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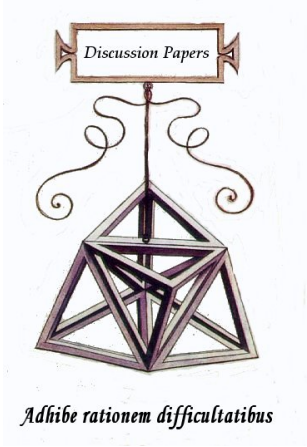

Guilherme Spinato Morlin, Marco Stamegna,
David Cano Ortiz, Simone D'Alessandro,
Pietro Guarnieri

Tackling labour market inequalities through minimum and maximum wages

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Authors' address/Indirizzo degli autori:

Guilherme Spinato Morlin — University of Pisa - Department of Economics and Management, Via Cosimo Ridolfi 10, 56124 Pisa – Italy. E-mail: guilherme.morlin@unipi.it

Marco Stamegna — Faculty of Political Sciences and Sociology, Scuola Normale Superiore, Piazza degli Strozzi, Florence, 50123, Italy. E-mail: marco.stamegna@sns.it

David Cano Ortiz — University of Pisa - Department of Economics and Management, Via Cosimo Ridolfi 10, 56124 Pisa – Italy. E-mail: dacanoo@gmail.com

Simone D'Alessandro — University of Pisa - Department of Economics and Management, Via Cosimo Ridolfi 10, 56124 Pisa – Italy. E-mail: simone.dalessandro@unipi.it

Pietro Guarnieri — University of Pisa - Department of Economics and Management, Via Cosimo Ridolfi 10, 56124 Pisa – Italy. E-mail: pietro.guarnieri@unipi.it

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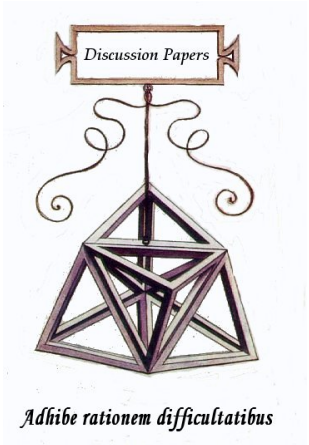

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Keywords: Labour-market policy, Industry heterogeneity, gender gap, Dynamic Macrosimulation

JEL CLassification: E24; E27; J24; J31

Tackling labour market inequalities through minimum and maximum wages

Guilherme Spinato Morlin[1], Marco Stamegna[2], David Cano Ortiz[1], Simone D'Alessandro[1], Pietro Guarnieri[1]

[1*]Department of Economics and Management, University of Pisa.
[2]Faculty of Political Sciences and Sociology, Scuola Normale Superiore.

Abstract

The effectiveness of statutory minimum wages in reducing income inequality and alleviating working poverty is widely recognized in labour market policy discussions. Less attention has been paid to the potential of salary caps to further reduce wage disparities by targeting the top of the income distribution. In this paper, we simulate the introduction of statutory minimum and maximum wages in Italy using Eurogreen, a dynamic macro-simulation model that combines input-output analysis with labour market heterogeneity. Our findings indicate that the joint implementation of the two policies can substantially reduce labour market inequalities across gender, skill levels, occupational categories, and industrial sectors, without negatively affecting the overall performance of the economy.

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1 Introduction

Income inequality is a growing concern in advanced economies driven by economic crises and transformations that exacerbated wage disparities between categories of workers and across sectors. In response, labour market policies tended to address wage inequality by ensuring minimum living standards for the most vulnerable workers. A notable example is the *Directive on Adequate Minimum Wages*, proposed by the European Commission in October 2020, which aims to reduce "in-work poverty and inequality at the lower end of the wage distribution" (European Commission (2022), p.2). Under this perspective, the upper end of the wage distribution and the possibility to

redistribute income between workers seem disregarded. In this paper, we explore the potentials – and limitations – of a policy package where the introduction of the statutory minimum wages is complemented by a salary cap that directly limits the difference between top and low wages.

For this purpose, we conduct a series of macro-simulations with the Eurogreen model Cieplinski et al (2021), an Integrated Assessment Model (IAM) that combines a dynamic input-output approach and labour market heterogeneity in a post-Keynesian Stock-Flow Consistent (SFC) macroeconomic framework. The model features 114 types of workers, differentiated by gender, skill and economic sector, which allow us to explore inequality and the effect of a minimum wage, a maximum wage and their joint introduction. On the other hand, the complex macroeconomic structure captures the effects of labour-saving technical progress on inequality, and allows for the manifestation of second-order effects of wage policies through prices, technological change and labour productivity dynamics.

We assess inequality through a set of different indicators: the Gini and Theil indices for labour and total income, the gender gap in labour incomes, the ratio of maximum to minimum wages, and the labour share in value added. We show that the introduction of mandatory minimum and maximum wages reduces all inequality indicators compared to a baseline scenario without such policies. The most significant improvements in inequality indicators are observed when both policies are implemented simultaneously. Although these policies affect inequality levels, they do not alter their long-run trends, driven by structural factors. Moreover, the policies do not have a strong impact on other key macroeconomic variables such as employment and GDP.

To conduct this analysis we take Italy as the economy of reference to calibrate the model and simulations. This decision rests on two main motivations. First, Italy witnessed an increase in wage disparities accompanied by a decrease in average real wages (Garnero et al, 2021; Giangregorio and Fana, 2023). In this regard, it represents a critical case showing trends that can affect other industrialized and developed economies in the EU and outside. Secondly, the political debate on wage labour policies has been significant, connected to the various legislative attempts to enact a statutory minimum wage since at least 2019, and following the 2022 EU initiative on minimum wage (European Commission, 2022). This debate revolved around the opposition between centralized wage-setting intervention (such as, the statutory minimum wage) and the decentralized mechanism of national collective agreements between unions, industrial associations, and the government that mediated labour relationships in Italy since the end of the Second World War. A legislative proposal in favor of introducing a statutory minimum wage of 9 euro per hour (gross), presented in July 2023, gained momentum by unifying the opposition to the right-wing government of Giorgia Meloni, but it was defeated in Parliament. The government defended the national collective agreement approach to minimum wages and proposed to strengthen it, by including those sectors that do not engage in this sort of collective bargaining, and to reduce labour taxes.

The literature emphasises how labour market policies are essential drivers of the reduction of economic inequalities (Atkinson et al, 2017). Taking action to enhance the adequacy of minimum wages is vital in a period of dramatic transformations that involve the labour market and the productive sectors. The lower labour share in response to automation (Autor and Salomons, 2018), the increase in working poverty and inequality due to globalization (Hellier and Kalugina, 2015), and the likely job reallocation impact of green policies in detriment of specific sectors, regions, and skills (Vandeplas et al, 2022) are just examples of the phenomena that expose low skills and poorer workers to critical risks. In the context of such disruptive transformations, the statutory approach appears more effective in providing a protection against the ensuing uncertainty and unpredictability

of social impacts. This claim appears further justified, if we also consider that the decrease in the bargaining power of unions, especially in the period of crises, is among the factors that lead to rising inequality (Farber et al, 2021; Card et al, 2004; Fortin et al, 2021), reduced wages (Rosenfeld et al, 2016), and lower prevalence of redistributive policies (Pontusson, 2013).

Moreover, the terms of the Italian debate seem to neglect the fact that wage inequality does not only depend on working poverty but critically concerns the concentration of income at the top of the distribution (Clementi and Giammatteo, 2014; Alvaredo and Pisano, 2010). If on the one hand, the statutory minimum wage represents a key policy to lower inequality by decreasing working-poverty (Dube, 2019; Pereira and Galego, 2019; Davidescu et al, 2022; Engelhardt and Purcell, 2021; Gooch and Dromey, 2020; Caliendo et al, 2022; Tamkoç and Torul, 2020), directly addressing wage inequality by fixing an income cap for top earners can result in a more prompt reduction in income gaps and in an effective redistribution. Albeit less investigated in the labour literature and often deemed as politically unfeasible, the imposition of salary caps may help in curbing excessively high top earnings and increasing the progressivity of the tax-and-transfers system (Buch-Hansen and Koch, 2019; Ramsay, 2005; Blumkin et al, 2013; Pizzigati, 2018), while complementing the positive social effects of statutory minimum wages. Salary caps may help reduce gender inequality, as women are often underrepresented at the top of the wage distribution (Atkinson et al, 2018).

The paper is structured as follows. Section 2 introduces the Italian case and reviews the empirical and theoretical literature on minimum and maximum wages. to identify possible effects and mechanisms at work for these policies. In section 3, we present the general features of the Eurogreen model, the modeling strategy and the data used to simulate the introduction of minimum and maximum wages. Section 4 presents the main results of the macrosimulation of policy scenarios in Eurogreen. A final section concludes by highlighting that the statutory introduction of the minimum and maximum wage reduces inequality without undesired macroeconomic side effects.

