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Structural Reforms in the Italian National Recovery and Resilience Plan: A macroeconomic assessment of their potential effects*

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Abstract

This paper assesses the potential macroeconomic impact of the critical structural reforms designed within the Italian Recovery and Resilience Plan (RRP). The reforms are investigated using a large-scale dynamic stochastic general equilibrium macro-model, adapted to capture the effects of the RRP measures. Exploiting the RRP official documents, we scrutinize and catalog detailed data from 482 milestones and 665 policy targets relevant to our assessment. Each reform is then mapped into the model and simulated, showing its transmission mechanisms and macroeconomic and social impact. We document a significant potential impact on medium- and long-term GDP. The efficacy of the reform package emerges in the long run. In 2050, Italy's GDP would be 10% higher than in the alternative scenario where no reform is implemented. However, sizeable effects will be observed starting in 2026, when observed GDP would rise by 3.4%. The labor market and education measures primarily drive the impact of the reforms on GDP and employment. We also explore the distributional effects of the reform program. We find that a significant labor and capital income increase accompanies the aggregate positive effect on output.

Keywords: Structural measures, macroeconomic and social impact, fiscal policies, potential output. JEL Classification: C54, E62, E65, F54, F47.

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1. Introduction

Acknowledging an overall allocation of 191.5 billion euros, the Italian Recovery and Resilience Plan (RRP) is the first beneficiary of the European resources made available under the Recovery and Resilience Facility (RRF). The Plan consists of massive public investment and reform packages to address the Italian economy's main structural weaknesses.[1] Given its size, the Italian Plan represents a critical case study for evaluating the Next Generation EU.

This paper only provides a model-based assessment of the macroeconomic impact of the structural reforms designed by the RRP. It should be emphasized that this paper focuses on the effects of the reforms on macroeconomic variables and the functional distribution of income associated with the (full or partial) achievement of the objectives of the reform Plan. Since the realization of some of these objectives is closely linked to certain public expenditures envisaged in the Plan, our study is not an addition but a complement to the assessment of the Plan's public expenditures; it overlaps the assessment.[2]

We group structural policy measures into five areas of reform: i) Public Administration; ii) Justice; iii) Competition (which also includes the reform of the procurement system); iv) Education and Research; v) Labor Market Policies and Training. The five reform areas have been selected following two criteria. The first one is their relevance to economic performance: the potential economic impact of the selected reforms is substantial since they are expected to trigger significant changes in the structure of the Italian economy. The second one is modeling robustness: the selected reforms allow a robust assessment since the attribution to changes in model parameters is less arbitrary and in line with methodologies already adopted for similar analyses in the literature.

The assessment is based on an analysis of granular information provided by official RRP documents from the Ministry of Economy and Finance. The Plan's implementation is supported by detailed monitoring and reporting mechanisms, defined in terms of timing milestones and targets (M&T). We proceed as follows. First, we scrutinize and catalog detailed data from 482 milestones and 665 policy targets linked to the measures described in the RRP implementation documents.[3] Next, using the M&T identified from granular data, we define structural reforms to be assessed through quantitative indicators that can be mapped in a dynamic general equilibrium model. Finally, we provide a model-based evaluation of the impact of the reforms, accounting for their direct and indirect

[1] The RRP implements the objectives of the Next Generation EU recovery instrument at the national level.

[2] A companion paper focuses on the macroeconomic impact of the public expenditures envisaged in the RRP (see Di Bartolomeo and D'Imperio, 2022.) However, as said in the main text, the aggregate assessment of the Next Generation EU cannot be obtained as the mere sum of the results contained in the present work and those contained in Di Bartolomeo and D'Imperio (2022) on the Plan's public expenditures, as this would overestimate the total impact.

[3] M&T can be retrieved from the Italian Government website, http://italiadomani.gov.it/en, and at the European Commission (2021). See Appendix D.

effects across time.

Assessments are carried out using the Italian version of the QUEST R&D model developed by the European Commission.[4] We generally attempt to assign the reform targets and timing directly to the model parameters; when a direct association is not possible, we use some indirect methods. Specifically, we employ results from empirical studies to translate the quantitative indicators into changes in the model parameters. As a result, changes in the structural parameters are calibrated using the information in the M&T. If this is not available, we use a benchmarking approach where the shock size is calibrated to align Italy to the best performers in a specific reform area. Finally, we consider the uncertainty surrounding our baseline setup by evaluating the effects of the reforms according to more optimistic (high-impact) and less optimistic (low-impact) scenarios.

The RRP's goals are broader than just economic growth. They also cover disparity reductions among regions, generations, and genders. Accordingly, the macroeconomic analysis is complemented by a simple social impact assessment, in which we look at the changes in the functional distribution of income triggered by the structural reforms.[5]

Our main results can be summarized as follows.

We document the structural reform package's significant impact on GDP in the medium and long term, considering that the implementation of each reform is strictly linked to its timing and efficiency (see the different scenarios and sensitivity analysis). At the end of the Plan, in 2026, GDP would be 3.4% higher compared to the alternative scenario in which no reform is implemented. However, the full efficacy of the reforms emerges in the long run. In 2050, the effect on GDP will be around 10%. The impact of the whole reform package on GDP is mainly driven by the labor market and education measures, particularly those designed to increase labor market participation and strengthen workers' skills.

Regarding the reforms' impact on other macroeconomic variables, the demand components roughly follow the GDP dynamics, except for a limited initial crowding out of private investments due to the expectations of productivity increases that cause investment postponements. In the long run, investments, consumption, and exports grow proportionally to GDP. Prices decrease as the structural reforms operate as a positive supply shock. In the long run, productivity increases lead to a rise in the average real wage of about 6%, while labor market policy reforms increase employment by about 4%.

The social impact assessment suggests that thanks to the increase in GDP, both wage and profit earners would be better off after the implementation of the structural reforms.

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[4] Specifically, at the Directorate General for Economic and Financial Affairs, DG ECFIN. See D'Auria *et al.* (2009) and Roeger *et al.* (2022).

[5] As the ECB (2022) noted, the NGEU should also enhance fiscal risk-sharing between EU countries, which has been negligible in the past (see Alcidi *et al.*, 2023). Regarding the more general aspects of the debate about reforms, growth, and inequality, interested readers can refer to Campos *et al.* (2018, 2020), who extensively reviewed the structural reforms literature.

Our study fills a significant gap in the literature. Although several works currently assess the macroeconomic impact of the Next Generation EU using a model-based approach (among others, Bańkowski *et al*., 2021; Pfeiffer *et al*., 2022, 2023; Di Bartolomeo and D'Imperio, 2022; Freier *et al*., 2022),[6] this limits their analysis to the effects of public investments/expenditures without a detailed analysis of the impact of the associated structural reforms.[7] In this respect, our paper complements their assessments. Of course, our paper is also related to the literature that evaluates the macro effects of structural reforms, particularly those affecting the Italian economy. We critically refer to this literature in the next section.[8]

The rest of the paper is organized as follows. The next section outlines the RRP reforms, focusing on the associated structural measures. It also provides synthetic evidence on the single-measure impacts obtained using different methodologies. Section 3 details the methodology used to run our assessment. Section 4 overviews the baseline Dynamic Stochastic General Equilibrium (DSGE) model adopted. Section 5 explains how we map the reform targets into the model parameters. Section 6 illustrates our main results and the sensitivity analysis considering different scenarios. Section 7 provides a model-based assessment of the social impact of the reforms by looking at the functional income distribution. Section 8 concludes the paper.

2. The reforms in the RRP

The RRP's overall reforms and investment package have been designed to boost total factor productivity and the growth potential of the Italian economy. In particular, the reforms included in the RRP target the structural weaknesses of the Italian economy as identified in the context of the *Country specific recommendations* (CSR) 2019 and 2020.

The Italian RRP is structured around six fields of intervention, called "missions," composed of 16 components, each involving a mix of public investments and reforms. Specifically, it foresees 63 reform interventions aimed at improving potential growth, supporting green and digital transitions and social and territorial cohesion. The reforms are divided into three categories: horizontal, enabling, and sectoral reforms.

Horizontal reforms have a cross-cutting impact on the Plan's missions. They involve structural innovations in the system of rules to improve equity, efficiency, competitiveness, and the economic climate. The Plan features two horizontal reforms: Public Administration (hereinafter PA) and Justice.

[6] Di Bartolomeo and D'Imperio (2022) focus on the Italian case.

[7] The role of structural reforms within the Next Generation EU is however discussed in Corti and Núñez Ferrer (2021) and Freier *et al.* (2022).

[8] We refer to selected cases (mainly related to the Italian case.) A more general and profound discussion about different reform issues focusing on the European case can be found in Campos *et al.* (2018, 2019, 2020, 2023) and the references therein.

The **Public Administration reform** aims to rationalize and improve the effectiveness of bureaucratic structures, with positive spillover effects for the whole economy. It takes place across five main areas of action: (i) improvement of staff selection mechanisms; (ii) continuous training for recruited staff and improvement of mobility mechanisms; (iii) simplification of administrative procedures; (iv) investment in human capital; (v) digitalization. The **Justice reform** is designed to reduce the length of civil and criminal court proceedings and improve the efficiency and predictability of the justice system. The three main areas of intervention involve completing the Trial Office project, strengthening the administrative capacity through investments in human capital, and enhancing digital infrastructures.

In the above respect, several studies have shown that the quality of institutions at the government and judicial level is a precondition for higher productivity, per capita income, quality of life, and citizen satisfaction.[9] OECD (2021) observes that improving the quality of PA would lower the need for fiscal incentives and actions to support investments. Moreover, various empirical studies find that a well-functioning judicial system contributes to creating a favorable business environment that can spur investments (also from abroad) and growth, expanding access to credit.[10] For instance, Giacomelli and Menon (2013) document that if the length of Italian civil proceedings decreased by 10%, the average firm size could increase by around 2%.

Enabling reforms include specific measures to simplify and streamline legislation and promote competition. We group these structural measures under the **Competition reform**, including the procurement system reform. These interventions are meant to improve the business environment, facilitating entrepreneurship and competitive conditions, fostering a more efficient allocation of resources and subsequent productivity gains. They involve, among other things, steps to streamline the regulation of public contracts, increase legal certainty for businesses, and speed up the awarding process. In addition, safeguarding procedural guarantees of transparency and equal treatment improves public procurement, reduces late payments, and removes barriers to competition. They also include implementing and better managing strategic infrastructures in telecommunications, port, and electricity networks and strengthening antitrust enforcement and sectoral regulatory powers.

The economic literature has long analyzed the positive effects of increasing competition, demonstrating, both at the micro and macro levels, that competition can foster economic growth through higher productivity, lower prices, and a better allocation of resources (Barone and Cingano, 2011; Arnold *et al.*, 2011). For instance, Bourlès *et al.* (2013) show that increased competition raises the growth of multi-factor productivity in OECD countries by 1 and 1.5% per year. Ciapanna *et al.* (2023) estimate that service sector liberalization in Italy could induce a permanent increase in service sector TFP of 4.3% and a permanent reduction in the service sector markup of 0.7 percentage points.

[9] See, among others, Heichlinger *et al.* (2018).

[10] See, among the others, Palumbo *et al.* (2013), UPB (2016), and Lanau *et al.* (2014).

Sectoral reforms are directed at specific policy areas to enhance more efficient regulatory and procedural regimes. The most relevant measures can be related to two intervention areas: education and R&D, including the reform of industrial property and labor market policies and training.

The **Education and Research reform** affects the whole education system. The RRP foresees various projects to bridge the regional gap in primary education and kindergartens. These range from the renovation of buildings and the implementation of an education plan on sustainability and accessibility to further actions to reduce territorial gaps, mainly through mentoring and targeting young people at risk of dropping out of school or those who have already left school. Regarding secondary education, the Italian RRP will strengthen its quality by providing a more practical orientation service for the school-university transition (paying particular attention to technical education) and improving teachers' skills, focusing on ICT. For tertiary education, the Italian RRP provides for a revision of curricula (with particular attention to accession to professional services) and higher publicly funded scholarships and social housing for students.

A knowledge-intensive, competitive, and resilient economy will be promoted by strengthening the training system, enhancing digital and STEM (Science, Technology, Engineering, and Mathematics) skills, and supporting research activities and technology transfers. Hanushek and Woessmann (2008) show how cognitive skills are relevant in promoting economic well-being and increasing individual earnings. Indeed, better human capital will help to adjust the labor supply to the labor demand in the context of ICT innovation.

Hanushek and Woessmann (2020) measure the economic benefits of educational improvement covered by the educational goals of the European Union. Based on the observed historical relationship between educational achievement and growth, the gradual improvement by 25 PISA points for students attending a 15-year schooling period would determine an increase in the long-run growth rate by 0.5 pp (80-year projection). Furthermore, Italy would increase its long-run growth rate by 0.31 pp in case of an increase in the PISA average score by 16 points, leading to an increase in GDP of 18% in 2100.

Égert *et al.* (2022) estimate the elasticity of total factor productivity to the PISA test scores. A 5.1% improvement in PISA scores (equivalent to an improvement of 25.5 points from the median OECD country) would increase TFP by 3.4-4.1% in the long run via an increase in human capital by 1.4%.

The reform of **Active Labor Market Policies and Training** is aimed at increasing and qualifying labor force participation through three primary lines of action: (i) the upskilling and reskilling of the inactive and unemployed; (ii) encouraging greater female participation; (iii) improving the matching efficiency between labor supply and demand. In addition, it is designed to improve active labor market policies and women's and youth's participation in the labor market, increase the supply of childcare facilities, reinforce vocational training, and encourage investment in the apprenticeship system.

Égert and Gal (2017) show that strengthening active labor market policies (ALMPs) would increase multi-factor productivity by 2.9%. The youth employment rate would increase by 14.7 pp, while the effect would be lower for prime-age women (+9.2 pp) and men (+4.7 pp), and the elderly (+6.3 pp). In a model-based assessment, Lusinyan and Muir (2013) claim that strengthening ALMPs would increase Italian GDP by 0.3% in the first and the second year, 0.4% in the fifth, and 0.5% in the long run via higher participation rates.

Comparing different types of ALMPs, Miyamoto and Suphaphiphat (2021) find that training and start-up incentives effectively reduce long-term European unemployment generated by skill mismatches. However, the simulations from the European Commission (2016) are more critical. Relevant increases in the ALMPs expenditures are estimated to give a marginal contribution to GDP growth. Escudero (2018) estimates that training policies contribute to the reduction of the unemployment rate by 1.1 pp.

3. Methodology

The macroeconomic impact of the reforms is investigated via a model-based assessment.[11] Structural reforms are first mapped into a set of structural parameters of a DSGE model. Next, the structural parameters are modified according to the expected output of the reforms, and the resulting transmission mechanisms and transition dynamics are analyzed. The approach naturally accounts for structural reforms' static and dynamic impacts and direct and indirect effects. As pointed out by Christiano *et al.* (2018), notwithstanding some limitations, DSGE models are the leading tool for performing such assessments transparently.

