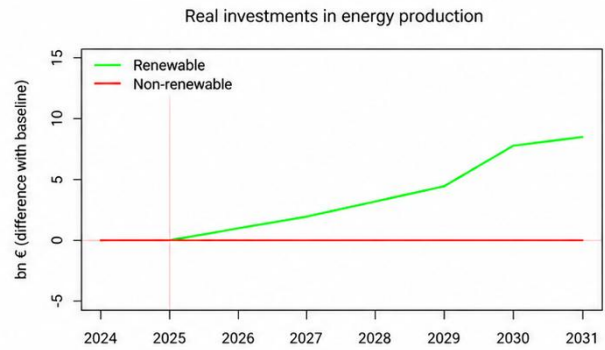
The contrast between the two financing regimes is particularly clear in the emissions results. Under borrowing-financed support, total emissions decline for several years but subsequently rebound as the investment stimulus raises the scale of production and energy use. Under levy-financed support, total emissions decline more clearly and remain lower over the policy horizon. Both scenarios expand renewable investment, but only the levy-financed regime also reduces non-renewable investment. The levy-financed regime therefore contains the scale effect more effectively and generates a more persistent reduction in total emissions. Table 2 summarises the main differences between the borrowing-financed and levy-financed experiments across the macroeconomic, fiscal, distributive and environmental dimensions considered above.

Environmental and energy-investment outcomes

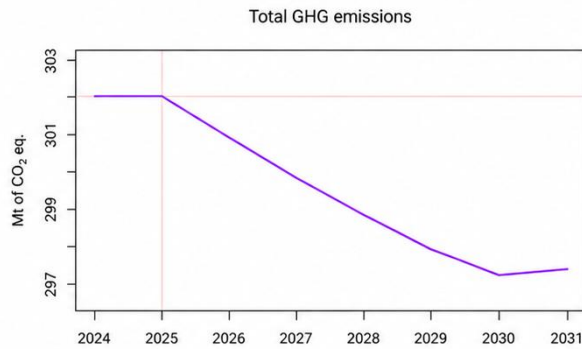
(a) Total GHG: borrowing-financed support



(b) Energy investment: borrowing-financed support



(c) Total GHG: levy-financed support



(d) Energy investment: levy-financed support

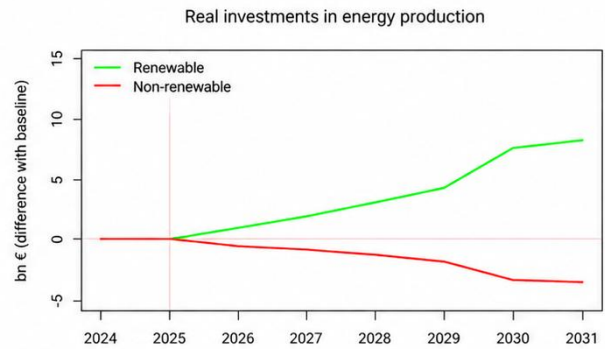


Figure 3. Environmental and energy-investment outcomes under borrowing-financed and levy-financed renewable support.
Source: authors' simulations based on the calibrated model.

Table 2. Qualitative comparison of the two financing regimes

Outcome	Borrowing-financed support	Levy-financed support
Investment and GDP	Strong expansion	Moderate expansion
Government balance	Deficit widens	Balance improves
Public debt	Rises	Declines slightly
Trade balance	Marked deterioration	Smaller deterioration
Wage share	Noticeable decline	Small decline
Renewable investment	Strong increase	Strong increase
Total GHG emissions	Initial fall, then partial rebound	Clearer and more persistent fall

6. Financing, Scale Effects and Transition Trade-offs

The simulations point to a general proposition: the financing of green investment is not neutral. Even when the sectoral direction and cumulative scale of support are held broadly constant, the financing mechanism changes aggregate demand and, through both direct and indirect channels, alters fiscal balances, distribution, external accounts and emissions. A borrowing-financed programme generates the stronger expansionary effect, but this also magnifies import demand, raises public debt and produces stronger scale effects on emissions. A levy-financed programme dampens the expansion while improving fiscal performance and limiting the rebound in emissions.

This result helps separate two mechanisms that are sometimes conflated in discussions of the green transition. The first is a composition effect: investment moves towards renewable energy and the energy mix becomes cleaner. The second is a scale effect: higher investment and income increase total production and energy use. In the borrowing-financed experiment, the scale effect is sufficiently strong to offset part of the environmental benefit of the composition effect. In the levy-financed case, the negative impulse to non-renewable producers reduces that offset. The environmental evaluation of green investment therefore requires attention to aggregate-demand dynamics, not only to the renewable share of energy production.

The distributive results reinforce the same point. The wage share falls in both experiments, but the decline is substantially larger under borrowing-financed support. This does not imply that levy financing is unambiguously preferable: the borrowing-financed case generates stronger increases in investment and activity. Rather, the simulations reveal a transition trade-off between the strength of the macroeconomic stimulus and the containment of fiscal, external, distributive and environmental

imbalances. The relative importance attached to these outcomes will depend on the objectives of the transition and on the institutional mechanisms available to redistribute its gains.

The external account also matters for an economy such as Italy. A green investment programme may reduce dependence on imported fossil fuels over time while simultaneously increasing demand for imported machinery, materials and other inputs required to build the new capital stock. This broader tension is consistent with the deterioration in the trade balance generated by the simulations, particularly under the more expansionary borrowing-financed regime. The results therefore point to the importance of considering the green transition together with the productive and industrial structure of the economy, especially where reduced dependence on imported fossil fuels may coexist with dependence on imported technologies and strategic inputs.

7. Conclusions

This paper has examined how alternative financing arrangements shape the macroeconomic, fiscal, distributive and environmental effects of green investment in Italy. To address this question, it has used an empirically calibrated IO-SFC model that combines detailed sectoral interdependence with monetary and financial consistency. This framework makes it possible to assess the same green-investment intervention in terms of economic activity, public finances, income distribution, the external position and GHG emissions.

Both financing regimes redirect investment towards renewable-energy production, confirming that targeted support can alter the composition of the energy system. Their broader consequences, however, differ substantially. Borrowing-financed support generates the stronger expansion in investment and economic activity, but is also associated with a larger public deficit, higher public debt, a more pronounced deterioration in the trade balance and a larger fall in the wage share. Levy-financed support produces a more moderate expansion, while containing the fiscal, external and distributive effects of the transition more effectively.

The environmental results reinforce this distinction. A greener energy mix does not automatically translate into a proportional reduction in total emissions. Under borrowing-financed support, the environmental gains associated with the shift towards renewables are partly offset by the stronger expansion of aggregate demand, production and energy use. Under levy-financed support, weaker scale effects allow the reduction in total greenhouse gas emissions to be more persistent. The

environmental effectiveness of green investment therefore depends on the interaction between changes in the composition of energy production and the scale of aggregate economic activity.

Taken together, these results show why the financing of the green transition should be treated as part of the transition itself rather than as a secondary question of implementation. Alternative financing arrangements affect not only who bears the immediate cost of green investment, but also the strength of the demand stimulus, the path of public finances, income distribution, external balances and the environmental effectiveness of the intervention. For an economy such as Italy, where high public debt, weak wage dynamics and dependence on imported energy and strategic inputs interact with large transition requirements, these dimensions need to be considered jointly when assessing alternative paths towards a greener productive structure.

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