2 Literature Review

In this section we make a brief review of the literature on labour market policies and inequalities in Italy, and of the theoretical and empirical studies on wage setting policies. Our purpose is threefold. First, to evidence that the worsening of inequalities in Italy has been linked to labour market institutions. Second, to argue that labour market policies of minimum and maximum wages can be a potent tool to address such inequalities, with low adverse effects according to the experiences of other countries. And third, to identify the possible impacts and mechanisms of such policies, whose complexities justify the use of macrosimulations as an assessment tool.

2.1 Labour market inequalities and institutions in Italy

The rise in labour market inequalities has been particularly acute in Italy in the last thirty years. The Gini index for labour incomes rose from 0,366 to 0,447 for 1990-2017 (Bavaro, 2022), and income inequality has increased especially after the Great Recession (Guzzardi et al, 2022). This responds to rising income shares at the top, mainly coming from capital income, and a reduction in real income for the employed and self-employed, especially for women, the young, and those in the lower half of the income distribution. On the other hand, Italy is the only OECD country where average real wages fell for the period 1990-2020, falling by 2.9% compared to a 33.1% increase for the OECD average. Further, the average in-work poverty rate increased from 10,3% in 2006 to 13,2% in 2017, while low-pay risk rose from 16,9% to 20,9% in the same period (Garnero et al, 2021).

Regarding gender-based inequalities, low-pay risk was 16,5% for men and 27,8% for women in 2017 according to Garnero et al (2021), while the estimations by Leythienne and Prez-Julin (2022) show a gender pay gap (GPG) of 10,9% after adjusting for average characteristics across genders in 2018. In turn, Guzzardi et al (2022) find that women in the bottom half of the distribution earn 35% less than men, a gap that falls to 8% for the middle 40%, and rises again in top-income groups, suggesting both a "sticky floor" and a "glass ceiling" for women in Italy.[1]

Labour market institutions have been decisive for these trends of rising labour market inequalities. Flexibilization reforms—the so called *Legge Treu* in 1997 and *Legge Biagi* in 2003—promoted the expansion of fixed-term jobs, part-time contracts, temporary employment agencies, and other atypical forms of work. These contracts are strongly associated with increased inequality and working poverty rates (Ballarino et al, 2014; Clementi and Giammatteo, 2014; Tomelleri, 2021; Garnero et al, 2021). For example, Garnero et al (2021) show that in-work poverty rates and low-pay risk are consistently higher for self-employed workers, part-time workers and for those working less months a year. Clementi and Giammatteo (2014) document the association between the expansion of atypical work and the increase in inequality. Giangregorio and Fana (2023) found that temporary and part-time contracts, by lowering wages at the bottom of the distribution, are the main drivers of wage inequality.

Wage setting has played an important role too, as labour relations in Italy are governed by national collective bargaining agreements between trade unions and employers' organizations that set wages at the sectoral level (Garnero, 2018). This mechanism increases wage heterogeneity across sectors and thus amplifies inequality (Devicienti et al, 2019). Evidence shows that decentralized wage-setting, in contrast with more centralized and coordinated systems, is associated with higher working-age poverty rates in developed countries (Pineda-Hernández et al, 2022). Giangregorio and Fana (2023) found that a large part of wage dispersion in Italy responds to differences in the wage scales bargained in sectoral collective agreements. Garnero et al (2021) documented a high heterogeneity of in-work poverty rates and low-pay risk across sectors of economic activity, while Briskar et al (2023) showed that 99% of the wage dispersion increase in the period 1985-2018 is explained by 3% of productive sectors, especially low-pay sectors that have also increased their employment share. These findings evidence the inequality-enhancing effect of the Italian wage-setting institutions.

The current collective bargaining system is also unable to prevent low pay work. This can be observed in a assessment report by ISTAT (2023) of the different minimum wage proposals in recent years. It is shown that, in 2019, for 18,2% of labour contracts the hourly wage was below 9 euros, and for 30,6% it was below 10 euros—the two levels for the minimum wage in the different proposals—and these contracts were concentrated in specific sectors.[2]. Further, a major problem of the system is the existence of *pirate agreements*, that is, agreements negotiated between non-representative organizations of employers and employees. Labour contracts in such agreements convey significant wage penalties of up to 8% (Lucifora and Vigani, 2021), and thus promote a race-to-the-bottom competition to reduce wages.

Nevertheless, for some unions and employers' associations in Italy, the primary argument against a minimum wage is its potential to undermine collective bargaining. In a report used by the government to block the minimum wage proposal, the CNEL (2023) argued that collective agreements

[1] Piazzalunga and Di Tommaso (2019) show that the gender wage gap has increased during the 2008-2012 crisis in Italy.

[2] The sectors are: hotels and restaurants; arts, sports and entertainment; rentals, travel agencies, and businesses support activities; and other services, mainly domestic labour. Such data correspond to non-agricultural work, but also agriculture exhibits very low wages. These sectors also concentrate the largest shares of vulnerable workers (ISTAT, 2023).

make a statutory minimum wage unnecessary. This because of the high rates of coverage of collective agreements (above 90%), the low percentage of pirate agreements, and because negotiated wage floors are above the 60% of median gross wages recommended by the European Commission (2022). However, Kozák et al (2024) find evidence that statutory minimum wages do not crowd-out unionization nor weaken collective bargaining, not even among vulnerable workers. On the other hand, Müller and Schulten (2020) contend that the 60% of the median wage is not necessarily an adequate wage in terms of standards of living. Moreover, although coverage rates of collective agreements may appear high, more than a half of workers in 2023 were working under expired agreements. In this context, a statutory minimum wage cannot replace collective bargaining, since the latter guarantees a wide range of rights for workers, but it can be complementary, by setting a floor for wages for all workers across sectors. Indeed, the main justifications for the introduction of the minimum wage are the growing vulnerability of workers, the phenomena of working poverty and precariousness, and the shortcomings of sectoral collective bargaining to guarantee a sufficient and adequate pay to Italian workers (ISTAT, 2023; Garnero et al, 2021).

On the other hand, another main driver of inequality in Italy is the concentration of income at the top of the distribution (Clementi and Giammatteo, 2014; Alvaredo and Pisano, 2010). In the last decades, income concentration among high-earners has increased in Italy, a process especially acute in the richest regions of the country (Guzzardi and Morelli, ????). With regards to wage inequality, Passaretta and Triventi (2023) find that the gender gap at the top is significantly higher than for the whole distribution, while Cetrulo et al (2023) show that wage dispersion among professional categories is the leading driver of wage inequality, in particular due to the rising compensation of managers and executives, as they find a generalized wage compression "except for the very top percentile" (p. 99). This evidence implies that, in addition to policies that reduce working poverty and improve the conditions of low-paid workers, addressing inequality requires other measures to contain income concentration at the top. Therefore, a cap on high wages may be another policy to consider against labour market inequalities.

2.2 Empirical evidence

Econometric studies across the developed world tend to find that minimum wages have small or no effects on employment. Dube (2019) provides a complete and comprehensive review of the empirical literature, mainly for the United States, which is the most studied case, but also considering the United Kingdom, Germany and Hungary. After adjusting wage indicators for comparability across studies, considering a structural change in employment differences across states, and correcting for publication bias, he shows that the estimated employment effects of minimum wages are on average zero.

Recent literature for some European countries found mixed results regarding the employment effects of minimum wages. Arranz et al (2019) found that the 2019 minimum wage increase in Spain had no effect on employment, whereas Gorjón et al (2022) reported evidence of negative impacts on employment and on working intensity. In Germany, the introduction in 2015 of a national minimum wage had small negative effects on employment and working hours according to Caliendo et al (2019), while Popp (2023) finds that employment effects differ along labour market structures, partly consistent with the competition-monopsony framework. For Greece, the 2012 reduction in the minimum wage for young workers increased employment more for adults than for the young, and for the latter it was found to even reduce employment in some cases (Georgiadis et al, 2020). However, Karamanis et al (2018) found no relation between minimum wage changes and employment levels

for Greece between 2000 and 2017. In turn, the 2013 minimum wage increase in Lithuania was found to have a stronger effect in rising wages than in reducing employment (Garcia-Louzao and Tarasonis, 2022). For Denmark, Kreiner et al (2020) exploit a discontinuity in wage setting for the young, finding negative employment effects.

Some panel-data studies for European countries found evidence of negative employment effects. Paun et al (2021) use a panel of 22 countries from 1999 to 2016 and show that the negative employment effects are stronger for vulnerable categories, while Christl et al (2018), in a panel of 12 countries from 1980 to 2011 find, for young workers, negative effects in some countries and positive in others, mainly Eastern European countries.