The main challenge of a model-based assessment is translating structural policy measures into the model. Three alternative approaches are used in this work.

1. The first strategy is a "bottom-up approach." In such a case, the measures are mapped into the model by exploiting the explicit targets in the official documents describing each specific reform. Then, using satellite calculations, the quantitative and qualitative features of the measures are expressed as quantitative goals in terms of structural parameters formalized in the model.[12]
2. The normative contents of structural reforms only occasionally provide a numerical target suitable for the simulations. A "top-down strategy" or "benchmarking" approach can be used in this case. We consider a set of comparable economies and define structural reforms as changes in structural indicators to close (the entire or a part of) the gap with

[11] A taxonomy of the different methodologies is beyond the scope of this paper. We limit our references to some studies sharing our approach in what follows.

[12] See, among others, the European Commission (2016), Pfeiffer *et al.* (2020, 2022), Di Bartolomeo and D'Imperio (2022), and Di Bartolomeo *et al.* (2022).

the best-performing economies (alternatively, it is possible to consider closing a gap with an efficient frontier).[13]

3. Finally, when information to identify numerical targets or cross-country data to assess the gap between the economy under analysis and a benchmark are unavailable, we assume a conservative target based on our subjective assessment of the reform, accounting for the qualitative information from the documents.[14]

It is worth noting that micro-econometric studies are usually adopted to mediate the mapping between the reform and the model parameters in all the above-mentioned cases. For example, a competition reform can be expected to impact a specific market-competitiveness indicator, which impacts the aggregate markup (modeled as a parameter of the general equilibrium model). While the impact of the reform on the competitiveness indicator can be evaluated using normative information, the elasticity between the competitiveness indicator and the structural parameter of the model needs to be based on external econometric studies.

The bottom-up strategy is our preferred choice, as it uses official numerical targets to map the reforms, thus minimizing the level of discretion of the proposed exercise. However, when direct or indirect reform mapping is impossible using the documents, the best alternative is the top-down one. Therefore, we adopt the third strategy (i.e., judgmental) as a residual option when we are unable to use the previous two.[15] In all cases, we clearly state the details of the assumptions introduced to map the structural measures associated with the different reforms.

Using simulations, we obtain a quantitative assessment of the impact of the structural reforms on selected macro-variables and uncover the transmission mechanisms and possible policy trade-offs. In a nutshell, we investigate the impact of whether the measures effectively achieved the goals for which they were designed.

It is important to stress that mapping the reforms is subject to significant uncertainty. Therefore, we construct an "uncertainty interval" around our simulations, representing the uncertainty linked to our assumptions. In practice, starting from a conservative (baseline) scenario of the effectiveness of the structural measures, we consider the possibility that structural policies are effective at different degrees. A mapping based on more optimistic values is used in the high-impact scenario to achieve the predetermined targets. In contrast, achieving minimum objectives is considered in a low-impact scenario.

The model used for the reform assessments is QUEST, the macroeconomic general economic equilibrium model developed at the European Commission Directorate General for Economic and

[13] See, among others, D'Auria *et al.* (2009) and Roeger *et al.* (2008, 2021).

[14] See, e.g., Annicchiarico *et al.* (2013, 2015).

[15] It is, however, important to stress that the first and second approaches also require increasing levels of discretion, e.g., in the choice of the exogenous variables for the simulation and the selection of the benchmark.

Financial Affairs (DG ECFIN). We used the large-scale multi-country R&D version calibrated and routinely updated by DG ECFIN for the Italian economy.

As previously mentioned, reforms are mapped using the granular information from the M&T that the Italian Government has agreed to accomplish during the six years of the Plan. Milestones are qualitative achievements, such as specific regulations and legislation, while targets are quantitative, measurable objectives.

The following two sections detail the model used for the assessment and the reform mapping.

4. The macroeconomic model

The Italian QUEST R&D model is a large-scale DSGE model of 500 equations/variables. A three-region structure characterizes it, i.e., the Italian economy, the rest of the euro area, and the rest of the world.

The model features semi-endogenous technological change, two production sectors (intermediate and final), and three skill categories in which employment is disaggregated: low, medium, and high. The low-skill group corresponds to individuals with primary or lower secondary education (ISCED 0-2). The high-skilled group is calibrated to match the share of human resources in science and technology employable in the R&D sector. The medium-skilled workers comprise the rest of the population. Households are of two kinds. Ricardian households can access credit markets and own physical capital and firms; Non-Ricardian households cannot trade in financial and physical assets and consume their disposable income each period. In line with the New-Keynesian tradition, prices and wages do not adjust immediately but are subject to adjustment costs *à la* Rotemberg (1982). Similarly, private investments are subject to standard quadratic costs.

The government and the central bank manage fiscal and monetary policies. The European Central Bank adopts a standard Taylor-kind rule responding to changes in expected inflation and the eurozone level output gap. On the fiscal side, government consumption, transfers, and investment are proportional to GDP, while unemployment benefits are indexed to wages. On the revenue side, the government collects taxes on consumption, labor, and capital income. A standard fiscal rule is included in the model, ensuring the debt-to-GDP ratio's stability through lump-sum taxes (and transfers).[16]

A complete overview of the model is beyond the scope of the present paper. However, a description of the main equations can be found in Appendix A. Additional information and more details on the model can be found in D'Auria *et al.* (2009) and Roger *et al.* (2008; 2022). In the following, we focus on the model's calibration, characterized by 187 parameters. Routinely updated by the European Commission, the calibration is obtained from a mix of estimation and matching

[16] A proper analysis of the impact of the reforms on public finance is beyond the scope of this study and would need additional assumptions about the cost of the reforms and how the government would cover them. However, as standard in the literature, the fiscal rule is lifted for the simulation's first ten years to isolate the reforms' early public finance effects.

approaches. Leaving all the details to D'Auria *et al.* (2009), again, we emphasize the main aspects of this calibration in the following.[17]

The model is calibrated to match the main Italian economic ratios observed in 2017: A consumption-to-GDP ratio equal to 0.58 and an investment-to-GDP ratio equal to 0.18. It also matches the shares of the government's consumption (0.22), investment (0.02), and transfers (0.23), which are obtained from Eurostat. Similarly, effective labor, capital, and consumption tax rates are obtained from Eurostat and used to determine government revenues. The monetary policy parameters are those estimated by Ratto *et al.* (2009). Core inflation is about 2% on an annual basis.

The parameters of the utility function (including habits) and the frictional parameters are calibrated using information from the estimation of the core QUEST III model (Ratto *et al.*, 2009). The calibration of markups is based on the method suggested by Roeger (1995), based on EU KLEMS data. The aggregate markup is around 13% in the final goods sector and 10% in the intermediate production sector (markups pin down the elasticity of substitutions). Aggregate entry barriers rely on Djankov *et al.* (2002), who estimate the costs new firms incur before starting to operate. Finally, fixed costs are set to reconcile markups with observed profit rates.

The steady-state rental rate of capital matches a capital-output ratio of 2.7 and an R&D share of 2% of GDP. Output elasticities of R&D production and subsidies to R&D investments are obtained from Bottazzi and Peri (2007) and Warda (2006). The growth rate of ideas is based on Pessoa (2005), assuming an obsolescence rate of 5%. Estimates of R&D tax credits are from Warda (2009) and OECD (2014). Import shares are calibrated on information from Eurostat COMEXT database. Ratto *et al.* (2009) estimate the price elasticity of trade.

Skill-specific population shares, participation rates, and wages are calibrated using the information provided by the Eurostat Labour Force Survey and Science and Technology databases. Low (L), medium (M), and high-skilled (H) workers' shares are set to 0.39, 0.57, and 0.04. Employment rates and non-participation rates are heterogenous in the three groups and calibrated according to Eurostat data on persons with primary and lower secondary education (low-skilled), upper secondary to short-cycle tertiary education (medium-skilled), and bachelor to doctoral graduates (high-skilled).

The average wage of high-skilled workers is obtained from the annual earnings of scientists and engineers with tertiary educational attainment employed as professionals or associate professionals in physical, mathematical, engineering, life science, or health occupations (ISCO-08 occupations 21, 22, 31, 32). The wage of medium-skilled workers is obtained from earnings data of employees with tertiary educational attainment not working as scientists and engineers and those with medium educational attainment (ISCED 3-4). Low-skilled wage is obtained from the annual earnings

[17] The model parameters are estimated *internally* by applying a Bayesian approach to the model (e.g., Schorfheide, 2000; Smets and Wouters, 2003) and *externally* using micro estimations and great ratio matchings (details are provided in Appendix C.)

of employees with low educational attainment (ISCED 0-2). Both medium- and low-skilled wages are used irrespective of the employees' occupation.

The labor-efficiency parameters of the three groups (EFF_s) are estimated to be 0.31, 0.50, and 1.33, respectively. The medium-skilled category includes high school and college graduates not in the R&D sector. In this respect, we depart from the baseline model by altering the calibration of the medium-skilled group efficiency depending on its composition. The relative share of high-school graduates (HS_t) and college graduates (CG_t) in the medium-skilled group is such that the labor efficiency (EFF_M) is equal to the weighted sum of the specific labor efficiencies:

$$EFF_M = EFF_{HS}HS_t + EFF_{CG}CG_t \quad (1)$$

where EFF_{HS} and EFF_{CG} represent the efficiency of high-school and college graduates. Exploiting Eurostat data, high-school and college graduate shares in the medium-skilled group are calibrated to 0.72 and 0.28, respectively.

The efficiency of college graduates can be formalized as the efficiency of high-school graduates multiplied by a skill-specific factor γ_{CG}, which we assume to be greater than one:

$$EFF_{CG} = \gamma_{CG}EFF_{HS}. \quad (2)$$

By using (2), we can rewrite equation (1) as:

$$EFF_M = EFF_{HS}HS + (\gamma_{CG}EFF_{HS})CG \quad (3)$$

where γ_{CG} is set to 1.37, which is equal to the wage differential between high-school and college graduates, according to OECD data. The calibration of γ_{CG} rests on the assumption that the observed wages of the two groups are a proxy for their labor efficiency. Equation (3) allows us to alter the composition of college graduates and high-school graduates in the medium-skilled group to match the education reform goals.

The elasticity of substitution between skilled and unskilled labor is calibrated at 1.7, following Acemoglu and Autor (2011), who updated Katz and Murphy (1992). Estimations in Ratto *et al.* (2009) are used to calibrate Rotenberg's adjustment parameters of the labor and goods markets. The same parameters are used for all the wage curves.

5. Mapping the structural reforms

The Italian RRP contains 151 investment items and 63 reform items, which should be completed following a detailed time path described in 482 milestones and 665 policy targets.[18] We use this information to map the reforms into the model. The baseline mappings are described in the following subsections, with a description underlying the high-impact and low-impact scenarios serving as upper

[18] European Commission (2021).

and lower bounds for our assessments.[19]

5.1 Public Administration

The PA reform can be broken down into three lines of action: i) increasing efficiency; ii) reducing bureaucratic costs; and iii) improving the level of human capital in PA.

The first line of action is mapped into the model following the micro-econometric study by Giordano *et al.* (2020). They investigate the effect of public sector efficiency on firm productivity using data from 400.000 Italian firms and public bodies at the provincial level. According to this study, closing the gap between the observed public sector efficiency and the efficient frontier would increase output by 3% on average. Accordingly, the increase in output is simulated through a positive exogenous shock to aggregate TFP in the model (A_t).[20]

Ideally, we need a reform target of distance from the efficient frontier to calibrate the shock precisely. However, such information cannot be inferred from the M&T. Therefore, in the baseline scenario, we simulate what we arguably consider a conservative goal: a reduction in the gap equal to one-third. In the high-impact and low-impact scenarios, we assume the closure of 2/3 and 1/6 of the gap, respectively.

As in previous studies (Roeger *et al.*, 2008; D'Auria *et al.*, 2009), the decrease in bureaucratic costs is mapped into the model through reductions in administrative costs ($FC_{L,t}$) and entry fees ($FC_{Y,t}$) in intermediate and final sectors. Again, we simulate a conservative target, namely a gradual decrease of these costs by 10%. In the high-impact and low-impact scenarios, we assume a reduction of these costs by 20 and 5%, respectively.

It is worth noting that one of the cross-cutting priorities of the Italian RRP concerns digitization. Indeed, simplification is one of the goals of the PA reform, based on a solid expansion of digital services in identity, authentication, healthcare, and justice. In the Plan, this goal is marked "de-bureaucratization" and is designed to reduce costs and time currently burdening businesses and citizens. Therefore, measures related to PA digitization are incorporated in the abovementioned assumptions about (i) increasing efficiency and (ii) reducing bureaucratic costs.

Finally, we simulate the measure designed to improve the quality of human capital. In this respect, the reform provides that 525,000 public employees will earn a tertiary degree between 2024 and 2026. This target can be mapped into the model by shifting employees inside the medium-skilled group from high-school graduates to tertiary graduates. As discussed, this implies a proportional improvement in the average efficiency of the medium-skilled group. In the low-impact scenario, we assume that only half of the targeted PA employees (262,500) obtain a degree. We do not change the

[19] A complete description of the M&T considered for each area of reform is reported in Appendix B. More detailed information can be found in the European Commission (2021) and the Presidency of the Council of Ministers (2021).

[20] See equation (A.1) in Appendix A for details. A similar approach has been adopted by Andrle *et al.* (2018).

baseline assumption in computing the best-case scenario for this measure.

Based on the information reported in the M&T, the first two lines of action are assumed to reach full implementation in ten and five years, respectively. The third line of action is assumed to have its first effects on the economy starting in 2024:Q1. The timeline is chosen considering that the first public employees should have started training in 2021 and that the first graduation will take place three years later. The end date (2026:Q4) is also consistent with what is reported in the M&T.

Our mapping is summarized in Table 1, which details the lines of action. It reports the selected target variables (objective), the assumed variation of the target variable in the baseline, low, and high scenario, the timing of the reform, the exogenous variable shocked in the model, and the simulation approach, namely bottom-up, benchmarking, or judgmental.

Table 1 – Public Administration mapping.

Line of action	Objective	Variation			Timing		Variable	Map
		Low	Baseline	High	Start	End		
Efficiency	Efficient frontier gap	-15%	-30%	-60%	2022:Q2	2032:Q1	TFP	B
Bureaucratic cost	Entry costs	-5%	-10%	-20%	2022:Q2	2027:Q1	Entry	J
	Overhead costs	-5%	-10%	-20%	2022:Q2	2027:Q1	Overhead	
Human capital	Tertiary graduates	+262,500	+525,000	+525,000	2024:Q1	2026:Q4	Efficiency medium-skilled	BU

Notes: The table reports detailed information on the reform mapping into QUEST. The mapping column refers to the simulation strategy: Bottom-Up (BU), Benchmarking (B), and Judgmental (J). Line of action, objective, and timing refer to the information contained in the M&T. Variation is the assumed improvement of the objective in the low, baseline, and high scenarios. Variable refers to the variable shocked in the model.