Unlike employment effects, the impact of minimum wages in reducing inequality is consistently observed across the literature. There is evidence that unions and minimum wages contribute strongly to reduce wage discrepancies in European countries (Lucifora et al, 2005), and an inequality-reducing effect of minimum wages has been found particularly in Greece, Hungary and Poland (Pereira and Galego, 2019) and Central and Eastern European countries (Davidescu et al, 2022).

For specific countries, minimum wages were found to reduce inequality as well: in the US across male workers (Engelhardt and Purcell, 2021), in Germany for hourly wages (Biewen et al, 2022) and regional wage disparities (Bossler and Schank, 2023), and in Brazil for monthly earnings (Engbom and Moser, 2022). As for working poverty and low-wage earnings, the minimum wage was found to reduce low-pay work in the UK (Gooch and Dromey, 2020), and to increase hourly wages for low-pay workers in Germany (Caliendo et al, 2022). From a different perspective, Grünberger et al (2022) use a microsimulation model for the European Union that incorporates the tax-benefits structures of different countries, and show that "minimum wage increases can significantly reduce in -work poverty, wage inequality and the gender pay gap while generally improving the public budget balance" (p. 3).

Minimum wages have been found to reduce the gender pay gap in Ireland—although not in the UK, because of gendered non-compliance—(Bargain et al, 2018), the US (Storrie et al, 2022), and Germany (Schmid, 2022). Although the impact of minimum wages on general wellbeing is less studied, there is evidence of a positive effect on health, happiness and wellbeing in European countries (Lebihan, 2023).

In Italy, sectoral collective bargaining is another major element to consider when discussing the minimum wage. As pointed out in section 2.1, several studies suggest that collective bargaining may amplify inequalities across sectors (Devicienti et al, 2019; Giangregorio and Fana, 2023; Garnero et al, 2021; Briskar et al, 2023). In this respect, some studies have contrasted collective bargaining with statutory minimum wages. For a group of 18 European countries between 2007 and 2009, Garnero et al (2014) found that collective bargaining systems with high coverage rates and sectoral wage floors are equivalent with statutory minimum wages, in terms of wage inequality and non-compliance rates. On the contrary, in a study for 30 countries from 2004 to 2019, Haapanala et al (2023) found important differences. They show that, given high coverage rates of collective bargaining, countries with a statutory minimum wage exhibit lower shares of workers earning below 60% of median wages than countries without a minimum wage. Therefore, the convenience of statutory minimum wage *vis a vis* collective bargaining seem to be an open question.

The empirical literature thus finds mixed evidence regarding the employment effects of minimum wages, while their impacts on inequality reduction, the increase in incomes of low-pay workers, and the narrowing of the gender pay gap are consistently observed for different methods and countries. On the other hand, there is no consensus regarding the convenience or not of collective bargaining

over minimum wages, an issue of great importance for the current debate in Italy. Given the extent of inequality and working poverty in Italy, which are linked with the current system of sectoral collective bargaining, introducing a statutory minimum wage could significantly help to reduce labour market disparities.

Concerning maximum wages, a few governmental proposals have been advanced in history[3], but without gaining political support. Moreover, there have been some cases of income caps policies directed at specific groups of workers or occupations: professional sports players, state and public banking employees, or executives of some firms (Cigna, 2019; François et al, 2023; Buch-Hansen and Koch, 2019). Given that no general maximum wage policy has been implemented whatsoever, no relevant empirical literature exists on the matter. As a consequence, to prepare our model simulation, we will refer to theories of maximum wage policies that are discussed at the end of the next subsection.

2.3 Theoretical debates on minimum and maximum wages

The benchmark tool to analyze wage-setting policies is the neoclassical general equilibrium model. It predicts that factor prices equal their respective marginal products, which results in the full employment of all factors. In this context, whenever the price of a factor exceeds its marginal product there will be an excess supply, since the cost of hiring an additional unit will be higher than the revenue that can be derived from it. This leads to the standard conclusion that a minimum wage above the competitive equilibrium wage level creates involuntary unemployment.

The lack of evidence for such outcomes (Dube, 2019) led to the development of imperfect labour market competition models, comprising market power, segmentation, search frictions and other imperfections (Manning, 2011). Monopsonistic firms in the labour market and efficiency wages became the preferred analytical tools in this respect. In the first case, an employer faces a constrained labour supply and pay wages below the marginal cost of labour, so a minimum wage might help to attract and retain workers without increasing marginal costs (Ashenfelter et al, 2010; Schütz, 2021). In the second case, higher wages stimulate effort and labour productivity, so a minimum wage might be profitable even if it increases marginal costs (Manning, 2011; Schütz, 2021). Labour market frictions in the context of searching and matching models imply that "some increases in the minimum wage can reduce vacancies and turnover instead of destroying jobs" (Dube, 2019, p. 20), so these models align better with the empirical evidence against the unemployment effects of minimum wages.

Minimum wages can have other effects, the so-called "non-employment margins" through which firms can adjust the higher labour costs without necessarily destroying jobs (Clemens, 2021). Two of these mechanisms, in particular those linked with technical change, have a direct impact on labour market inequalities (Naguib, 2022): the substitution of low-skilled workers with high-skilled workers—given that the former are costier but less productive under a minimum wage—and technical change that increases capital intensity and/or destroys low-productivity jobs. Both mechanisms can amplify earnings disparities, the former across skill and education levels, the latter also between workers and capitalists in general. Other relatively less explored margins of adjustment include rising output prices, lowering profits, rising productivity, reducing hours worked for low-wage workers, adjusting working conditions and other non-pecuniary job attributes, increasing turnover, or even non-complying with minimum wage rules (Clemens, 2021; Neumark et al, 2004; Hirsch et al, 2015).

[3]It was proposed for the US by Hue Long in 1929 and by F.D. Roosevelt in 1942, and in 2013 for Switzerland. The US proposals were, respectively, an annual income cap of $1 million and a 100% marginal tax rate on incomes above $25.000. The Swiss proposal was a 12:1 maximum-to-minimum wage ratio, which was rejected in a referendum (Cigna, 2019).

Although searching and matching models increased the versatility of labour economics, they have some limitations. On the one hand, these models evolved to explain the findings of the empirical literature, generally based on causal identification techniques (Dube, 2019). Such empirical frameworks focus on very specific settings and rule out by design any emergent properties or system dynamics effects—also known as general equilibrium effects. Ultimately, searching and matching are still partial equilibrium models, which makes them inherently incomplete and non-generalizable. On the other hand, the use of neoclassical general equilibrium models is not necessarily a better option, since they rely on the implausible assumption of a downward sloping demand for labour (Petri, 2019) and are not well equipped to capture some of the most relevant system dynamics effects of wage policies.

These effects are related to two main processes. First, labour-displacing technical change, which may be unleashed by the higher labour costs coming from the minimum wage (Autor and Salomons, 2018), and second, the aggregate demand effects coming from higher labour incomes, but also from the new investments related to technical change. However, these effects can be widely complex. Technical progress induced by higher wages might boost growth and employment as firms adjust their capacity to meet increasing demand, but these effects depend on the distribution of income between labour and capital, and on the relative tightness of the labour market (Tavani and Zamparelli, 2017). Aggregate demand effects, in turn, imply that minimum wages—by rising labour incomes and lowering inequality—can have positive impacts on both output and employment, while providing stability for labour markets and hence for the whole economy (Herr, 2023). These macroeconomic mechanisms, when combined with the multiple adjustment margins at the micro level, may lead to several different outcomes, which are specific for each economy and cannot be easily discernible through pure abstract and partial theoretical modelling.

With regards to maximum wages the theoretical literature is relatively scarce, but it is gaining traction in the fight against rising inequality. Indeed, reducing inequality is often portrayed as the main reason to enact maximum wages (Ramsay, 2005; Pizzigati, 2018), given the leading role of high-incomes concentration in rising inequality worldwide (Piketty and Saez, 2006; Lemieux, 2007). In a theoretical model of optimal taxation, Blumkin et al (2013) show that a maximum wage ensures a Pareto improvement of the tax-and-transfers system. As it reduces the mimicking incentive of high-skill workers, a cap on wages allows the government to reduce the marginal tax rate on low-skill workers, while firms' extra-profits can be taxed and redistributed progressively. However, the literature on maximum wages is largely rooted in multidisciplinary studies, and it is becoming more prominent in the context of degrowth and post-growth debates (François et al, 2023; Buch-Hansen and Koch, 2019). Income caps are defended for a variety of reasons in addition to reducing inequality: as a moral response to economic unfairness, an instrument to strengthen democracy and social cohesion, an essential element of social corporate responsibility, or a tool to address the ecological crisis through lower conspicuous consumption (Buch-Hansen and Koch, 2019; Ramsay, 2005; Sovacool, 2022).