5.2 Justice

The main goal of the justice reform is to improve the efficiency of the judicial system. Accordingly, two explicit and measurable targets are envisioned in the RRP, i.e., a reduction in the length of civil proceedings and criminal trials by 40% and 25%, respectively, compared to the figures recorded in 2019.[21]

The length of proceedings can be captured by the so-called disposition time, which in year *t* is defined as:

$$Disposition\ Time_t = \frac{Pending\ Cases_t}{Resolved\ Cases_t} * 365$$

[21] The official targets for this reform also include a reduction in the backlog that we indirectly take into consideration when looking at the reduction in the length of trials.

where *Pending Cases* are the unresolved cases on 31 December in year t, while *Resolved Cases* are the cases finalized within the same year. The ratio is annualized by multiplying it by 365.

The reduction in the disposition time is mapped into QUEST by exploiting the results reported by Ciapanna *et al.* (2023). They estimate the elasticity between the duration of civil proceedings and TFP. Using microdata, the authors find that decreasing the length of civil proceedings by one percent increases TFP by 0.03%.[22] We exploit this elasticity for the civil proceedings, assuming that a one-percent reduction in the length of criminal trials would increase TFP by 0.01%.[23]

The full achievement of the M&T would thus imply a TFP increase of 1.45%. We use this value to simulate the reforms in the high-impact scenario, while in the baseline, we halve the impact to 0.72%. The rationale for our conservative stance (a baseline elasticity lower than what was found in the literature) is twofold. On the one hand, the expected additional reduction might have a lower impact on TFP because of likely non-linearities. On the other hand, it is impossible to exclude that reforms introduced before the RRP are still having effect (the length of proceedings was already decreasing before the introduction of the RRP, i.e., -15% over the period 2010-2018). Instead, in the low-impact scenario, the increase in TFP is assumed to be 0.36% (half of the baseline).

The reform is considered to start affecting the economy in 2022:Q2, i.e., when the first measures can have their initial impact on the efficiency of the judicial system, according to the M&T. The end date is aligned with the reform targets. According to these targets, the length of the proceedings should be reduced by the end of 2026.

The mapping for this area of reform is summarized in Table 2.

As previously noted, in the baseline scenario, we consider a reduction in the length of civil proceedings and criminal trials equal to 20% and 12.5%, respectively. Both lines of action are simulated compatibly with the bottom-up approach.

[22] A different approach would assume that the impact on the economy is transmitted through more contestable markets and higher domestic and international investments because of the reduction in their returns. See, e.g., the European Commission (2014).

[23] This value, although discretional, is consistent with the fact that the number of criminal proceedings is close to one-third of civil ones.

Table 2 – Justice mapping

Line of action	Objective	Variation			Timing		Variable	Map
		Low	Baseline	High	Start	End		
Civil proceedings	Length	-10%	-20%	-40%	2022:Q2	2027:Q1	TFP	BU
Criminal trials	Length	-6.3%	-12.5%	-25%	2022:Q2	2027:Q1	TFP	BU

Notes: The table reports detailed information on the reform mapping into QUEST. The mapping column refers to the simulation strategy: Bottom-Up (BU), Benchmarking (B), and Judgmental (J). Line of action, objective, and timing refer to the information contained in the M&T. Variation is the assumed improvement of the objective in the low, baseline, and high scenarios. Variable refers to the variable shocked in the model.

5.3 The reform of competition and the procurement system

The competition reform is analyzed in conjunction with the procurement system reform since the latter also has the potential to increase competition.

Increased competition is expected to lower profit margins and price markups. Canton and Thum-Thysen (2015) investigated the impact of changes in the Product Market Regulation (PMR) index, a composite indicator developed by the OECD to measure pro-competition regulation in the markets for goods and services.[24] They quantify how improvements in the PMR result in lower price markups. Hence, we use their estimated elasticities to map the reform in the model.

The impact of pro-competition interventions is simulated by considering a measure of the impact the reform will have on the PMR index. We use the values computed by OECD (2022), which calculated the expected impact of each national recovery plan on country-specific PMRs. According to this study, the regulation changes provided in the Italian RRP would only improve Italy's score in Rail Transport from 3.29 to 2.86. The improvement translates into a reduction of the total transport sector's indicator from 1.33 to 1.22 (−8%).[25] According to Canton and Thum-Thysen (2015), the elasticity of the price markup to the transport network PMR index is equal to 0.013. The reduction in the PMR sub-index would thus be reflected in a 0.11 percentage-point decrease in the final goods sector markup (η_t). In the low-impact scenario, we halve the improvement of the PMR to 4%.

The annual competition law also fosters competition in the retail electricity market.

[24] See Vitale *et al.* (2020).

[25] It should be noted that, in the Transport Sector, Italy has the third-best PMR index among the OECD countries, following the United Kingdom and Iceland. Regulation changes are also expected to marginally decrease the Italian score in the "Barriers in Network Sectors" PMR indicator from 0.97 to 0.94.

However, as pointed out in the same study by the OECD, the proposed phasing out of regulated prices for micro-enterprises and households and other measures in this sector is not covered by the PMR sectoral index on electricity. Moreover, Italy already scores zero in the retail price regulation in the electricity sector, i.e., the best possible value.

With regard to public procurement, policy interventions in this reform area are mapped following Belhocine and Jirasavetakul (2020), who employ the public procurement performance indicator of the Single Market Scoreboard developed by the European Commission to measure the procurement system's quality.

The overall performance of the Single Market Scoreboard is a sum of scores of 12 individual indicators. Satisfactory performance for an individual indicator increases the overall score by one point.[26] The performance is measured according to a threshold calculated for each sub-indicator.

In the case of the procurement system, the analysis of the normative measures contained in the RRP can be expected to improve sub-indicator No. 6, 'Decision speed.' This indicator reflects the speed of the public-buyer decision-making process, measuring the time between the deadline for receiving offers and the date the contract is awarded. According to the last data, the score of Italy is −1 since the decision time is longer than the threshold of 120 days. The draft legislation envisages reaching a decision time of 100 days, allowing Italy to score a +1 in this sub-indicator. Consequently, it would result in an improvement of the overall indicator from −3.33 to −1.33.

According to Belhocine and Jirasavetakul (2020), improvements in the scoreboard are accompanied by an increase in the share of public investment to GDP. Belhocine and Jirasavetakul (2020) estimate that a one-point increase in the scoreboard would trigger an increase in public investment between 0.04 and 0.07%. For the baseline scenario, we use their lowest estimated value (0.04), thus simulating an increase in the share of public investment, IG_t, equal to 0.08%. An equivalent reduction of current public expenditures (G_t) accompanies the latter to obtain a neutral effect on the public deficit. In the best-case scenario, we use the upper-bound elasticity value (0.07), leading to an increase in public investments of 0.14%.[27] In the low-impact scenario, we halve the elasticity used in the baseline scenario, producing a change in public investments equal to 0.04%.

[26] As the Single Market Scoreboard manual outlines, the three most important indicators are triple-weighted (Single bidder, No. calls for bids, and Publication rate). The reason is that they are linked to competition, transparency, and market access—the core principles of good public procurement. Indicators from 7 to 12 receive a one-third weighting because they measure the same concepts from different perspectives: participation by small firms (indicators from 7 to 9) and data quality (from 10 to 12). The other sub-indicator weights are equal to one.

[27] Or equivalently, keeping constant the elasticity (0.04), in the high-impact scenario the Single Market Scoreboard would increase by 3.5 points and in the low-impact scenario by 1 point, as reported in Table 3.

The exogenous shocks related to simplification are assumed to start affecting the economy in 2022:Q2 and 2023:Q1 for competition. The timing is based on the M&T. The first legislative measures related to simplification are expected to be adopted in the second half of 2022. Competitiveness-related measures are expected to be adopted at the beginning of 2023 and completed by 2026. We set the end date accordingly.

Our mapping is summarized in Table 3. We consider the simulation strategies of both lines of action as bottom-up. The M&T, in fact, provide information on the impact on the indicators (PMR and Single-Market-Scoreboard).

Table 3 - Competition and procurement system mapping

Line of action	Objective	Variation			Timing		Variable	Map
		Low	Baseline	High	Start	End		
Competition	PMR Transport	-4%	-8%	-8%	2023:Q1	2027:Q4	Markup	BU
Simplification	Single-Market-Scoreboard	+1	+2	+3.5	2022:Q2	2027:Q1	Public Investment/ Consumption	BU

Notes: The table reports detailed information on the reform mapping into QUEST. The mapping column refers to the simulation strategy: Bottom-Up (BU), Benchmarking (B), and Judgmental (J). Line of action, objective, and timing refer to the information contained in the M&T. Variation is the assumed improvement of the objective in the low, baseline, and high scenarios. Variable refers to the variable shocked in the model.

5.4 Education and research

The reform aims at improving the entire educational system, from nursery schools to universities and research. The relevant measures for the simulations can be summarized in three lines of action: (i) reduction in the number of school dropouts; (ii) improvements in the composition of human capital; and (iii) improvements in the quality of education.

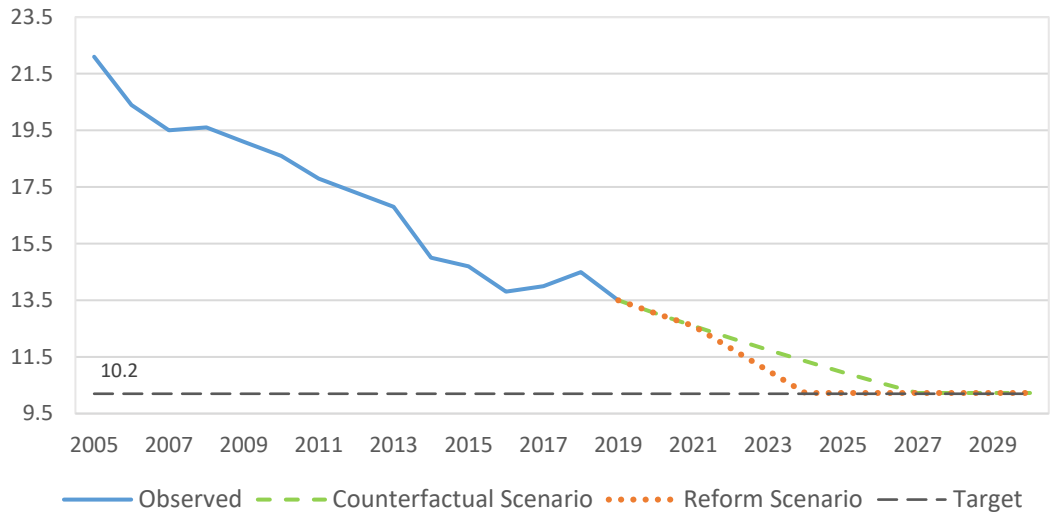
The main target associated with the first line of action is a reduction in the school dropout rate from 13.5 to 10.2% between 2019 and 2024, equivalent to a decrease of early leaving individuals from 538,300 to 386,000 (Eurostat data).[28] The dropout rate has a decreasing trend because of previous measures; therefore, we implement the effects of the reform target by accounting for its observed dynamics. The observed dropout rate (2005-19) is described in Figure 1 (blue-solid line).

By extrapolating a linear trend from the series, it is possible to assume that without the introduction of the reform, the target (10.2 percent) would be reached in 2027 (green-dashed line).

[28] The dropout rate is the share of early leavers from education and training. Early leavers are individuals aged 18-24 with, at most, a lower secondary level of educational attainment (ISCED 0-2) not engaged in further education and training in the four weeks preceding the survey.

For the sake of simplicity, we assume that after 2027 the dropout rate would stabilize at 10.2 percent, represented by the flat part of the green-dashed line. The trend constitutes our counterfactual scenario, i.e., what would happen without the Plan. In implementing the reform, we assume that the fall of dropout-ratio speeds up, reaching the target by 2024 (orange-dotted line).

Figure 1 – Observed, counterfactual, and targeted school dropout rate



Notes: The figure reports the historical (observed) dropout rate for Italy (blue line) and the RRP reform of education target (grey-dashed line), i.e., 10.2. The green dashed line represents the counterfactual scenario, while the orange-dotted line describes the reform scenario. Source: own elaborations on EUROSTAT data.

The difference between the counterfactual and the reform scenario is the contribution of the reform, which implies, on average, 27,000 fewer early leavers per year up to 2027. The latter is mapped into the model assuming that those who do not drop out will obtain a high-school or tertiary-level education. Our assumption implies a reduction in the low-skilled share of the labor force and an equivalent increase in the medium-skilled share.

The reform foresees several measures enhancing human capital composition in its second line of action. First, it envisions investments in the tertiary vocational education system to help enroll 11,000 additional individuals. Second, it foresees 80,000 additional college scholarships. Both measures imply a gradual shift from high-school to tertiary graduates, which can be mapped into the model by increasing the average efficiency of the medium-skilled category (see Section 4). Third, 23,144 Ph.D. grants will be awarded; those are translated into the model with a shift from the medium-skilled group to the high-skilled group. Overall, this reform line entails a reduction of 91,000 individuals in the low-skilled category and an increase of 67,856 and 23,144 individuals in the medium and high-skilled groups, respectively.

The third line of action of the reform includes several measures designed to improve the quality of the education system, such as improving school facilities, funds to improve the quality

of training, and continuing education programs for teachers and school deans. The mapping into the model is based on a recent study by Égert *et al.* (2022). They estimate the elasticity of total factor productivity to the PISA test scores. The PISA tests—administered by the OECD—measure students' reading, mathematics, and science knowledge and are generally used as a proxy for the quality of education. Adopting a benchmarking approach, we assume that the planned measures will raise the score of the Italian PISA test (currently at 487 points) to match the average of the three best European performances (519 points).[29] Using the elasticities estimated by Égert *et al.* (2022), equal to 0.8, this translates into a 5.3% increase in the TFP (A_t).[30]

To test the sensitivity of our results to different assumptions, we explored two alternative scenarios. In the high-impact scenario, we assume that the PISA score aligns with the best European performer (Estonia, with 523 points), leading to an increase in TFP of 5.9% instead of 5.3%. The other assumptions are left to their baseline values. In the low-impact scenario, we assume that the number of individuals obtaining the various qualifications considered in the first and second components is halved. Moreover, we also hypothesize that the domestic PISA score would align with the European Union average (497 points). The reform-induced change in aggregate productivity would then be equal to 1.6%.

The measures envisaged to reduce school dropouts started in 2021. As a result, additional high-school diplomas will be obtained starting in 2022. The effect is assumed to last up to the end of 2027. This timing is in line with the previous assumption on the counterfactual and reform scenarios (cf. Figure 1). The timing of the actions related to human capital composition is based on i) the official starting period of each measure as reported in the M&T and ii) the years required to obtain each degree. Finally, the measures aiming at improving the quality of education are considered to impact the stock of human capital in fifty years. In line with Égert *et al.* (2022), a long period is required to gradually allow the new graduates to substitute the current labor force.