François et al (2023) analyze the historical proposals and ten further academic designs of income caps, to derive some insights for policy-making and feasibility, given that public support is one of the main obstacles for enacting a maximum wage (Buch-Hansen and Koch, 2019). They identify 7 key parameters that an income cap proposal should consider carefully: motivation, scope, level of proposed caps, target groups, implementation instruments, purpose of raised funds, and integration with broader measures. For the simulations of this paper, we focus on some of these parameters,

specifically: the motivation, which is to reduce inequality from the high end of the income distribution; the target group, which consists of high-skill workers; the integration of the policy with the minimum wage; and the level of the proposed cap, which is determined by its potential to reduce inequality, as will be explained in subsection 3.5.

Possible implications about the political viability of such a measure and possible drawbacks are out of the scope of this paper. We also do not consider a possible caveat derived from the possibility that the maximum wage could provoke emigration of top earners(Buch-Hansen and Koch, 2019). However, our approach is in line with the methodology deployed in the climate change literature, where scenario analysis through macrosimulation models is used as a tool for imagining and exploring alternative future pathways (Van Beek et al, 2020). In light of the previous discussion, a maximum wage policy should be considered when imagining pathways towards more equal societies. At the end of the paper we briefly take into consideration for our argument the possible caveats and limitations of the maximum wage policy.

3 Methodology

As illustrated in the literature review, the minimum wage can have complex economic and social impacts, working through several second-order and systemic effects, along with emerging properties at the macro level (Schütz, 2021). The interaction between these phenomena – that include technical change and aggregate demand dynamics, and the presence of multiple adjustment mechanisms through prices, profits and productivity – requires a comprehensive analysis capable of embracing the various causal loops to account for complex dynamics. On the other hand, the maximum wage appears under-investigated both in the empirical and the theoretical literature, despite its potential for reducing inequality in the labour market and in the whole economy. We set our simulation approach to fill these literature gaps and provide, within an IAM framework, an assessment of the impacts of the two wage policy measures on inequality indexes. In this section, we first introduce the main features of the Eurogreen model, with a specific focus on its labour market module. Then, we present the policies and scenarios that are taken into consideration in our macro-simulation exercise.

3.1 Eurogreen model

We rely on the Eurogreen model to simulate the impact of minimum and maximum wage policies on the Italian labour market. Eurogreen is a dynamic simulation model based on a combination of system dynamics, post-Keynesian macroeconomics, and input output analysis (DAlessandro et al (2020); Cieplinski et al (2021)). The model encompasses a realistic representation of the Italian economy that takes into account numerous feedback effects among the macroeconomy, labour market, income distribution, technical progress, energy use, and environment. Employing this framework, we can evaluate how different policy-scenarios affect a range of indicators, such as Gross Domestic Product, unemployment rate, labour share, gender wage gap, public debt-to-GDP ratio, emissions, and energy product consumption. To analyze the effects of labour market policies, we have additionally formulated indicators such as the Gini coefficient of wages and the Theil index of wages.[4]

In line with post-Keynesian economics, output level and growth are driven by demand (Lavoie, 2022), which is composed of private consumption, gross fixed capital formation, government spending, and exports. Households' consumption depends on both an income-dependent marginal propensity to consume and expected disposable income. Savings accumulate in household wealth in

[4]For a detail exposition of Eurogreen, the reader can also refer to Campigotto et al. (2021) and Cieplinski et al (2021).

a stock-flow consistent manner (Godley and Lavoie, 2006).[5] The disposable income of households depends on market incomes, unemployment benefits and other social security contributions, income and other taxes. Market incomes comprise wages and financial incomes (i.e. interests on government bonds and dividends on equity). Firms make their investment plans on the basis of the difference between the actual and the normal rate of capacity utilization, following the capital stock adjustment principle (Freitas, 2023). However, firms ability to expand capacity is financially constrained. The level of profits after debt repayment and taxes and an exogenous leverage ratio determine the maximum investment firms can finance. Government spending depends on endogenous values for transfers related to social policies and pensions, as well as on an exogenous growth rate that projects the long-term trend in the data. Nevertheless, government spending is constrained by an upper limit on the deficit-to-GDP ratio, which reflects current fiscal policy rules. Exports depend on an exogenous growth rate that projects the long-term trend in the data, which is assumed to reflect the (not modeled) growth of external demand. Exports also vary according to the effect of inflation, given the price-elasticity of demand for exports. Finally, imports are determined using sector-specific for import share coefficients in intermediate inputs and final demand. These coefficients are based on data from the initial period and are assumed to remain constant thereafter.

Total output is obtained by multiplying domestic final demand by the Leontief inverse matrix, which is composed of 19 industries following the NACE classification (revision 2).[6] In each industry, firms set prices by charging a mark-up over unit production costs, which are given by the sum of unit labour costs, unit costs of intermediate inputs, unit costs of fixed capital, and indirect taxes.

Unlike most of the models found in the literature, Eurogreen does not assume a constant matrix of intermediate inputs. In fact, the model includes a specific "Technological Innovation" module which introduces endogenous changes in production techniques, by updating the input-output technical coefficients and labour productivity in each industry. Innovation follows a random process. However, the probability that an innovation affects either the input-output technical coefficients, or labour productivity, or both, depends on the evolution of relative costs of intermediate inputs and labour (see Villani et al (2023), p. 10-11, for an extensive presentation of innovation in Eurogreen). In other words, if unit labour costs increase faster than the unit costs of intermediate inputs in a certain industry, then firms become more likely to discover innovations that save labour inputs rather than intermediate inputs. In a final step, firms compare available technologies and choose and implement the cost-minimizing alternative. The random component in the "Technical change" module undergoes a sensitivity analysis, producing a range of results through repeated simulations with varying seeds for the random component.

After this concise introduction to Eurogreen, we can focus on the model developments proposed in this paper to explore the analysis of the labour market and wage inequality.

3.2 The Labour Market module

The main elements and mechanisms that govern labour market and wage dynamics in Eurogreen are depicted in figure 1. Solid lines denote contemporaneous direct effects, while dashed lines denote feedback effects, working mainly through lagged variables and adaptive expectations.

[5] Consumption may be partially financed out of wealth. Since consumption depends on *expected* disposable income, it may be greater than the *effective* level of disposable income, and this difference is adjusted through changes in the wealth stock.

[6] The 19 sectors in the model consider the following NACE groups: A (agriculture), B (mining), C (manufaturing), C19 (petroleum refining), D (electricity, gas and heat), E (water), F (construction), G (trade), H (transport), I (accommodation and food service), J (information and communications), K (finance), L (real estate), M+N (professional services) O (public administration and defence), P (education), Q (health), R (entertainment) and S+T+U (other services).

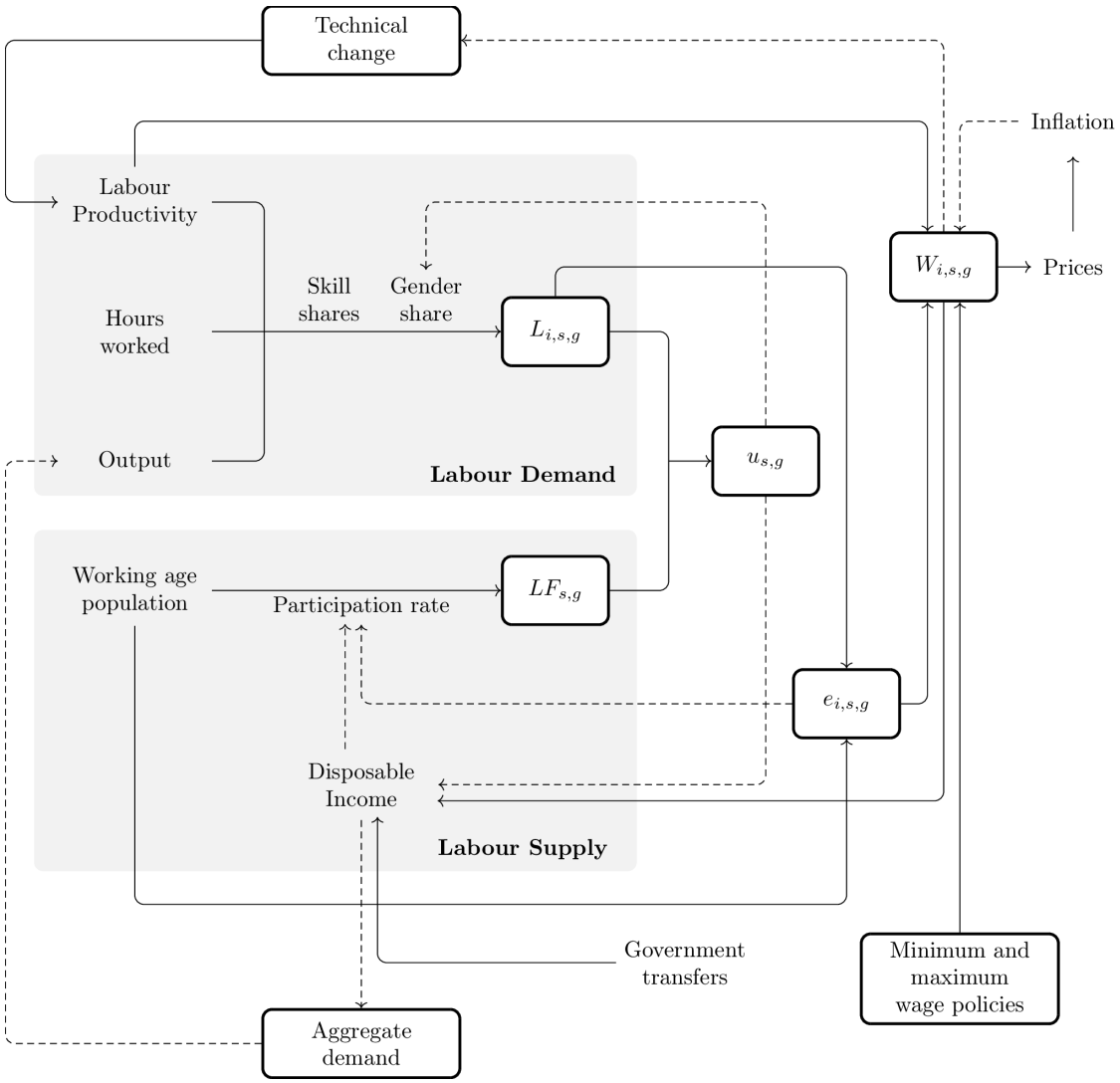


Figure 1: Labour Market module of the Eurogreen model

Note: Solid lines denote contemporaneous effects and dashed lines denoted feedback effects through lagged variables. Variables L, LF, W, u and e refer respectively to labour demand, labour supply, wages, unemployment rate and employment rate. Subindices i, s and g denote respectively industry, skill and gender.

In Eurogreen, adult population is differentiated across gender (male and female, subscript g), skill level (low, mid and high, subscript s) and occupational category (employed, unemployed, out of labour force and retired). The employed population is further split into the 19 industries (subscript i), so that we have 114 employee groups (2 genders $\times$ 3 skills $\times$ 19 industries). Labour market variables and wages are differentiated across these groups, which introduces a high degree of heterogeneity to analyze inequality.

The level of employment is jointly determined by a Keynesian effective demand mechanism and labour productivity. Lagged aggregate demand— representing demand expectations by firms— determines the desired level of output, and the endogenous process of technical change determines labour productivity, per each industry of the economy. Using data on the number of annually hours worked,[7] these variables determine labour demand per industry (L_i). Labour demand is further allocated across skills and genders ($L_{i,s,g}$), where skill shares evolve according to exogenous observed trends, while the male share of employment responds positively to the relative tightness of the male labour market with respect to the female one.

In turn, the decision to participate in the labour market determines labour supply ($LF_{s,g}$), using exogenous data to model population dynamics. Each period, working age individuals (comprising the employed, unemployed, and those outside of the labour force) make their participation decision based on the expected disposable income, considering three outcomes: not participating, participating and finding a job, or participating and being unemployed. For this, they take into consideration the different income sources—wages, unemployment benefits, other government transfers, and financial income—and weight them with the relevant probabilities, which are functions of the employment and unemployment rates ($e_{i,s,g}$ and $u_{s,g}$).

Wages are differentiated across industry, skill and gender ($W_{i,s,g}$), and their dynamics, in turn, are determined by three key variables. First, labour productivity, since some fraction of productivity gains are captured by workers; second, gender- and skill-specific employment rates, which captures the bargaining power of workers; and third, the rate of inflation, so that the model includes conflict inflation mechanisms. The parameters measuring the effects of these variables are calibrated to match observed data.

Therefore, in Eurogreen wages reflect the distributive conflict, with workers claiming a higher participation in productivity gains and increases in real wages, and firms trying to preserve their profitability. These effects occur at the industry and macroeconomic level, and include three main feedback channels. First, rising unit labour costs increase the probability of labour-saving technical change, which might lead to higher productivity that, in turn, puts a further upward pressure on wages. Second, rising wages increase unit labour costs leading firms to raise prices, and the resulting higher inflation also puts an upward pressure on wages. And third, higher wages increase disposable income, which on the one hand stimulates labour force participation and, on the other hand, boosts aggregate demand and employment. The resulting balance between these forces might increase or decrease employment rates, which will then affect wages through the bargaining power of workers.

All these effects provide a complete macroeconomic depiction of the functioning of employment and wages from a system dynamics perspective. With respect to partial equilibrium models, this method is better suited to analyze the effects of the introduction of minimum and maximum wage policies on inequality, while controlling for economic factors that interact with the labour market, such as aggregate demand and productivity. After describing the data used in the model, the implementation of such policies is explained in section 3.4.

3.3 Data

Eurogreen is calibrated to match National Accounts data coming mainly from Eurostat and Istat. Initial values for most variables are taken from Eurostat, the input-output structure is taken from WIOD, and sectoral employment and productivity data is taken from EU-KLEMS. Wages were

[7] By taking hours worked as an exogenous, we are not considering one possible adjustment mechanism to minimum wages (Neumark et al, 2004).

calibrated using cross-sectional micro-data from the EU-SILC survey for Italy in 2010 (the base year of the model).[8] This allows us to capture the labour market heterogeneity with precision and to simulate wage policies.

We computed the hourly wage using data on employee cash and non-cash income and hours worked per week for each of the 114 employee groups. EU-SILC provides information on workers varying according to gender, industry of activity, and the educational level. To introduce these data in the model, we established a relationship between the skill level in the model and the educational level coming from EU-SILC data. Employees who attained up to lower secondary education are classified as low-skilled; employees with upper secondary or post-secondary education are defined as middle-skilled; and employees with tertiary education are classified as high-skilled. On the other hand, EU-SILC classifies workers according to the NACE activities, so we can establish a clear-cut correspondence with the employee groups in the model.[9]

Therefore, for each employee group, we set the initial hourly wage level equal to the mean of the wage distribution for the same group coming from EU-SILC data. As is discussed below in section 3.4, we use data on wage distributions to simulate the policy interventions, by estimating the impact of a minimum and a maximum wage on the mean wage of each of the 114 employee groups.

After the initial period (2010), the wage level becomes endogenous to the simulation model, following the mechanisms of the labour market module explained above.

3.4 Labour Market Policies

In Eurogreen's initial period, each occupied worker is assumed to earn the average wage of the respective employee group in the EU-SILC survey. To introduce a minimum and a maximum wage policy into the model, we simulate the effects of these policies on the average wage of each employee group using the survey's microdata. For each employee group, we compute the standardized wage changes resulting from the policies. This process is repeated for various minimum and maximum wage values, producing a range of wage change outcomes for each policy. Finally, we implement the policies in the model by applying the corresponding wage changes to the average wage level of each employee group. Standardizing wage changes makes the policies compatible with the model, as wages evolve endogenously in the simulations and therefore differ from the survey data. Note that the average changes in each group's wage are based on microdata for the survey for 2010. We are thus assuming that the wage distribution within each group remains stable during the period. Since Italy has experienced rising wage inequality in the last decade (Giangregorio and Fana, 2023; Bavaro, 2022), our results can be regarded as a lower bound for the inequality effects of wage policies.

The detailed procedure for simulating the effects of policies is explained in the following paragraphs.

First, we classify individuals in the microdata of EU-SILC according to the 114 employee groups in Eurogreen, defined by the industry of activity i, skill level s, and gender g. We then compute the mean ($\bar{w}_{i,s,g}$) and the standard deviation ($\sigma_{i,s,g}$) for wages of each employee group (i, s, g). From these information, we are able to compute the coefficient of wage dispersion ($\phi_{i,s,g}$) for each group, using the equation below:

[8] This represents an improvement with respect to the former version of Eurogreen (Cieplinski et al, 2021), in which wages were calibrated using data from Eurostat, without a detailed microstructure.