Our mapping is summarized in Table 4.

[29] The three best performers are Estonia, the Netherlands, and Poland.

[30] The elasticity we consider is the product between the elasticity of the stock of human capital index to the increase in PISA scores (0.278) and the one between human capital and the TFP (2.84). See Égert *et al.* (2022: Table 8).

Table 4 – Education and research mapping

Line of action	Objective	Variation			Timing		Variable	Map
		Low	Baseline	High	Start	End		
School dropout	Annual dropout	-13,000	-27,000	-27,000	2022:Q1	2027:Q4	Share of low-skilled	BU
Human capital composition	Tertiary graduates	+33,928	+67,856	+67,856	2024:Q1	2029:Q4	Share of medium-skilled	BU
	Researchers	+11,572	+23,144	+23,144	2025:Q1	2028:Q4	Share of high-skilled	BU
Quality of education	PISA scores	+2.1%	+6.6%	+7.4%	2022:Q1	2070:Q1	TFP	B

Notes: The table reports detailed information on the reform mapping into QUEST. The mapping column refers to the simulation strategy: Bottom-Up (BU), Benchmarking (B), and Judgmental (J). Line of action, objective, and timing refer to the information contained in the M&T. Variation is the assumed improvement of the objective in the low, baseline, and high scenarios. Variable refers to the variable shocked in the model.

5.5 Labor market policies and training

In 2019, before the pandemic, Italy's activity rate was 65.7% against an EU average of 73.4%. The gap was even wider for female and young people participation rates. The reform aims at increasing participation in the labor market through three lines of action: (i) the upskilling and reskilling of inactive and unemployed individuals; (ii) encouraging greater female participation; and (iii) improving the matching efficiency between labor supply and demand.

Concerning the first line of action, the RRP introduces the so-called Employability Guarantee of Workers (*Garanzia di occupabilità dei lavoratori*, GOL), a program aimed at skilling, upskilling and reskilling at least 2.6M inactive and unemployed individuals by the end of 2026. Among them, 75% (about 2M) should be women, long-term unemployed, disabled, aged under 30, or aged over 55 workers. The GOL also envisages that 800,000 people will be involved in vocational training programs. The number of individuals eligible for the GOL equals 11.2M, i.e., the total number of unemployed and inactive individuals in the 25-64 age class. According to the RRP, over the 2022-2026 period, 3M inactive and unemployed individuals will be involved in the GOL program. Based on a conservative estimate, we assume that 500,000 individuals will join the labor force, that is, a 3.3% increase in the labor force, which is mapped into the model by reducing the inactivity rates ($NP_{s,t}$).[31]

The second line of action refers to female participation. It can be summarized in two measures: a) support for female entrepreneurship; b) support for female participation through early

[31] See equation (A.16) in Appendix A for formal implementation details. The calibration of the shocks for the low, medium, and high-skilled groups is based on Eurostat data on the current composition of the labor force.

childhood education and care services.

Female entrepreneurship is encouraged through venture capital operations and technical-management support. Moreover, M&T foresees that at least 1,000 companies will obtain gender equality certification. Other RRP interventions aim to boost female participation rates (MEF, 2021, for details). Without an explicit target, we assume these interventions will close one-tenth of the gap between the observed Italian female activity rate and the average of the three best European performers (Sweden, Lithuania, and Estonia). The gap closure corresponds to about 220,000 additional women in the labor force, which translates into a proportionate reduction in the share of inactive individuals.[32]

Regarding the support of female participation through early childhood education and care services (0-6 years old), the RRP aims to create 264,500 new positions. We consider that investments in childhood education increase female labor force participation, as suggested by Thévenon (2013). Dividing the additional positions in early childhood education and care services (264,500) for the fertility rate registered in Italy (1.24), we estimate that 213,000 women can take advantage of these additional facilities. Out of this figure, we only consider the currently inactive but willing-to-work individuals who, according to ISTAT data, make up 12.1% of the female population. Applying this percentage to the pool of potential beneficiaries of the measure, we estimate that about 25,750 additional women could join the labor force.

The third line of action is expected to improve the matching between the demand and supply of labor through training programs directed toward the inactive and unemployed individuals (second line of intervention). To map the improvement of the search and matching in the labor market, we assume a 10% increase in the marginal cost of searching for a job ($csrc_t$), a value that we deem conservative.[33]

To sum up, our mapping implies that: (i) 0.5 million individuals involved in the GOL program would enter the labor force; (ii) the gap in the female activity rate with the top 3 European performers is closed by 1/10; (iii) 25,750 additional mothers could enter the labor force, taking advantage of childcare services; (iv) the marginal cost of searching for a job $csrc_t$ increases by 10%. Alternative high and low scenarios are built by doubling and halving the previous shocks, except for the measures related to childcare services, which are halved in the low and kept constant in the high scenario, given that we consider the increase of 25,750 women in the labor force already as an upper bound.

Regarding the timing of each line of action, the GOL program is expected to impact the

[32] Proportionately for the three skill levels considered in the QUEST III R&D model.

[33] See equation (A.15) in Appendix A for implementation details. Note that we approximate search matching effects in QUEST using the job search costs featured in the model. The results from this approach align with those obtained using a DSGE model with fully-fledged search-matching dynamics in the labor markets.

economy and increase the labor force levels starting in the third quarter of 2022. The latter considers that, according to the M&T, the GOL program should affect the first group of inactive individuals by that date. As regards female labor participation, new places in kindergartens should be ready by the beginning of 2024, while the reduction in the gap vis-à-vis the best EU performers is assumed to take ten years, as well as the improvements in the labor market search and matching.

Our mapping is summarized in Table 5.

Table 5 - Labor market policies and training mapping

Line of action	Objective	Variation			Timing		Variable	Map
		Low	Baseline	High	Start	End		
GOL program	Inactive individuals	-0.25M	-0.5M	-1M	2022:Q3	2026:Q4	Non-part. rate	BU
Female participation	Three best EU performer gap	-5%	-10%	-20%	2023:Q1	2032:Q4	Non-part. rate	B
	Active female	12,870	25,750	25,750	2024:Q1	2026:Q1	Non-part. rate	BU
Search and Matching	Matching efficiency	+5%	+10%	+20%	2022:Q2	2031:Q4	Cost of search	J

Notes: The table reports detailed information on the reform mapping into QUEST. The mapping column refers to the simulation strategy: Bottom-Up (BU), Benchmarking (B), and Judgmental (J). Line of action, objective, and timing refer to the information contained in the M&T. Variation is the assumed improvement of the objective in the low, baseline, and high scenarios. Variable refers to the variable shocked in the model.

6. Results

In this section, we present and analyze the results of our simulations. First, we report the impact of reforms in the baseline scenario. Next, we describe the sensitivity analysis, which considers a higher and a lower impact scenario.

6.1 Baseline results

Structural reforms have a significant impact on GDP both in the medium and longer term. Our assessment is reported in Figure 2, which presents the transition dynamics of the reforms for selected macroeconomic variables (GDP and its main components, as well as the GDP deflator). The outcomes are percentage deviations from a no-reform (steady-state) scenario. The figure presents a reform-decomposition analysis, i.e., we provide information about the relative contribution of each reform to the change observed in the macroeconomic variables considered.

At the end of the Plan, in 2026, GDP would already be 3.4% higher than in the no-reform scenario. In the long run, in 2050, GDP would be around 10% higher compared to the no-reform scenario. According to our decomposition, the reform with the highest impact in terms of additional

GDP is the labor market reform. A significant impact on GDP also stems from Education and PA reforms, followed by Justice and Competition and Public Procurement reform.

These results are not surprising, given that policy measures associated with labor markets mainly deal with one of the main structural weaknesses of the Italian economy, namely the low participation rates, which compress the potential output. Instead, the low impact associated with the competition measures depends on Italy's past positive performance, i.e., implemented reforms in the past have successfully reduced the room for further significant improvements in this intervention area. Finally, it is worth mentioning that the evaluation of the other measures has been remarkably conservative.[34]

Figure 2: Macroeconomic impact of the structural reforms – Baseline scenario

Notes: The figure shows the impact of structural reforms on selected macroeconomic variables in percentage deviations from a no-policy scenario. GDP and its components are expressed in real terms. The figure disentangles the effects of the different reforms.

[34] In the Justice and PA areas, we considered only the direct effect on productivity rather than the potential effects such reforms could have on private investment, domestically and abroad. Our assessment of the public procurement reform has been remarkably conservative, as we assumed that the RRP would only slightly improve, by 2 points, the single-market scoreboard indicator.

The impact on aggregate investment and consumption is proportional to what we observe for GDP. The figure shows an initial crowding-out of private investment, which is standard in this class of models and motivated by the fact that firms anticipate that TFP will increase over time, thus making future investments more productive than present ones.[35]

The impact on prices is negative, as most reforms are assumed to affect TFP positively. This standard supply-side shock triggers production increases accompanied by a generalized price reduction. Furthermore, price dynamics can be easily inferred from the dynamics of the GDP deflator, which mirrors GDP dynamics. Regarding external trade, productivity-enhancing reforms positively and similarly affect imports and exports.

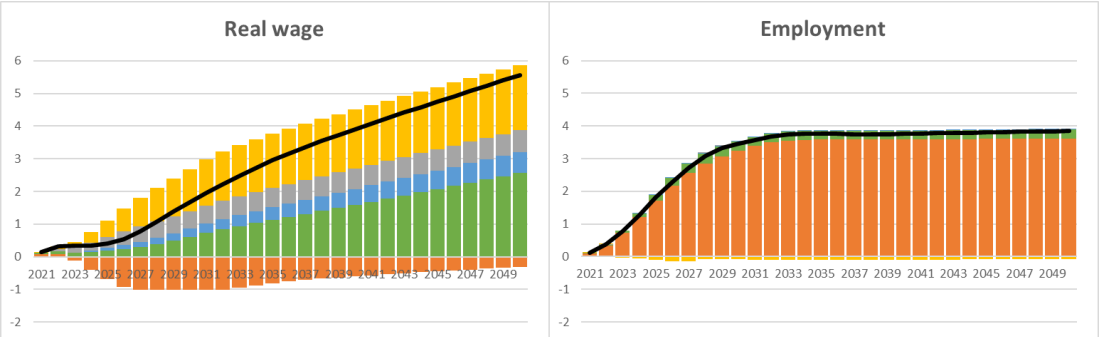
Figure 3 details the impact of the reforms on selected labor market variables (average real wage and aggregate employment). Again, the figure outcomes are expressed as percentage deviations from a no-reform scenario.

Apart from the Labor Market reform, all structural measures increase labor productivity and real wages. The expected negative impact of the Labor Market reform on wages stems from the increase in labor supply, reducing workers' market power and triggering a reduction in their wage markups. However, the same reform has a robust positive effect on employment due to increased participation in the labor market. The negligible effects of the other reforms on employment are not surprising, given that all the reforms, apart from the Labor Market one, mainly improve productivity, thus allowing higher output without necessarily increasing the number of workers.

Should we thus interpret our result by saying that structural reforms, different from the labor market ones, have no positive effects on employment? The answer is no. Structural reforms lay the foundation for a more productive economic environment, while employment should be sustained by additional investments enabled and encouraged by structural reforms. This indirect (mostly demand-side) effect should be considered in our exercise. Additionally, our exercise needs to evaluate the impact of public investments in the Recovery Plan. However, the success of the reforms is necessary for the increase in public investments expected to raise employment in the medium and long run (see, e.g., Di Bartolomeo and D'Imperio, 2022).

[35] See, e.g., Ciapanna *et al.* (2023).

Figure 3: Impact of the structural reforms on the labor market



Notes: The figure shows the impact of structural reforms on selected labor market variables in percentage deviations from a no-policy baseline scenario. The figure disentangles the effects of the different reforms (for the legend, see Figure 2).

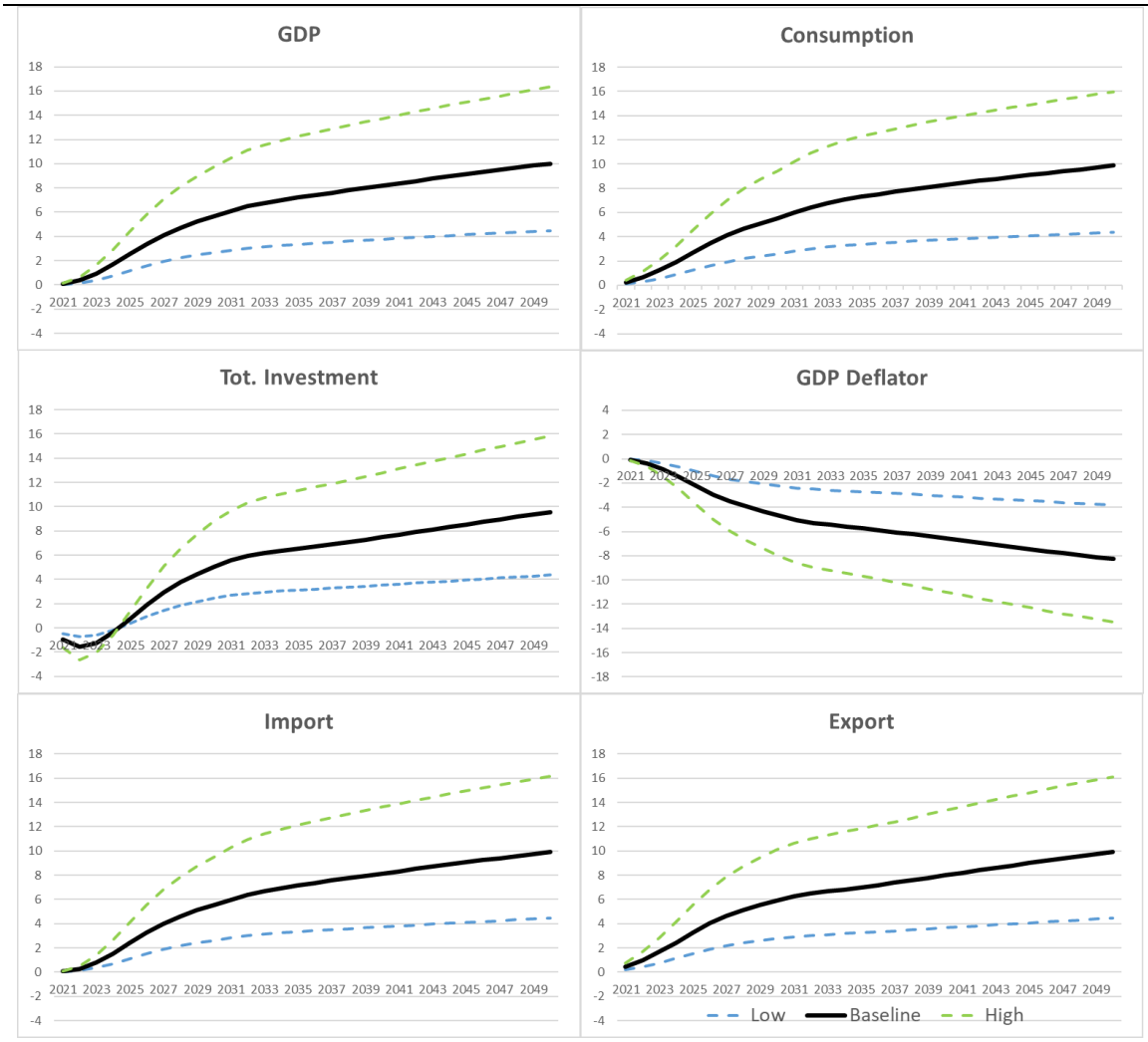
6.2 Sensitivity analysis

The baseline assessment is subject to significant margins of uncertainty that might arise from risks related to the implementation timing and the reforms' efficiency. An additional degree of uncertainty stems from our modeling choices and the econometric studies employed to calibrate the simulations (e.g., choosing transmission channels for reforms and quantifying their impact on the model parameters). Accordingly, in the previous sections, we have detailed our assumptions and described high and low scenarios to build uncertainty intervals around the baseline setup.