[9] EU-SILC groups some NACE activities into one: B to E, L to N, and R to U. Accordingly, we assign the same wage levels to workers in the categories of these aggregate groupings.

$$\phi_{i,s,g} = \frac{\bar{w}_{i,s,g}}{\sigma_{i,s,g}} \tag{1}$$

Second, let $w^P = w^{min}, w^{max}$ denote a certain minimum or maximum wage set by policy. We compute the standardized change in the mean wage of each employee group gsi in the survey, by setting up either w^{min} as floor or w^{max} as a ceiling for the wage distribution. In other words, for the minimum wage policy, we impose that all workers of each group with a wage smaller than the minimum $w < w^{min}$ will have their wages increased until w^{min}. Likewise, for the maximum wage policy, we assume that all workers earning more than the ceiling ($w > w^{max}$) will have their wages reduced until the maximum wage w^{max}. We then compute the new mean wage after the policy $\bar{w}^P_{i,s,g}$. After that, we compute the standardized difference between the mean wage after the policy and the mean wage before the policy ($sdd(\Delta\bar{w}^P_{i,s,g})$) for each employee group, as in equation 2. Clearly, the difference between the post and pre-policy means depends on the fraction of employees affected by the policies within each group in the microdata.

$$sdd(\Delta\bar{w}^P_{i,s,g}) = \phi_{i,s,g}\frac{\bar{w}^P_{i,s,g} - \bar{w}_{i,s,g}}{\bar{w}_{i,s,g}} \tag{2}$$

Third, in a similar way, we calculate the standardized difference between the policy wage (w^P) and the pre-policy mean wage ($\bar{w}_{i,s,g}$) for each group, as in equation 3.

$$sdd(\Delta w^P_{i,s,g}) = \phi_{i,s,g}\frac{w^P - \bar{w}_{i,s,g}}{\bar{w}_{i,s,g}} \tag{3}$$

All these steps are done using the EU-SILC micro-data. We iteratively repeat the three steps for several values of the policy wage. Hence, for each value of the minimum wage w^{min} simulated in the micro-data we have a correspondence between $sdd(\Delta\bar{w}^{min}_{i,s,g})$ and $sdd(\Delta w^{min}_{i,s,g})$, and the same holds for the maximum wage. This correspondence expresses by how much the mean wage changes after a given policy wage, whose value is expressed in relation to the pre-policy wage. Based on this results, we build the function $sdd(\Delta\bar{w}^P_{i,s,g}) = f^P\left(sdd(\Delta w^P_{i,s,g})\right)$, for $P = min, max$, relating the standardized response of mean wages to standardized values for the policy wage, for each group.[10]

In the fourth step, we introduce the correspondence function in the macrosimulation model. We define the value for the minimum or maximum wage W^P to be implemented in the model. Then, we compute the difference of W^P with respect to pre-policy (i.e., current) wages for each employee group. This operation follows equation 4. We use capital letters to denote the variables in the model.

$$\Delta W^P_{i,s,g,t} = \phi_{i,s,g}\frac{W^P - W_{i,s,g,t-1}}{W_{i,s,g,t-1}} \tag{4}$$

We use this value as an input to the correspondence function, thus computing the wage change of each employee group as:[11]

$$\Delta\bar{W}^P_{i,s,g,t} = f^P(\Delta W^P_{i,s,g,t}) \tag{5}$$

Finally, the wage level after the policy is:

[10] Since the two variables exhibit a monotonic relationship, we perform a linear interpolation to obtain a continuous function relating $sdd(\bar{w}^{min}_{i,s,g})$ and $sdd(w^{min}_{i,s,g})$.

[11] Naturally, the minimum wage policy raises the average wage, while the maximum wage policy lowers the average wage paid to each employee group. It follows that $\Delta\bar{W}^{min}_{i,s,g,t}$ assumes positive values, while $\Delta\bar{W}^{max}_{i,s,g,t}$ assumes negative values.

$$W_{gsi,t} = W_{i,s,g,t-1} \cdot \left(1 + \Delta\bar{W}^{max}_{i,s,g,t} + \Delta\bar{W}^{min}_{i,s,g,t} + \omega(\dot{\lambda}_{i,t}, \pi_t, \dot{e}_{i,s,g,t})\right) \quad (6)$$

Where ω denotes the function by which wages respond to overall price inflation π and the rates of growth of skill- and industry-specific productivity $\dot{\lambda}_{si}$ and group-specific employment rate $\dot{e}_{gsi}$ as described above. Here we simulate wage policies as a one-time shock at a certain period (2023) that permanently changes the level of wages, which evolve endogenously according to the function ω afterwards. Therefore, $\Delta\bar{W}^{max}_{gsi,t} = \Delta\bar{W}^{min}_{gsi,t} = 0$ if $t \neq 2023$.

3.5 Scenario Selection

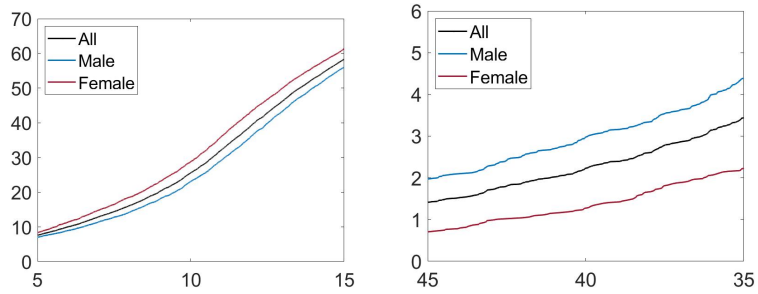
We analyse scenarios emerging from our model. Scenarios describe alternative pathways following from the modelling under a combination of plausible hypotheses (Nieto et al, 2020). Scenario analysis allow us to compare the potential outcomes of diverse policy options in a context of high uncertainty. We firstly define a Baseline scenario representing current trends in Italian economy and labour market, in the absence of policy interventions. Subsequently we define the scenarios by introducing a policy change with respect to the Baseline, while structural parameters remain the same.

In our analysis, the policy scenarios will show the effects of introducing a minimum and a maximum wage. However, we have not yet determined specific values for these policies. We thus test the static impact of different values for each wage policy on key indicators. This analysis supports the definition of specific values for minimum and maximum wages, which are then implemented in the macrosimulation model. We consider a range of values that can be broadly deemed feasible and potentially implementable in the real world. Therefore, we simulated a minimum wage varying from 5-15 euros per hour, and computed the immediate effect on each indicator. In the case of the maximum wage policy, we considered the range of 35-45 euros per hour.

The first indicator we consider is the number of workers impacted by the policy at different wage levels, based on microdata from the EU-SILC survey. We examine how many workers fall below different potential minimum wage levels (Figure 2a) and how many workers fall above various potential maximum wage levels (Figure 2b). The introduction of a minimum wage policy in Italy reveals significant variation in the share of workers affected. This share ranges from 7.6% at a minimum wage of 5 euros per hour to 58.3% at a minimum wage of 15 euros per hour. A minimum wage set to 10 euros per hour will impact a substantial portion of Italian workers (25.6%) without causing the potential disruptive effects on the labour market associated with higher thresholds. Figure 2a also highlights the disparity in the incidence of low wages between male and female workers: a 10 euros per hour minimum wage will affect 28.8% of female workers compared to 23.2% of male workers. As shown in Figure 2b, the share of workers impacted by a maximum wage policy is comparatively lower, varying from 1.4% at 45 to 3.4% at 35 euros per hour. However, the introduction of a maximum wage will have a more pronounced differential impact on male and female workers, with male workers being more than twice as likely to be affected: a maximum wage of 40 € will impact 3.0% of male workers versus only 1.3% of female workers.

Next, we analyze the static impact of the policy wages on the average wage and selected inequality indicators.

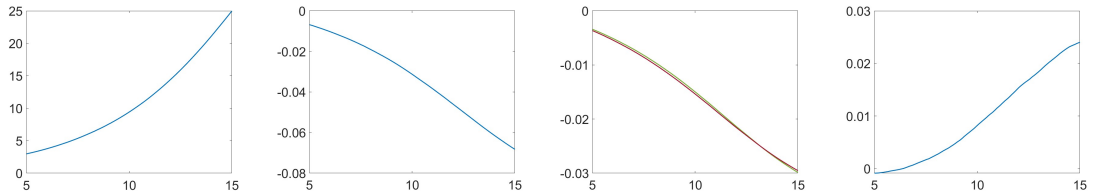
Figure 3 shows how the average wage (3a), the Gini coefficient of labour income (3b), Theil L and Theil T of labour income (3c), and the Gender wage ratio (3d) vary according to different values



(a) Minimum Wage (b) Maximum Wage

Figure 2: Share of workers impacted by wage policies

Note: Percentage of workers impacted by the implementation of a Minimum Wage policy (range 5-15 euros) and a Maximum Wage policy (range 35-45 euros).The black line shows the percentage of workers impacted by the wage policies. The blue (red) line shows the percentage of male (female) workers affected by the wage policies.