The results we obtain when considering the uncertainty surrounding our assessment are reported in Figure 4, which shows the aggregate impact of structural reforms in the baseline scenario (solid black line), together with a low- and a high-impact one, built on the alternative calibrations described in Section 5.

A significant degree of uncertainty exists regarding the impact of the reforms. This margin grows with the time horizon considered as the impacts of structural reforms have permanent effects that (when present) tend to consolidate over time. This result is unsurprising since the uncertainty interval is based on alternative scenarios. The low-impact scenario represents a situation where the planned goals must still be fully achieved. In contrast, the high-impact scenario should be regarded as the most favorable outcome in which all reforms are implemented to their maximum potential. According to the scenario considered (low-high), the long-term impact on GDP would range from 4.5% to 16.3%.

Figure 4: Macroeconomic impact of the structural reforms – Sensitivity analysis



Notes: The figure shows the aggregate impact of structural reforms on selected macroeconomic variables. It reports percentage deviations from a no-policy baseline scenario. The three scenarios - low, medium, and high - correspond to different assumptions about the efficacy of structural reforms. See Section 5 for a detailed description of these assumptions.

7. The social impact of the reform package

The reform package can soundly contribute to the long- and medium-run growth, tackling some structural weaknesses of the Italian economy. However, heterogeneous dynamics across income earners and categories can also be observed, as the benefits of the reforms would not necessarily be equally distributed. This section explores this issue by investigating the impact of the reforms on the different income categories. We investigate the model-based functional income distribution in line with Roeger *et al.* (2021), who focused on labor market reforms. Moreover, we also look at the heterogeneous impact of the reforms on liquidity-constrained and non-liquidity-constrained households. We analyze the impact of the reforms on wages, capital and profits, financial wealth, unemployment benefits, and transfers, which constitute the Net Disposable Income (NDI) in the

model.[36]

Figure 5 reports the impact of each structural reform on income categories. It reports the impact in absolute terms (left column) and the changes in the relative shares of the total NDI (right column). Results are shown at 10, 20, and 30 years after the beginning of the RRP.

In absolute terms, the reforms can simultaneously increase income from wages, capital, and profits. These improvements can be ascribed to the increase in GDP previously observed and a reduction in the revenues stemming from financial wealth. However, an exception is represented by the simulated impact of the competition and public procurement reform. As expected, it reduces the income from capital and profits triggered by higher competition across firms.

Across the different reforms, income stemming from bond markets tends to be initially positive, while it turns negative during the last part of the simulation. This dynamic mainly depends on the government bond accumulation from which the financial income stems. In the following, we provide some insight into the result.

The simulated reforms increase GDP and government revenues, thus reducing the bonds supplied by the government in each period. The slowdown in the acquisition of public bonds has a positive effect on the year-by-year financial income of bond buyers. The latter can be better understood by noticing that the yearly financial income depends positively on the interest received on debt securities acquired in the past and negatively on the number of bonds purchased during the same year. Consequently, a decreasing debt stock triggers an increase in bond income in the first years of our analysis (up to 2030). The negative deviations of bond income observed during the following ten years (up to 2040) can be explained by recalling our assumptions on the fiscal rule (described in Section 4). It triggers an increase in the debt stock after ten years to stabilize the GDP-to-debt ratio, adversely affecting bond income. In the long run (up to 2050), bond income, in absolute terms, tends to return to its initial steady-state level.

In relative terms, the wage and the capital/profit shares tend to increase across the different reforms at the expense of financial wealth, government benefits, and transfers, with two noticeable exceptions. First, in line with what was previously observed, the reform of competition and procurement induces a reduction in the share of income obtained through capital and profits. Second, the PA reform is associated with an increase in the capital/profit share (also) at the expense of the wage share. The observed dynamics are not due to a decrease in wages—which improve in absolute

[36] The model-based NDI is net income from labor, capital, profits, financial wealth, and government transfers. Differently from Roeger *et al.* (2021), to whom we refer for additional details, we do not consider the income stemming from lump-sum transfers (so-called reform dividends) as part of the NDI. All things being equal, given the fiscal rule (eq. (A.40)), the GDP increase leads to a rise in fiscal transfers. We are interested in the macroeconomic effects of the reform. Although interesting, the impact on public finance is beyond the scope of the present paper as its evaluation needs to introduce further assumptions on the costs of the reforms and how they are financed. The difference between the actual GDP and the NDI could be a potential long-term debt/GDP ratio reduction.

terms—but to the higher growth of capital and profits to wages in absolute terms, as shown on the left side of Figure 5.

The latter results can be explained by looking at the public sector reform simulation channels: i) the increase of total factor productivity, ii) the reduction in the bureaucratic costs faced by firms, and iii) the labor force upskilling. The first tends to impact labor and capital income via increased factor productivity positively. The second one positively affects profits but negatively impacts wage income because of the reduced employment devoted to overhead labor. Finally, the third channel has a weak positive effect on wage income. The combined effects of the analyzed shocks favor a more substantial increase in the income from capital and profits to wages, resulting in a reduction in the latter's share.

Figure 5: The impact of the structural reforms on the functional distribution of income

Public Administration

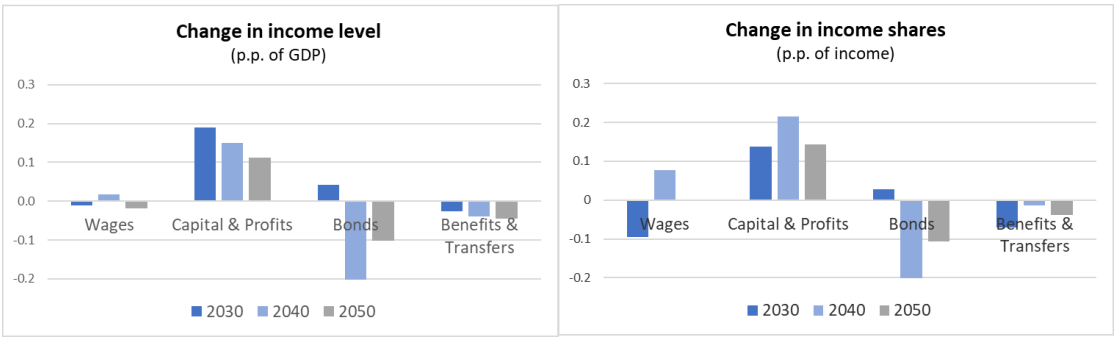
Justice

Figure 5 (continued)

Competition and public procurement

Education

Labor



Notes: The figure shows the impact of each structural reform on income categories. It reports the impact in absolute terms (left column) and the changes in the relative shares of the total NDI (right column). Results are reported at 10, 20, and 30 years after the beginning of the RRP.

The heterogeneous impact of the structural reforms can also be seen from a different perspective, namely by looking at the impact of the reforms on the consumption dynamics of liquidity-constrained (non-Ricardian) and non-liquidity-constrained (Ricardian) households.

The results reported in Table 4 show that private consumption would increase significantly, around 10 percent above the baseline in 2050 for both groups. The introduction of the reform package would favor non-liquidity-constrained households during the Plan's early years, but this gap tends to

be reverted over time. As a result, in 2050, the increase in consumption will be slightly higher for liquidity-constrained households.

One way to explain this latter finding is to look at the results reported in Figure 3. The bulk of the increase in total wages only occurs after 2026, when reforms begin to unfold their effects on this variable. As outlined in Section 4, Ricardian households derive their income from bonds, investments, and wages, while non-Ricardians only from the latter. The lagged wage increase, combined with a more favorable base effect (lower initial steady state) for liquidity-constrained households, produces the dynamics observed in the table.

Table 4 – Impact on liquidity- and non-liquidity-constrained households

Private consumption	2026	2030	2050
Aggregate	3.5	5.5	9.9
Liquidity-constrained	2.9	5.0	10.1
Non-liquidity-constrained	3.7	5.8	9.8

Note: This table reports the impact evaluation of the reforms on (aggregate) private consumption, liquidity-constrained households' consumption, and non-liquidity-constrained households' consumption. Results are annual percent deviations from a no-policy change (baseline) scenario.

8. Conclusions

This paper has assessed the impact of the structural reform package associated with the Next Generation EU. In a nutshell, we document a significant impact on GDP in the medium and longer term. The efficacy of the reform package emerges in the long run. In 2050, GDP would be 10% higher than in the alternative scenario without reform. However, sizeable effects will be observed starting in 2026, the end of the Plan, when observed GDP would rise by 3.4%. The labor market and education measures primarily drive the impact of the reforms on GDP and employment. We also looked at the distributional effects of the reform program. We find that a significant labor and capital income increase accompanies the aggregate positive effect on output. The latter partially occurs at the expense of bond market income.

Our assessment of the reforms' impact shows a large margin of uncertainty. However, the uncertainty considered does not only refer to the assessment *per se* but also to the uncertainty about the efficient implementation of the Plan. In other words, our assessment also highlights the potential risks (and the possible social costs) associated with poor management in implementing reforms that cannot achieve the expected objectives. Furthermore, inflationary dynamics could also reduce the total macroeconomic effects of the reforms. When the Plan was designed, the average expected inflation

was below 2%, while the current expected values are much higher.[37] Since the financial Plan is defined in nominal terms, without additional funding, this would imply lower investments in real terms, which could preclude the full effectiveness of the reforms considered.[38] To offset the effects of the unanticipated inflation in the past months, the Italian Government has allocated substantial additional resources.

Finally, it is worth mentioning that the long-run outcomes of the reform only depend on the policy measure designed and implemented. However, in our forward-looking context, the short-run (transition) dynamics also depend on agents' expectations. We assumed the contents and timing of the reforms were announced and thus fully anticipated by the agents. Different short-run dynamics would emerge if agents misperceived the reforms' contents or timing.[39] We did not consider this aspect, leaving it to future research.

[37] The December 2022 Eurosystem staff projections foresee that inflation will drop sharply, from 8.4% in 2022 to 3.6% by the end of 2023, mainly reflecting lower energy prices. But it will then stay at around 3.4% in 2024 and will reach 2% only in the third quarter of 2025.

[38] For a discussion on the point, see Pfeiffer *et al.* (2023).

[39] Long-run outcomes are independent of private sector expectations. Instead, generally, the less agents are able to anticipate the effects of reforms, the more forward their macroeconomic effects will be.

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Appendix A – Model details

As the text outlines, the model features three interacting economies: Italy, the rest of the euro area (EA), and the rest of the world (ROW). Two types of households populate each economy: Ricardian $R \in [0, 1-\epsilon]$ and non-Ricardian households $N \in (1-\epsilon, 1]$. The latter are liquidity-constrained households and thus cannot trade in financial and physical assets. The members of both types of households offer labor services, which are differentiated into three skill levels indexed by $s \in \{L, M, H\}$, namely low (L), medium (M), and high (H). A union sets the wage for each skill level in monopolistically competitive labor markets. The unions pool wage income and distribute it equally among their members. Nominal rigidities arise because of adjustment costs proportional to wage changes.

Firms produce intermediate goods or final goods in monopolistic competition. Intermediate goods producers enter the market by paying a fee to overcome administrative barriers and rent physical capital designs from the R&D sector (Jones, 1995, 2005). They sell their products to final goods producers, each producing various domestic goods that are imperfect substitutes for the final goods produced by other firms (Dixit and Stiglitz, 1977). Final goods producers combine intermediate goods and labor and fix the final price by setting a markup over the marginal cost.

The R&D sector hires only high-skilled labor to discover a new variety of producer durables. The stock of new knowledge evolves based on domestic and foreign existing knowledge. The first depends on the agent's optimization choices, while the latter is exogenous and based on a calibrated growth rate.

Combined domestic and foreign varieties of final goods are aggregated through calibrated CES functions to obtain private and government consumption and investment. Government expenditures (consumption, transfers, and investment) are proportional to GDP, while revenues derive from taxes on consumption, labor, and capital income. Debt is issued accordingly. The central bank follows a Taylor-type rule that allows for the interest rate smoothing based on deviations from the inflation target and the potential output.

In the following, we describe the structure of the model. Although we limit our description to the domestic country (Italy), a similar structure holds for the rest of the EA and the ROW block.

A.1 Entrepreneur

In the final goods sector, entrepreneurs combine the labor aggregate and A_t varieties of intermediate inputs x with an elasticity of substitution $\theta \in (0,1)$ using a Cobb-Douglas technology. Each firm j produces a variety of the domestic good, which is an imperfect substitute for the varieties produced by other firms, as follows:

$$Y_t^j = \left(L_{Y,t}^j - FC_L\right)^{\alpha} \left(\int_0^{A_t} (x_{i,t}^j)^{\theta} di\right)^{\frac{1-\alpha}{\theta}} KG_t^{1-\alpha_g} - FC_Y, \tag{A.1}$$

and it is subject to fixed costs FC_Y and overhead labor FC_L. The latter includes fixed costs associated with bureaucracy. In the same equation, KG_t is the level of public capital, while α and α_g are production coefficients.

The CES labor aggregate in the production of the final goods function (A.1) combines the three skill categories:

$$L_{Y,t}^j = \left(S_L^{\frac{1}{\sigma_L}} \left(ef_L L_t^{j,L}\right)^{\frac{\sigma_L - 1}{\sigma_L}} + S_M^{\frac{1}{\sigma_L}} \left(ef_M L_t^{j,M}\right)^{\frac{\sigma_L - 1}{\sigma_L}} + S_{H,Y}^{\frac{1}{\sigma_L}} \left(ef_H L_t^{j,H}\right)^{\frac{\sigma_L - 1}{\sigma_L}}\right)^{\frac{\sigma_L}{\sigma_L - 1}}, \tag{A.2}$$

where S_s is the population share of each labor-force subgroup, $L_t^{j,s}$ corresponds to their employment levels, and ef_s to their efficiency. High-skilled workers can be employed in the final goods and the R&D sectors, therefore we index those allocated in the sector producing the final goods by L_t^H and those in R&D by L_t^A. The parameter σ_L measures the elasticity of substitution among labor types, fixed across different labor types.

The final goods entrepreneur j maximizes profits:

$$PR_t^{f,j} = P_t^j Y_t^j - \left(W_t^L L_t^{j,L} + W_t^M L_t^{j,M} + W_t^H L_t^{j,HY}\right) - \int_0^{A_t} px_{i,t} x_{i,t}^j di, \tag{A.3}$$

where $px_{i,t}$ is the price of intermediate inputs $x_{i,t}^j$ and W_t^s is the wage index of each CES aggregate $L_t^{j,s}$.

Solving the problem in a symmetric equilibrium yields the following demand for labor[40]

$$W_t^s = \alpha \frac{Y_t + FC_Y}{L_{Y,t} + FC_L} \left(\frac{L_{Y,t}}{L_t^s}\right)^{\frac{1}{\sigma_L}} S_s^{\frac{1}{\sigma_L}} ef_s^{\frac{\sigma_L - 1}{\sigma_L}} \eta_t^p \tag{A.4}$$

and for intermediate inputs

$$px_{i,t} = \eta_t^p (1 - \alpha) \frac{Y_t + FC_Y}{K_t} x_{i,t}^{\theta - 1} \tag{A.5}$$

where in a steady state $\eta_p = 1 - \frac{1}{\sigma^d}$ and σ^d is the price elasticity of the demand function of final goods producers. Moreover, the following identity applies $K_t = \int_0^{A_t} (x_{i,t}^j)^{\theta} di$.

In the intermediate goods sector, entrepreneurs license a design from domestic households and rent tangible capital at a rental rate i^k. Monopolistically competitive firms must pay an initial fixed cost FC_A (entry cost) to enter the market. They can transform each capital unit into a single unit of an intermediate input $x_{i,t}$ and sell products to final goods producers, whose inverse demand function has been developed in equation (A.5).

[40] As we considered the symmetric equilibrium, we removed the *j* subscript.

Each entrepreneur i maximizes profits:

$$PR_{i,t}^{x} = \max_{x_{i,t}} \{ px_{i,t}x_{i,t} - i_t^K P_t^C K_{i,t} - i_t^A P_t^A - FC_A \}, \quad \text{(A.6)}$$

where P^C is the price of tangible capital and i^A is the rental rate (user's cost) of intangible capital whose price is P^A. Entrepreneurs are subject to a linear technology able to transform one unit of effective capital ($K_{i,t}ucap_t$) into one unit of intermediate input:

$$x_{i,t} = K_{i,t}ucap_t, \quad \text{(A.7)}$$

where $ucap_t$ is the utilization capacity of the existing capital stock.[41]

By solving the producer's problem, the resulting first-order condition is

$$i_t^K P_t^C = \theta \eta_t^p (1-\alpha)(Y_t + FC_Y)(\int_0^{A_t} (x_{i,t}^j)^\theta di)^{-1} (x_{i,t})^{\theta-1}. \quad \text{(A.8)}$$

The price of intermediate goods is thus set as a gross markup (θ^{-1}) on the marginal cost, i.e.,

$$PX_t = px_{i,t} = \frac{1}{\theta} i_t^K P_t^C. \quad \text{(A.9)}$$

Finally, each intermediate firm x can enter the market until the present discounted value of its profits (PR_t^x) reimburses the initial fixed costs and the net value of patents, i.e.,

$$\sum_{\tau=0}^{\infty} \prod_{j=0}^{\tau} \left(\frac{1}{1+r_{t+j}} \right) PR_{t+\tau}^x = P_t^A \frac{1}{1-t_t^K(1-\delta^A)+\tau^A} + FC^A, \quad \text{(A.10)}$$

because of the no-arbitrage condition

$$PR_{i,t}^x = PR_t^x = i_t^A P_t^A + (i_t^A + \pi_t^A) FC_A, \quad \forall i. \quad \text{(A.11)}$$

In equations (A.10) and (A.11), r_t is the real interest rate, t^K represents capital income taxes, δ^A is the depreciation rate of intangibles, τ^A is a tax credit on intangibles, and π^A is the gross price change of intangibles. Fixed entry costs enter (A.11) directly, while tax credits do so indirectly by the user's cost of intangible capital.

The R&D sector hires high-skilled (R&D research) labor (L_A) at their market wage, facing an adjustment cost to hire new employees. It generates new designs according to the following production function:

$$\Delta A_t = \nu A_{t-1}^{\varphi} L_{A,t}^{\lambda}, \quad \text{(A.12)}$$

where the parameter ν can be interpreted as the total factor efficiency of R&D production, while λ measures the elasticity of R&D production to the number of researchers (L_A). The parameter (φ) measures the spillover effect from the aggregate domestic stock of knowledge A_t.[42] Note that $\varphi = 1$

[41] The capacity is changed by considering an adjustment cost governed by two parameters that capture its slope and curvature.

[42] Positive values for these parameters refer to the *standing-on-shoulders effect* and imply positive research spillovers. In

would imply the strong scale effect feature of fully endogenous growth models concerning A_t. The international stock of knowledge grows exogenously at the rate g_{A^w}.

The R&D maximizes the discounted profit stream:

$$\max_{L_{A,t}} \sum_{t=0}^{\infty} d_t \left(P_t^A \Delta A_t - W_t^H L_{A,t} - \frac{\gamma_A}{2} W_t^H \Delta L_{A,t}^2 \right), \tag{A.13}$$

where d_t is the discount factor, while γ_A represents the adjustment costs parameter on R&D labor demand. In equilibrium, high-skilled workers are paid the same wages across sectors. The first-order condition associated with the R&D sector is as follows:

$$\lambda P_t^A \frac{\Delta A_t}{L_{,t}} = W_t^H + \gamma_A \left(W_t^H \Delta L_{A,t} - d_t W_{t+1}^H \Delta L_{A,t+1} \right). \tag{A.14}$$

A short-run employment trade-off between R&D and output should be noted, as allocating more high-skilled labor to R&D decreases the share of high-skilled labor available for final goods production.

A.2 Employment, labor market participation, and work skills

Both Ricardian and non-Ricardian households receive after-tax wage incomes and unemployment benefits. The skill-specific wage is set by trade unions, which charge a markup of $1/\eta_t^W$, which depends on the intra-temporal elasticity of substitution among skill types σ_{sk}, over the reservation wage. Similarly to the price markup, in a steady state $\eta^W = 1 - 1/\sigma_{sk}$.

Formally, unions set wages as:

$$\frac{W_t^s (1 - t_t^{w,s} - b_t^s (1 - \mathrm{csrc}_t))}{(1 + t_t^C) P_t^C} = \frac{1}{\eta_t^W} \frac{U_{1-L,t}^{h,s}}{U_{C,t}^h} \text{ for } h \in \{R, N\} \tag{A.15}$$

i.e., the real gross wage adjusted for labor taxes (t_t^W) and unemployment benefits (l.h.s.) is set as a markup on the ratio of the marginal utility of leisure to the marginal utility of consumption (reservation wage, r.h.s.). Note that benefits are treated as a subsidy to leisure, but they are scaled according to the cost of searching for a job $(csrc_t)$. Any increase in the marginal cost of the search thus reduces the reservation wage and, consequently, unemployment. It is worth noting that the wage markup is time-varying because of indexation.

Unemployment benefits (BEN_t) enter the household budget constraint and are considered an expenditure on the government side. Therefore, in the government budget, they are aggregated as:

$$BEN_t = \sum_s b_t^s W_t^s (1 - NP_t^s - L_t^s). \tag{A.16}$$

Unemployment benefits are not paid to the share of employed L_t^s and the inactive share of the population NP_t^s. The benefit-replacement rate b_t^s is proportional to wages.

The total number of employees is calculated as follows:

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contrast, negative values can be interpreted as the *fishing out effect*, i.e., when innovation decreases with the level of knowledge.

$$L_t = S_L L_t^l + S_M L_t^M + S_H L_t^H. \quad \text{(A.17)}$$

Similarly, unemployed individuals are obtained from the following aggregation:

$$UN_t = \sum_s S_s(1 - NP_t^s - L_t^s). \quad \text{(A.18)}$$

Finally, the unemployment rate (un_t) is defined as the ratio of the unemployed over the labor force. Therefore, from equations (A.17) and (A.18), we obtain:

$$un_t = \frac{UN_t}{UN_t + L_t}. \quad \text{(A.19)}$$

A.3 Households

Each Ricardian household (indexed by R) maximizes an intertemporal utility function separable in consumption and leisure.

$$u_t^i = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_t^R) + \sum_s V(1 - L_t^{R,s})\right). \quad \text{(A.20)}$$

We assume $U(C_t^r) = (1-h)\, log(C_t^R - hC_{t-1})$ and $V(1 - L_t^{R,s}) = \frac{\omega_s}{1-\kappa}(1 - L_t^{R,s})^{1-\kappa}$, where the parameter $\kappa > 0$ is linked to the skill-specific Frisch elasticity of labor supply.[43]

The utility function is additively separable in consumption (C_t^R) and leisure $(1 - L_t^{R,s})$ and allows for habit persistence (measured by h). The CES preferences for leisure exhibit a common labor supply elasticity, while the different skill-specific weights (ω_s) on leisure capture differences in employment levels across skill groups.

Ricardian households have access to financial markets where they can buy and sell domestic and foreign assets (government bonds), accumulate physical capital, and buy patents of designs produced by the R&D sector. Then they rent physical capital and license patents to the intermediate goods-producing firms. In addition, as already explained, the members of the households offer low-, medium- and high-skilled labor services.

Non-liquidity-constrained households own all tangible (K_t^R) and intangible capital (A_t^R), which evolve according to the following law of motions:

$$K_t^R = J_t^R + (1 - \delta^K) K_{t-1}^R, \quad \text{(A.21)}$$

$$A_t^R = J_t^{A,R} + (1 - \delta^A) A_{t-1}^R, \quad \text{(A.22)}$$

where J_t^r and $J_t^{A,R}$ are investments in tangible and intangible capital, δ^K and δ^A are their depreciation rates.

Ricardian households receive wage income (WI_t^R), unemployment benefits and transfer income from the government (BT_t^R), and interest income from the tangible (IK_t^R) and intangible (IA_t^R)

[43] The κ parameter is common across the skill groups. The skill-specific Frisch elasticity can be obtained by multiplying κ by the ratio between the employed and the unemployed in each skill group (Roeger *et al.*, 2021).

capital services as well as financial assets (FA_t^R) they hold, and profits (PR_t^R). They choose how much to consume (C_t^R), their labor supply (L_t^R), financial investments in domestic and foreign assets (B_t^R and $B_t^{F,R}$), the purchase of the investment good (J_t^R), to rent their physical capital stock (K_t^R), the purchase of new patents from R&D firms ($J_t^{A,R}$), the licensing of existing patents (A_t^R), and capital utilization ($ucap_t^R$).

The investment decisions are subject to convex adjustment costs:

$$\Gamma_J(J_t^R) = \frac{\gamma_K}{2}\frac{\left(J_t^R\right)^2}{K_{t-1}^R} + \frac{\gamma_I}{2}(\Delta J_t^R)^2, \tag{A.23}$$

where γ_K and γ_I are positive parameters that measure the adjustment costs.

The budget constraint is as follows:[44]

$$WI_t^R + BT_t^R + IK_t^R + IA_t^R + FA_t^R + PR_t^R = \\ = (1 + t_t^c)P_t^C C_t^R + B_t^R + E_t B_t^{F,R} + P_t^I\left(J_t^R + \Gamma_J(J_t^R)\right) + P_t^A J_t^{A,R} \tag{A.24}$$

where:

$$WI_t^R = \sum_s \left\{(1 - t_t^{w,s})W_t^{R,s}L_t^{R,s} + \frac{\gamma_W L_t^{R,s}}{2}\frac{\left(\Delta W_t^{R,s}\right)^2}{W_{t-1}^{R,s}}\right\};$$

$$BT_t^R = \sum_s \left\{b_t^s W_t^{R,s}(1 - NP_t^{R,s} - L_t^{R,s})\right\} + TR_t^R;$$

$$IK_t^R = (1 - t_{t-1}^K)(i_{t-1}^K - rp_{t-1}^K)P_{t-1}^K K_{t-1}^R + t_{t-1}^K \delta^K P_t^K K_{t-1}^R + \tau^K P_t^K J_t^{K,R}$$

$$IA_t^R = (1 - t_{t-1}^K)(i_{t-1}^A - rp_{t-1}^A)P_{t-1}^A A_{t-1}^R + t_{t-1}^K \delta^A P_t^A A_{t-1}^R + \tau^A P_t^A J_t^{A,R};$$

$$FA_t^R = (1 + r_{t-1})B_{t-1}^R + \left(1 + r_{t-1}^F - \Gamma_{B^F}\left(\frac{e_t B_{t-1}^F}{Y_{t-1}}\right)\right)e_t B_{t-1}^{F,R};$$

$$PR_t^R = \int_0^n PR_{j,t}^{f,R}\, dj + \int_0^{A_t} PR_{j,t}^{x,R}\, dj.$$

Labor income, WI_t^r, includes convex wage adjustment costs formally given by $\Gamma_W(W_t^{R,s}) = \sum_s(\gamma_W L_t^{R,s})/2\left(\Delta W_t^{R,s}\right)^2/W_{t-1}^{R,s}$ with γ_W>0. Physical (IK_t^R) and non-tangible (IA_t^R) asset income depends on investment in tangible and intangible capital (which leads to premia rp_t^K and rp_t^A to cover the increased risk on the return related to these assets) and includes tax credits on tangible (τ^K) and non-tangible investments (τ^A). Considering the financial asset income, FA_t^R, there is no perfect arbitrage. Interest rates on domestic and foreign bonds are denoted by r_t and r_t^F, respectively. In taking a position in the international bond market, the household faces a financial intermediation premium $\Gamma_{B^F}(.)$ that depends on the economy-wide net holdings of internationally traded bonds.

[44] The budget constraints are written in real terms with all prices and wages normalized with P_t, the price of final domestic goods.

Regarding profit income (PR_t^R), all firms are owned by non-liquidity-constrained households who thus share the total profit of the n final ($\int_0^n PR_{j,t}^{f,R}\, dj$) and the A_t intermediate sector firms ($\int_0^{A_t} PR_{j,t}^{x,R}\, dj$).