(a) Average Wage (%) (b) Gini coefficient (c) Theil L and T (d) Gender wage ratio

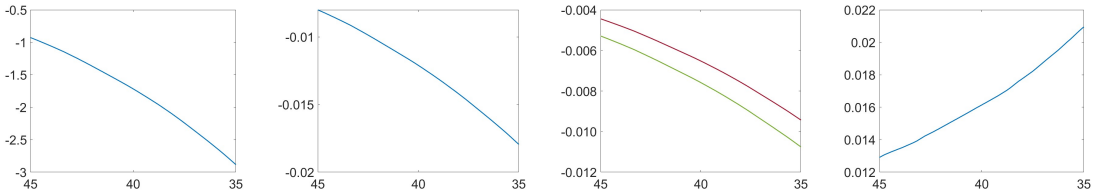
Figure 3: Effect of Minimum Wage (horizontal axis) on Selected Indicators

Note: Effect of different values of the minimum wage (range 5-15) on selected indicators, in the period of the introduction of the policy. Average wage is reported in percentage change with respect to its value before the policy. Gini coefficient, Theil L (red in figure c) and Theil T (green), Gender wage ratio are reported as absolute deviation with respect to their value in the Baseline scenario. Gini, Theil L and Theil T are computed considering labour income only. Gender wage ratio stands for the ratio of average wage of female workers to the average wage of male workers.

of the minimum wage. A low minimum wage of 5 euros per hour is sufficient to increase the average wage by 1.8%. However, this value of the minimum wage has a small effect on inequality, reducing the Gini by less than 1 p.p., and an almost null but negative effect on the Gender wage ratio. In fact, the ratio between the wages of female and male workers reveals the importance of defining a minimum wage near the 10 euros per hour. A minimum wage of 9 euros can improve this ratio by 0.5 p.p., while a minimum wage of 10 euros has an effect of 0.8 p.p., finally a minimum wage of 10.52 euros can lead to an increase in wage ratio by 1 p.p.. An increase in the value of the minimum wage also enhances its effect on the other indicators of figure 3, thus further reducing wage inequality indices (Gini, Theil L and Theil T) and increasing the average wage. A minimum wage of 10 euros

would increase the average wage by 9.4%, reduce the Gini by 3.1 p.p. and reduce the Theil T and L by approximately 1.5 p.p..[12]

The maximum wage policy affects the inequality indicators in the same direction as the minimum wage policy, but, as expected, tends to reduce the average wage. Figure 4 shows how the selected indicators respond to different values of the maximum wage in the range 45-35 euros per hour. For reducing top wages, the maximum wage has a small negative effect on the average wage, which explains its impact on the reduction of wage inequality. A maximum wage of 45 euros per hour reduces the average wage by 0.9% (8a), while it reduces Gini by 0.8 p.p. (4b) and Theil indices by approximately 0.5 p.p.(4c). This maximum wage value is sufficient to generate an improvement in the Gender wage ratio of 1.3 p.p..



(a) Average Wage (%) (b) Gini coefficient (c) Theil L and T (d) Gender wage ratio

Figure 4: Effect of Maximum Wage (horizontal axis) on Selected Indicators

Note: Effect of different values of the maximum wage (range 30-45) on selected indicators, in the period of the introduction of the policy. Average wage, reported in percentage change with respect to its value before the policy. Gini coefficient, Theil L (red in figure c) and Theil T (green), Gender wage ratio are reported as absolute deviation with respect to their value in the Baseline scenario. Gini, Theil L and Theil T are computed considering labour income only. Gender wage ratio stands for the ratio of average wage of female workers to the average wage of male workers.

The comparison between figures 3 and 4 suggests that a minimum wage policy is more effective to reduce labour market inequality than the maximum wage policy. At least, this is what we obtain for the range of values considered to be reasonably close to feasible values for these policies. For instance, a minimum wage below 10 euros reduce the Gini coefficient of wages by a larger extent than a maximum wage of 35 euros. Nevertheless, the maximum wage policy presents a much stronger effect on the Gender wage ratio, which confirms the importance of this policy.

In light of the previous discussion, we choose the middle points of the intervals above as values for the wage policies. That is, 10 euros per hour for the minimum wage and 40 euros per hour for the maximum wage. In the case of the minimum wage, this value is close to the latest legislative proposal (9 euros per hour), while the maximum wage implies a 4:1 maximum-to-minimum wage ratio, far more ambitions than the most widespread proposal of a 10:1 ratio (Pizzigati, 2018; Ramsay, 2005), which would affect a quite small percentage of workers and generate small reductions in inequality as per figures 4 and 2b. These values are thus chosen to generate positive outcomes in terms of reducing inequality and, particularly in the case of the maximum wage, to effectively reduce gender wage disparities. Therefore, the scenarios that we will consider in the simulations are:

[12]Note that the inequality indices in the figure reflect only the changes in the between component due to limitations of the model, as we discuss in section 4.1.

1. **Baseline**: No wage policies.
2. **Minimum Wage**: A minimum wage of 10 euros per hour only.
3. **Maximum Wage**: A maximum wage of 40 euros per hour only.
4. **Min+Max**: Both policies simultaneously

Eurogreen simulations include a random component that reflects the probability of discovery of new technologies and the variability in their impact on efficiency. Consequently, we evaluate scenarios based on the median value derived from 1000 simulations. We also compute a confidence interval for each scenario, based on two median absolute deviations, representing approximately 95% under a normal distribution. All simulations follow the baseline scenario until 2023 when the policy interventions are introduced in each scenario.

4 Results

We report results in two ways. First, we present results for Gini of wages and Theil indices following from the policy intervention simulated inside the sample (subsection 4.1). After that, we report the results when the policies are included in the dynamic macrosimulation framework provided by Eurogreen, considering, therefore, feedback effects of the labour market and other socioeconomic variables (subsection 4.2).

4.1 Microsimulation

Simulations using EU-SILC microdata allow us to identify the static impact of the policy interventions on inequality indices. With this microsimulation, we can decompose the inequality indices into a "between group" component and a "within group" component. The "between group" component represents the variability of wages across different employee groups, and it is calculated by replacing the actual wages of the group with the corresponding group mean. In the microsimulation, we classify individuals in the sample by gender, skill level, and industry to build the groups according to the categories of Eurogreen. The "within group" component captures the inequality arising from wage variability within each employee group, which varies due to factors other than gender, skill level, or industry.

In the Eurogreen model, wages are defined at the group level, so the inequality measures we compute from the model's results refer only to the between component and are an underestimation of inequality. However, it still leads to a good approximation of the trend in labour market inequality following the introduction of the policy measures. The microsimulation allows us to have a measure of such underestimation, and gives us a benchmark to correctly compare the results of the macrosimulations.

We compute the Gini, Theil T, and Theil L indices and their components for each of the four scenarios defined above. Although the Gini index is not perfectly decomposable, it is possible to compute its within and between components. The within component is calculated as the weighted sum of each group's Gini index, with weights equal to the product of the group's wage and population shares. The between component is calculated by replacing the actual wages of the group with the corresponding group mean wage. When the income distributions of the different groups overlap, as it happens in this case, the Gini index contains a residual term, computed as the difference between the Gini index of overall inequality and the sum of its within and between components.

Table 1 shows the Gini index of wages and its decomposition for each scenario. The Gini of wages falls after each policy intervention with respect to the baseline scenario. In fact, all components of the Gini (Between, Within, and Residual) decrease in the policy scenarios with respect to the Baseline. The Minimum Wage policy reduces the Gini of wages in about 0.073 points, while the Maximum wage policy has a weaker effect, reducing it on 0.014 points. As expected, the strongest effect appears when both policy are combined (Scenario Min+Max), in which the Gini of wages is 0.087 points below the Baseline scenario.

Scenario	Gini	Within	Between	Residual
Baseline	0.31183	0.00695	0.16831	0.13657
Minimum Wage	0.23866	0.00520	0.13691	0.09655
Maximum Wage	0.29765	0.00683	0.15931	0.13151
Min+Max	0.22396	0.00505	0.12730	0.09161

Table 1: Gini index in the sample and after policy intervention

Table 2 shows the decomposition of the Gini index of wage distribution based on EU-SILC data for Italy in 2010. The "between group" component represents approximately 54% of the overall labour market inequality, the remainder being largely explained by the residual term (44%). These proportions are broadly unchanged if we introduce a minimum wage of 10 euros, a maximum wage of 40 euros, or both policies simultaneously. Therefore, the Gini index in our numerical simulations captures approximately half of the overall labour market inequality in all simulated scenarios. However, the residual component consistently accounts for a significant portion of the Gini coefficient in all scenarios (always above 40%), indicating that we cannot attribute this portion of inequality to factors related to inequality between or within employee groups. Generalized entropy measures, as Theil indices, support this type of analysis by enabling a complete decomposition into between and within-group portions of inequality (Lambert and Aronson, 1993).

Scenario	Within (%)	Between (%)	Residual term (%)
Baseline	2.23	53.98	43.79
Minimum Wage	2.18	57.37	40.46
Maximum Wage	2.29	53.52	44.18
Min+Max	2.25	56.84	40.90

Table 2: Decomposition of the Gini index of wage distribution in 2010 and after policy interventions. EU-SILC data.