The model has a rich fiscal structure: all households pay t_t^w wage income taxes and t_t^K capital income taxes minus tax credits and depreciation allowances ($t_t^K \delta^K$ and $t_t^K \delta^A$) after their earnings on physical capital and patents. Note also that consumption and investment are aggregates of domestic and foreign varieties of final goods, with preferences expressed by a CES utility function. We denote with P_t^C the corresponding utility-based deflator for them (note that $P_t^I = P_t^C$).

Maximizing the utility subject to the budget constraint, the capital law of motions, and the adjustment costs concerning consumption, financial and real assets, it is possible to obtain the household's first-order conditions:

$$\frac{\partial U(C_t^R)}{\partial C_t^R} - \lambda_t^R (1 + t_t^c) P_t^C = 0, \tag{A.25}$$

$$-\lambda_t^R + \beta E_t\left(\lambda_{t+1}^R (1 + r_t)\right) = 0, \tag{A.26}$$

$$-\lambda_t^R + \beta E_t\left(\lambda_{t+1}^R \left(1 + r_t^F - \Gamma_{B^F}\left(\frac{e_t B_t^F}{Y_t}\right)\right)\frac{e_{t+1}}{e_t}\right) = 0, \tag{A.27}$$

$$E_t\left(\frac{\lambda_{t+1}^R \xi_{t+1}^R}{\lambda_t^R}\beta(1-\delta) - \xi_t^R + \frac{\lambda_{t+1}^R}{\lambda_t^R}\beta[(1-t_t^K)(i_t^K ucap_t^R - rp_t^K - \Gamma_U(ucap_t^R)) + t_t^K \delta^K] P_{t+1}^C\right) = 0, \tag{A.28}$$

$$\lambda_t^R P_t^C \left(1 + \gamma_K\left(\frac{J_t^R}{K_{t-1}^R}\right) + \gamma_I \Delta J_t^R - \tau^K\right) - \beta E_t(\lambda_{t+1}^R P_{t+1}^C \gamma_I \Delta J_{t+1}^R) - \lambda_t^R \xi_t^R = 0 \tag{A.29}$$

where λ_t^R are the Lagrange multipliers, $\Gamma_U(ucap_t^R)$ are the adjustment costs linked to capital utilization, and e_t is the nominal exchange rate. The real interest rate r_t is equal to the nominal interest rate minus expected inflation: $r_t = i_t - E_t(\pi_{t+1})$. All arbitrage conditions are standard except for trading frictions ($\Gamma_{B^F}(.)$) on foreign bonds, modeled as a function of the ratio of assets to GDP.

Using the arbitrage conditions and neglecting the second-order terms, investment is given as a function of the variable $Q_t = \xi_t / P_t^C$:

$$Q_t - 1 = \gamma_K\left(\frac{J_t^R}{K_{t-1}^R}\right) + \gamma_I \Delta J_t^R - \tau^K - \gamma_I E_t\left(\frac{\Delta J_{t+1}^R}{1 + i_t - \pi_{t+1}^C}\right), \tag{A.30}$$

where Q_t is the present discounted value of the rental rate of return from investing in real assets

$$Q_t = E_t\left(\frac{1-\delta}{1+i_t-\pi_{t+1}^C} Q_{t+1} + \frac{(1-t_t^K)(i_t^K ucap_t^R - rp_t^K - \Gamma_U(ucap_t^R)) + t_t^K \delta^K}{1+i_t-\pi_{t+1}^C}\right). \tag{A.31}$$

Note that the relevant discount factor for the investor is the nominal interest rate adjusted by the trading friction minus the expected inflation of investment goods (π_{t+1}^C).

Ricardian households buy new patents for designs produced by the R&D sector (I_t^A) and rent

their total stock of designs (A_t) at the rental rate i_t^A to intermediate goods producers in period *t*. Households pay income tax at a rate t_t^K on the period return of intangibles, and they receive tax subsidies at the rate τ^A. Hence, the first-order conditions concerning R&D investments are given by:

$$E_t\left(\lambda_{t+1}^R\beta\left(\psi_{t+1}^R(1-\delta^A)+\left((1-t_t^K)(i_t^A-rp_t^A)+t_t^K\delta^A\right)P_{t+1}^A\right)\right)-\lambda_t^R\psi_t^R=0, \tag{A.32}$$

$$-P_t^A(1-\tau^A)+\psi_t^R=0. \tag{A.33}$$

The rental rate of intangible capital can be obtained by combining the above expressions with the first-order condition for domestic bond holdings. After neglecting the second-order terms, it follows that:

$$i_t^A\approx\frac{1}{1-t_t^K}[(1-\tau^A)E_t(i_t-\pi_{t+1}^A+\delta^A)-t_t^K\delta^A]+rp_t^A. \tag{A.34}$$

Ricardian households require a rate of return on intangible capital which is equal to the nominal interest rate minus the rate of change of the value of intangible assets, covering the cost of depreciation, plus a risk premium (rp_t^A).[45]

Non-Ricardian households cannot trade in financial and physical assets and consume their disposable income each period. As for Ricardian households, they offer low-, medium- and high-skilled labor services. Their consumption in real terms is thus determined by the net wage income plus net transfers, i.e.,

$$C_t^N=\frac{\sum_s\left((1-t_t^{w,s})W_t^{N,s}L_t^{N,s}+b_t^sW_t^{N,s}\left(1-NP_t^{N,s}-L_t^{N,s}\right)-\frac{\gamma_W L_t^{N,s}\left(\Delta W_t^{N,s}\right)^2}{2\,W_{t-1}^{N,s}}\right)}{(1+t_t^c)P_t^C}+\frac{TR_t^N}{(1+t_t^c)P_t^C} \tag{A.35}$$

Aggregate consumption is obtained by integration. Remembering that the share of the non-Ricardian household is ε, it follows that $C_t=(1-\varepsilon)C_t^R+\varepsilon C_t^N$. Labor is aggregated similarly, as well as physical capital and patents. However, physical capital and patents are aggregated only among Ricardian households.

A.4 Trade and international financial flows

Economies trade their final goods. Aggregate imports are given by

$$IM_t=s^M\left(\frac{P_t^C}{P_t^{IM}}\right)^{\sigma_{IM}}(C_t+I_t+G_t), \tag{A.36}$$

where σ_{IM} is the elasticity of substitution between bundles of domestic and foreign goods, s^M is a parameter governing the calibrated openness of the country towards foreign economies, and $P_t^{IM}=e_tP_t^*$ are producer prices of imports (IM_t) with P_t^* denoting foreign prices.

[45] The government can thus affect investment decisions in intangible capital by giving tax incentives in the form of tax credits and depreciation allowances or by lowering the tax on the return from patents.

The net foreign assets (B_t^F) evolve according to the following equation:

$$e_t B_t^F = (1 + r_t^F) e_t B_{t-1}^F + P_t^{EX} EX_t - P_t^{IM} IM_t, \quad \text{(A.37)}$$

where $P_t^{EX} = P_t$ are producer prices of exports (EX_t). Note that foreign assets are denoted in foreign currency.

A.5 Government

On the expenditure side, we assume that government consumption, transfers, and investment are proportional to GDP, and unemployment benefits are partially indexed to inflation.

The government also provides subsidies (S_t) on physical capital and R&D investments in the form of tax credits and depreciation allowances, i.e.,

$$S_t = t_{t-1}^K \left(\delta^K P_t^I K_{t-1}^{i,H} + \delta^A P_t^A A_{t-1}^{i,H} \right) + \tau^K P_t^I J_t^{i,H} + \tau^A P_t^A J_t^{A,i,H}. \quad \text{(A.38)}$$

The stock of public capital is fueled by public investment (I_t^G). Formally, the public capital stock evolves according to:

$$K_t^G = \frac{1}{4} \sum_{i=1}^{4} I_{t-n}^G + (1 - \delta^G) K_{t-1}^G. \quad \text{(A.39)}$$

The evolution of the public capital stock considers its depreciation (δ^G) and its gradual implementation following a *time-to-build process* (Leeper *et al*., 2010; Ramey, 2020).

All things being equal, an increase in public investment directly impacts the potential output. However, it also has an indirect effect. A positive shock of public capital increases the productivity of other factors, encouraging companies to hire more workers and increase private investment.[46] The direct impact of public investment, given the formalization introduced, crucially depends on the elasticity of output to the public capital stock ($1 - a_g$) and the accumulated stock (K_t^G). Formally, the impact is given by the following equation: $\frac{\partial Y_t}{\partial K_t^G} = (1 - a_g) \frac{Y_t}{K_t^G}$. The direct effect of public investment, given the production function, will therefore depend negatively on the initial public investment stock (the higher the initial stock, the lower the marginal increase effect of investment) and positively on the elasticity of output relative to the public capital stock (Di Bartolomeo and D'Imperio, 2022).

Government revenues, R_t^G, are made up of taxes on consumption and capital and labor income. Government debt (B_t) evolves according to

$$B_t = (1 + r_t) B_{t-1} + P_t^C G_t + TR_t + BEN_t + S_t - R_t^G - T_t^{LS}. \quad \text{(A.40)}$$

There is a lump-sum tax (T_t^{LS}) used for controlling the debt-to-GDP ratio according to the following rule:

[46] A change in the stock of public capital has a positive impact on capital and labor productivity to the extent that the direct effect is positive ($\partial Y_t / \partial K_t^G > 0$.)

$$\Delta T_t^{LS} = \tau^B \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) + \tau^{DEF} \Delta \left(\frac{B_t}{Y_t P_t}\right), \quad \text{(A.41)}$$

where b^T is the government debt target. The two parameters τ^B and τ^{DEF} rule the response of lump-sum taxes to deviations of public debt from the debt target and the growth rate of the public debt stock, respectively.

The European Central Bank adopts a Taylor-kind rule. The domestic monetary authority thus responds to changes in expected inflation and output gap at the euro-area level according to the following Taylor rule:

$$i_t = \tau_{lag}^{INOM} i_{t-1} + \left(1 - \tau_{lag}^{INOM}\right)\left[r^{EQ} + \pi^T + \tau_\pi^{INOM}(\pi_t^C - \pi^T) + \tau_{y,1}^{INOM} ygap_t\right]. \quad \text{(A.42)}$$

Equation (A.41) features some smoothness in response to the deviation of inflation (π_t^C) concerning the inflation target (π_t^C) and to the output gap $(ygap_{t-1})$. In equation (A.42), r^{EQ} is the real interest rate in the steady state while $\tau_{lag}^{INOM}, \tau_\pi^{INOM}$, and τ_y^{INOM} are parameters ruling the interest rate smoothness, the response of the central bank to inflation, and the response to the output gap. A similar rule is adopted for describing the monetary policy behavior in the rest of the world. Finally, the output gap definition approximates the standard practice of output gap calculation used for fiscal surveillance and monetary policy. A production function approach defines the output gap as the capital and labor utilization deviation from their long-run trends.

Appendix B – Selected reforms' M&T considered for the simulations

The Italian RRP contains 151 investments and 63 reforms, which should be completed following a detailed time path described in 482 milestones and 665 policy targets. The following tables report the reform line of actions for the simulation associated with the significant M&T for the Plan's reforms, which informed our simulation exercises.

Table B.1 - Public administration

Line of action	M&T Sequential # Mission (M) Component (C)	M&T Short Description
Efficiency	M1C1-1	Entry into force of law decrees for reform 1.1 ICT Procurement.
	M1C1-2	Entry into force of law decrees for reform 1.3 Cloud First and Inter-operability.
	M1C1-10	Entry into force of the setup of Transformation Team and NewCo.
	M1C1-51	Complete the recruitment procedures for the pool of 1,000 experts to be deployed for three years to support administrations in managing the new procedures by providing technical assistance.
	M1C1-52	Entry into force of primary legislation on simplification of administrative procedures for the implementation of the Italian Recovery and Resilience Plan.
	M1C1-53	Entry into force of primary legislation to provide technical assistance and strengthen capacity building for implementing the Italian Recovery and Resilience Plan.
	M1C1-54	Completed recruitment of experts to implement the Italian Recovery and Resilience Plan.
	M1C1-59	Entry into force of strategic human resource management in the Public Administration.
Bureaucracy	M1C1-1	Entry into force of law decrees for reform 1.1 ICT Procurement.
	M1C1-2	Entry into force of law decrees for reform 1.3 Cloud First and Inter-operability.
	M1C1-10	Entry into force of the setup of Transformation Team and NewCo.
	M1C1-55	Extending the methodology applied to the Italian Recovery and Resilience Plan to the national budget to increase investment absorption.
	M1C1-56	Entry into force of the enabling legislation for the reform of public employment.
	M1C1-57	Entry into force of administrative procedures for the simplification reform aimed at implementing the RRF.
	M1C1-58	Entry into force of legal acts for the reform of public employment.
	M1C1-60	Complete implementation (including all delegated acts) of the simplification and digitalization of a set of 200 critical procedures affecting citizens and businesses.
	M1C1-61	Complete the implementation (including all delegated acts) of the simplification and digitalization of an additional set of 50 critical procedures directly affecting citizens.
Human capital	M1C1-66	At least 245,000 (70%) training activities should be completed (formal certification or impact assessment) for central public administrations.
	M1C1-67	At least 280,000 (70%) training activities should be completed (formal certification or impact assessment) for other public administrations.

In Table B.1, note that the M&T related to the PA digitization (M1C1-1, M1C1-2, M1C1-10) can be linked to both efficiency and bureaucratic costs line of actions.

Table B.2 - Justice

Line of action	M&T Sequential # Mission (M) Component (C)	M&T Short Description
Civil proceedings	M1C1-45	Reduce the disposition time by 40% of all instances of civil and commercial litigious cases compared to 2019.
Criminal trials	M1C1-46	Reduce the disposition time by 25% of all instances of criminal cases compared to 2019.

Table B.3 - Competition and procurement system

Line of action	M&T Sequential # Mission (M) Component (C)	M&T Short Description
Competition	M1C2-6; M1C2-8	Entry into force of the Annual Competition Law 2021.
	M1C2-7	Entry into force of all energy-related implementing measures and secondary legislation.
	M1C2-9; M1C2-10	Adopt the 2022 Annual Competition Law.
	M1C2-11; M1C2-12	Adopt the 2023 Annual Competition Law.
	M1C2-13	Adopt the 2024 Annual Competition Law.
Simplification	M1C1 – 69	Entry into force of the Decree on simplification of the public procurement system.
	M1C1 – 70	Entry into force of the revision of the Code of Public procurement.
	M1C1 – 71	Entry into force of all necessary legislation, regulations, and implementing acts (including secondary legislation) for the public procurement system.
	M1C1 – 73	Entry into force of the reform of the Public Procurement Code.
	M1C1 – 74	Entry into force of all necessary implementing measures and secondary legislation for the reform on simplification of the public procurement.
	M1C1 – 75	Full operation of the National eProcurement System.
	M1C1 – 84; M1C1 – 96	Reduction in the average time between the publication and the contract award.
	M1C1 – 85; M1C1 - 97	Reduction in the average time between the contract award and the realization of the infrastructure.
	M1C1 – 86; M1C1 - 98	Civil servants trained through the Public Buyers Professionalization Strategy.
	M1C1 – 87	Contracting authorities using dynamic purchasing systems.
	M1C1 – 96	The average time between the publication and the contract award.
	M1C1 – 99	Contracting authorities using dynamic purchasing systems.

Table B.4 - Education

Line of action	M&T Sequential # Mission (M) Component (C)	M&T Short Description
School dropout	M4C1-7	Mentoring activities for at least 470 000 young people at risk of dropping out of school early and for at least 350.000 young people who have already dropped out.
	M4C1-25	Reduce the gap in drop-out rate in secondary education to reach the EU average in 2019 (10.2%).
Human capital composition	M4C1-11	University scholarships will be granted to at least 300,000 students.
	M4C1-12	At least 1,200 additional Ph.D. fellowship programs will be granted per year over three years); at least 1,000 additional Ph.D. fellowships programs on public administration will be granted per year (over three years); at least 200 new Ph.D. fellowships programs on cultural heritage will be granted per year (over three years).
	M4C1-15	At least 336,000 students benefit from scholarships paid.
	M4C1-20	An increase in the number of students enrolled in the vocational training system yearly (100%).
	M4C1-23	At least 500 new PhDs will be awarded for three years in programs devoted to digital and environmental transitions.
	M4C2-1	Award at least 300 research grants to students.
	M4C2-2	At least 205 projects from companies shall be awarded.
	M4C2-3	Award of at least 15 000 Ph.D. scholarships.
Education quality	M4C1-13	At least 650,000 school managers, teachers, and administrative staff are trained.
	M4C1-14	At least 70,000 teachers, recruited with the reformed recruitment system.
	M4C1-16	At least 8,000 schools have activated STEM guidance projects.
	M4C1-17	At least 1,000 annual languages and methodological courses are provided to all teachers.
	M4C1-19	One hundred thousand classrooms transformed into innovative learning environments to the "School 4.0" Plan.
	M4C1-21	At least 1,000 structures can facilitate the extension of school time and the opening of schools to the territory beyond school hours.
	M4C1-22	At least 230,400 Sqm built or renovated to be used as gyms or sports facilities attached to schools.
	M4C1-24	At least 1,000,000 students attended transition courses from secondary school to university.
	M4C1-26	At least 2,784,000 Sqm of school buildings are restored.

Table B.5 - Labor

Line of action	**M&T Sequential #** Mission (M) Component (C)	**M&T Short Description**
GOL basic program	M5C1-3	At least 3,000,000 people benefit from the GOL program.
Female participation	M5C1-13	At least 800 companies (out of 450 SMEs) have obtained gender equality certification.
	M5C1-14	At least 1,000 companies supported through technical assistance have obtained the gender equality certification.
	M5C1-18	At least 700 additional enterprises compared to the baseline have received financial support through the Fund "Impresa donna."
	M5C1-19	At least 2,400 women enterprises, as defined in the relevant investment policy, have received financial support.
	M4C1-18	At least 264,480 new places should be created for educational and early childhood care services (from zero to six years old).
Search and matching	M5C1-4	At least 800,000 of the 3,000,000 GOL beneficiaries have participated in vocational training.
	M5C1-5	At least 80% of Public Employment Services (PES) in each region have met the criteria of the fundamental level of PES services as defined in the GOL program.
	M5C1-6	At least 250 Public Employment Services (PES) have completed at least 50% of the activities envisaged in the 'Strengthening Plan' over 2021-2023.
	M5C1-7	At least 500 Public Employment Services (PES) have completed 100% of the activities envisaged in the Strengthening Plan over 2021-2023.
	M5C1-10	Increase at least +20% in labor inspections concerning the 2019-2021 period.

Appendix C – Model calibration

The European Commission and its Member States widely use the QUEST model as a policy evaluation tool. The calibration for every country is obtained from a mix of estimation and matching approaches. We summarize the quantitative calibration aspects for the model's parameters and steady states in this Appendix. The model consists of about 500 equations/variables and 187 parameters. Therefore, this Appendix summarizes the calibration. The methodology employed to set the parameter values can be studied further by reading D'Auria *et al.* (2009), Ratto *et al.* (2009), and Rogers *et al.* (2022). Calibration is also routinely updated by the Commission. Our assessment is based on the 2018 update.

A summary of the parameter calibration is provided in Table C.1. QUEST III R&D is calibrated using a mix of different methodologies. First, some parameters are estimated using a Bayesian approach.[47] These are labeled as "Ratto *et al.* (2009)." Others are calibrated by using external study micro-estimations or statistical matchings. In such a case, we indicate the source, i.e., the relevant study or dataset. Finally, the last group of parameters is set to match the steady-state-great ratio described in Table C.2 or specific shares reported in Table C.1.[48] We refer to these parameters with the label "Calibration." Likewise, calibration is also used to refer to parameters set to match the theoretical restrictions of the model in equilibrium.

[47] The model parameters are estimated by applying a Bayesian approach to the model (e.g., Schorfheide, 2000; Smets and Wouters, 2003) and externally by using micro estimations.

[48] See Ratto *et al.* (2009). It is worth noting that these are estimated by the "average" version of QUEST, therefore they are assumed to be the same in different areas.

Table C.1(a) – Parameter calibration: R&D sector[49]

Parameter	Symbol	Italy	EA	ROW	Source
Elasticity of R&D w.r.t. labor	λ	0.53	0.52	0.52	Bottazzi and Peri (2007)
Elasticity of R&D w.r.t. domestic ideas	φ	0.49	0.51	0.51	Bottazzi and Peri (2007)
R&D efficiency parameter	ν	0.59	0.43	0.41	Calibration
Adjustment (quadratic) cost on R&D	γ_A	1563.90	1115.32	1526.14	Calibration
The depreciation rate of ideas (%)	δ^A	2.5	2.5	2.5	Pessoa (2005)
The growth rate of ideas (%)	g_{A^w}	1.15	1.15	1.15	Pessoa (2005)
Selected variables matched					
R&D (% GDP)		1.48	2.40	1.81	Eurostat
Researchers (% employment)	L_t^A	0.55	0.86	0.93	Eurostat

Table C.1(b) – Parameter calibration: Intermediate and final goods sectors

Parameter name	Symbol	Italy	EA	ROW	Source
Net markup (%) intermediate sector	$1/\theta - 1$	10.0	10.0	10.0	EUKLEMS
Entry cost in the intermediate sector	FC_A	0.15	0.06	0.03	WB Doing Business*
Risk premium on intangibles (%)	rp^A	1.54	0.43	1.72	Calibration
Depreciation rate of capital (%)	δ^K	1.50	1.50	1.50	Calibration
Depreciation rate of public capital (%)	δ^G	1.25	1.25	1.25	Calibration
Net markup (%) final goods sector	$1/\eta^p - 1$	11.41	12.86	10.99	EUKLEMS
Overhead labor costs (final goods sector)	FC_L	0.01	0.02	0.02	Calibration
Fixed costs in the final goods sector	FC_Y	0.01	0.03	0.03	Calibration
Elasticity of labor (final goods sector)	α	0.65	0.65	0.65	Calibration
Elasticity of public capital	$1 - \alpha_g$	0.12	0.12	0.12	Bom and Ligthart (2014)
Selected variables matched					
Capital utilization	$ucap$	1.00	1.00	1.00	Normalized

(*) See Djankov *et al.* (2002) for details.

[49] Calibration of the R&D sector is qualitatively well-described by Roeger *et al.* (2022) and Benedetti Fasil *et al.* (2022).

Table C.1(c) – Parameter calibration: labor market

Parameter name	Symbol	Italy	EA	ROW	Source
Low-skilled population share (%)	S_L	39.07	25.80	19.86	Eurostat
Medium-skilled population share (%)	S_M	56.67	66.55	73.35	Eurostat
High-skilled population share (%)	S_H	4.24	7.65	6.79	Eurostat
Labor skill elasticity of substitution	σ_L	1.7	1.7	1.7	Acemoglu and Autor (2011)
Low-skilled efficiency level	ef_L	0.31	0.19	0.22	Calibration
Medium-skilled efficiency level	ef_M	0.50	0.42	0.35	Calibration
High-skilled efficiency level	ef_H	1.33	1.40	0.65	Calibration
Low-skilled non-participation rate	NP^L	39.55	34.76	32.04	Eurostat
Medium-skilled non-participation rate	NP^M	22.41	18.63	17.27	Eurostat
High-skilled non-participation rate	NP^H	14.00	10.79	12.12	Eurostat
Low-skilled leisure parameter	ω_L	0.43	0.52	0.71	Calibration
Medium-skilled leisure parameter	ω_M	0.14	0.11	0.09	Calibration
High-skilled leisure parameter	ω_H	1.74	1.01	0.98	Calibration
Wage adjustment costs	γ_w	120	120	120	Ratto *et al.* (2009)
Low-skilled benefit replacement rate (%)	b^L	17.97	31.46	16.05	Calibration*
Medium-skilled benefit replacement rate (%)	b^M	21.79	44.14	19.60	Calibration*
High-skilled benefit replacement rate (%)	b^H	32.49	72.41	25.20	Calibration*
Net wage markup (%)	$1/\eta^w$	20.00	20.00	20.00	EUKLEMS
Selected variables matched					
Employment	L	65.27	73.03	79.32	Ameco
Low-skilled employment (%)	L^L	51.79	55.05	64.26	Eurostat
Medium-skilled employment (%)	L^M	73.41	78.67	82.80	Eurostat
High-skilled employment (%)	L^H	80.63	84.62	85.76	Eurostat

(*) Calibration from benefit replacement rate used in Ratto *et al.* (2009).

Table C.1(d) – Parameter calibration: Households

Parameter name	Symbol	Italy	EA	ROW	Source
Habits	h	0.7	0.7	0.7	Ratto *et al.* (2009)
Share of Ricardians	ε	0.60	0.60	0.60	Calibration
Inverse elasticity of labor supply	k	2.45	2.20	2.20	Calibration
Capital adjustment costs	γ_K	20	20	20	Ratto *et al.* (2009)
Investment adjustment costs	γ_I	75	75	75	Ratto *et al.* (2009)
Cost of search	$csrc_t$	0.70	0.70	0.70	Calibration
Openness share	s^M	0.16	0.14	0.02	Calibration
Elasticity domestic-foreign bundle of goods	σ_{IM}	0.10	0.10	0.10	Calibration
Selected variables matched					
Import share (%) from Italy		-	9	12	ECFIN, comex
Import share (%) from EA		46	-	88	ECFIN, comex
Import share (%) from RoW		54	91	-	ECFIN, comex

Table C.1(e) – Parameter calibration: Public sector

Parameter name	Symbol	Italy	EA	ROW	Source
Taxes/subsidies					
Tax credit on intangibles (%)	τ^A	2.99	4.68	2.51	OECD
Tax rate on capital income (%)	t^K	27.80	24.05	19.00	DG TAXAUD
Consumption tax rate (%)	t^C	22.56	25.83	21.43	DG TAXAUD
Labor tax rate (%)	t^L	42.60	38.38	25.73	DG TAXAUD
Fiscal rule					
Debt target	τ^B	0.01	0.01	0.01	Calibration
Deficit	τ^{DEF}	0.00	0.00	0.00	Calibration
Monetary rule					
Inflation weight	τ_{π}^{INOM}	-	1.5	1.5	Taylor (1999)
Output gap weight	$\tau_{y,1}^{INOM}$	-	0.05	0.05	Taylor (1999)
Lagged interest rate	τ_{lag}^{INOM}	-	0.81	0.81	D'Auria *et al.* (2009)
Inflation target (annualized)	π^T	-	2.00	2.00	Calibration
Real interest rate (annualized)	r^{EQ}	-	1.29	1.29	Calibration
Selected variables matched					
Quarterly debt on GDP*	B	6.06	4.02	4.62	Ameco
Public transfer share	TR	22.98	18.94	15.63	Ameco
Inflation rate (%) (annualized)	π	2.00	2.00	2.00	Ameco

(*) General government consolidated gross nominal debt

Table C.2 – Steady states, main variables (great ratios)

Selected variables	Italy	EA	ROW	Source
Private consumption (% GDP)	58	55	63	Ameco
Public consumption (% GDP)	22	23	15	Ameco
Investment (% GDP)	18	19	19	Ameco
Public investment (% GDP)	2	3	3	Ameco
Imports (% GDP)	28	25	5	Ameco
Exports (% GDP)	28	25	5	Ameco
GDP (% world GDP)	3	15	82	Ameco

Notes: Values rounded to the nearest integer.

Finally, calibrations are also based on the world population and total factor productivity growth rates set at 0.0005 and 0.00375, respectively (Source: EUKLEMS).

Appendix D – Data sources

Simulations are based on the Italian NRRP, described in the following documents:

- Presidency of the Council of Ministers (2021), *National Recovery and Resilience Plan*, Presidency of the Council of Ministers, Italian Government, Rome, Italy;
- European Commission (2021), "Revised annex to the council implementing decision on the approval of the assessment of the Recovery and Resilience Plan for Italy," Brussels, 8 July 2021.

Additionally, our dataset is based on detailed information on the NRRP measures and sub-measures contained in the following datasets:

- **Milestones and Targets programming of the NRRP dataset.** The dataset associates each measure or sub-measure in the Plan with its milestones and targets (M&T). For each measure/sub-measure, the dataset reports a description and identification codes that allow its identification, the description and identification code of the mission and component, and the administration that owns the intervention. Measures and sub-measures are associated with the unique identification code of the milestone or target, the type (investment/reform), the detailed description of the milestone/target, the national or European relevance, and the quarter and year of the planned achievement. For each milestone, the dataset contains a description of the linked qualitative indicators; for targets, it contains the quantitative starting and target values and their unit of measurement. Further information on verification mechanisms is provided for M&T of European relevance.
- **The monitoring of NRRP measures through sustainable development indicators (SDGs) and the Agenda 2030 dataset.** The dataset contains a detailed mapping of the NRRP measures, the Sustainable Development Goals (SDGs), and the 2030 Agenda for Sustainable Development targets.
- **NRRP financial framework dataset.** The dataset contains information on the measures and sub-measures of the Plan. For each measure/sub-measure, the dataset contains a description, codes (that enable identification on the various reference systems,) the description and identification code of the mission and the component, the total amount of financing, and the financial support modality (loans or grants) defined by the Revised Annex to the Council of the EU Decision of July 8, 2021. Furthermore, the measures and sub-measures are associated with the administration performing the intervention and the amounts allocated, which pertain to the "Development and Cohesion Fund 2021-2027." Projects are also categorized as existing or new projects, as defined by the Minister of the Economy Decree of August 6, 2021, and subsequent amendments.

The three datasets can be retrieved from the Italian Government Portal: http://italiadomani.gov.it/en.

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