The Theil index is an entropy-based indicator of inequality that measures how different are the distributions of two characteristics across a set of population groups (Conceição and Ferreira, 2000). An interesting advantage of the Theil index over the Gini coefficient for analysing inequality is that it can be fully decomposed into the Between and Within components, without any residual left unexplained. The Theil index is commonly utilized in two distinct forms: the Theil L, which gives

more weight t the bottom, and the Theil T, which gives more weight to discrepancies at the top of the distribution. Both indices usually give similar results.

Table 3 reports the Theil L and Theil T indices computed with the microdata of EU-SILC. The three policy scenarios reduce both Between and Within components of the Theil indices. As in the case of the Gini, the Minimum Wage has a stronger effect on inequality with respect to the Maximum Wage. The scenario with the lowest inequality is the one in which the policies are combined (Scenario Min+Max). Notably, the magnitude of the impact of Minimum and Maximum Wage policies differs in Theil L and Theil T indices. Since Theil T gives more weight to discrepancies in the top quintiles of the distribution, it captures a much stronger effect of the Maximum Wage than the Theil L index. On the other hand, for assigning a greater weight for distribution at the bottom, Theil L tends to reveal a stronger effect of Minimum Wage with respect to the Theil T.

	Theil L			Theil T		
Scenario	Full Index	Between	Within	Full Index	Between	Within
Baseline	0.210864	0.045446	0.165418	0.175042	0.046450	0.128592
Minimum Wage	0.092099	0.029930	0.062169	0.108509	0.031911	0.076599
Maximum Wage	0.195800	0.040407	0.155394	0.149967	0.040470	0.109497
Min+Max	0.078353	0.025365	0.052989	0.085037	0.026511	0.058526

Table 3: Theil index in the sample and after policy intervention

In general, inequality falls after the introduction of the policies, with a consistent decrease of Between and Within components for the Gini, Theil L, and Theil T. Therefore, the actual reduction in inequality, tends to exceed the reduction observed in Eurogreen. Such computations thus provide a benchmark for the anaysis pursued throught the model, where we can only simulate the Between component of these inequality indices. The distinction among Between, Within, and Residual components is particularly useful since our macrosimulation analysis (discussed in the next subsection) only addresses the Between component of the inequality indices.

4.2 Dynamic Macrosimulation

In this section, we present the results from the macrosimulations of the four scenarios in Eurogreen. First, we focus on selected inequality indices and labour market indicators. Subsequently, we provide an analysis of wages across different employee groups and industry of activity. Each figure reports median values for the simulated time-horizon for each scenario and confidence intervals built with a range of two median absolute deviations around the median. The median and median absolute deviations are computed from 1000 simulations varying the random component in the innovation module of Eurogreen.

4.2.1 Macroeconomic indicators

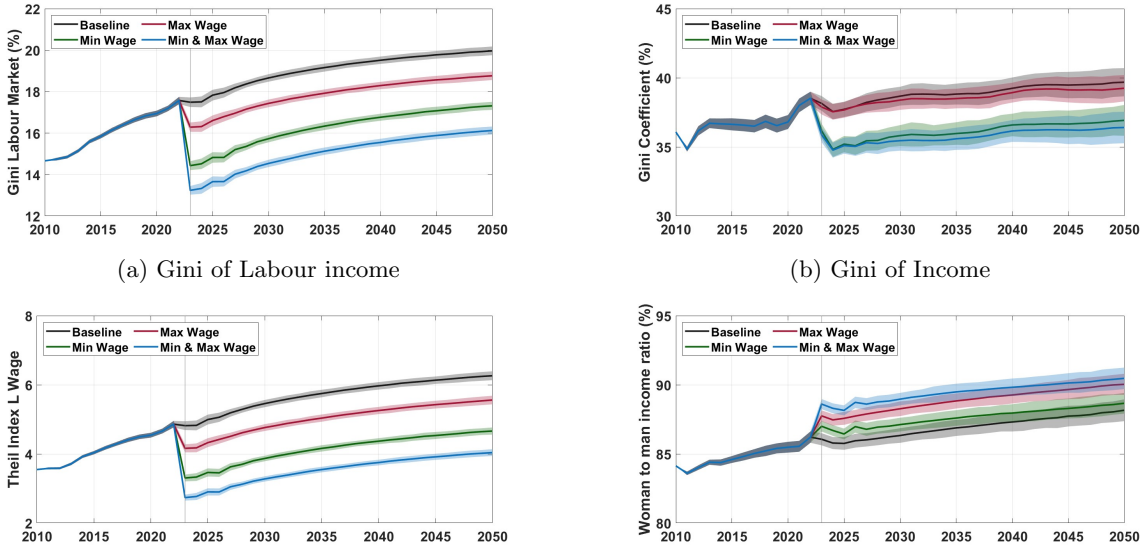
Minimum and maximum wage policies effectively reduce inequality as measured by the Gini coefficient and the Theil L index of wages, as seen in figures 5a and 5c.[13] The minimum wage has a

[13]The Theil T index exhibits a trend similar to that of the Theil L index, as reported in the Appendix A.

stronger effect on inequality with respect to the maximum wage for these indicators. As expected, the strongest reduction of inequality appears in the scenario including both policies. Although both policies significantly impact the Gini and Theil L indices of wages, they are unable to reverse the upward trend in inequality observed in the Baseline scenario and maintained in the three policy scenarios. While the policies have a notable and relevant effect, additional labour market interventions may be necessary to prevent the reversal of these gains in the long term.

Figure 5b reports the results for the Gini coefficient of disposable income, which accounts for labour income, financial and capital incomes, pensions, transfers, and the effect of taxation. The introduction of a minimum wage reduces the Gini coefficient by 3 points. In contrast, the maximum wage policy does not have an impact on this indicator.

The Gender wage ratio (figure 5d), i.e., the ratio between women to men average wages, is positively affected by both policies. However, unlike the previous indicators, the gender wage ratio varies more after the introduction of the maximum wage policy rather than the minimum wage. That happens because the top incomes affected by the wage cap are predominantly concentrated among male employees. Consequently, reducing top wages proves effective in diminishing gender wage inequality. Once more, the best outcome is observed in the scenario that includes both policies.



(a) Gini of Labour income

(b) Gini of Income

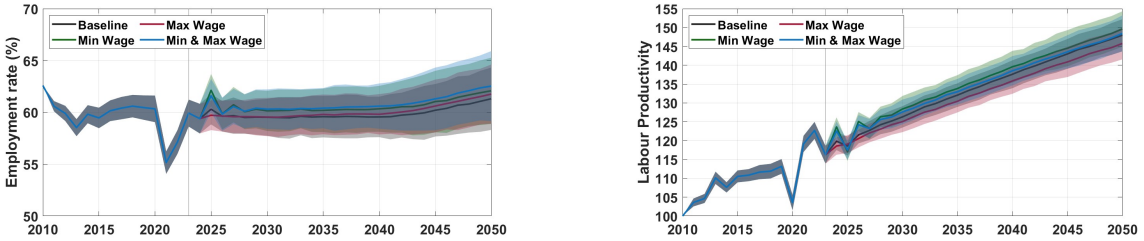
(c) Theil L Wages

(d) Gender Wage Ratio

Figure 5: Inequality Indices

Note: Simulation results for selected indicators of inequality. For each scenario, the figures report the median value of 1000 simulations varying the seed of the random component of the model. The shaded areas depict two median absolute deviations around the mean. The vertical gray line defines the period of the introduction of the policy (2023) in the three policy-scenarios.

In general, the results do not show a clear impact of the policies on macroeconomic indicators. Scenarios for employment and productivity, illustrated in Figures 6a and 6b, reveal that the policy scenarios may have minor effects on these variables, as evidenced by the overlapping confidence intervals. The results for the employment rate are not significantly different when considering the range of confidence intervals, but the median employment rate is higher in the Min Wage and Min & Max Wage scenarios. The minimum wage increases employment in the periods following its implementation. The increase in wages at the lower end of the wage distribution boosts demand, thus increasing the demand for labour. On the other hand, higher labour costs tend to stimulate labour-saving innovations, which are reflected in greater labour productivity in the scenarios with the minimum wage. The increase in labour productivity negatively affects labour demand, but this is not sufficient to offset the rise in employment resulting from greater demand. Introducing a maximum wage policy appears to have negligible effects on the employment rate, maintaining a median level nearly identical to that of the baseline scenario. However, the maximum wage policy discourages labour-saving innovation, as evidenced by a slightly slower growth in labour productivity in this scenario. Hence, the nearly negligible impact on the employment rate in the maximum wage scenario results from two counterbalancing effects: a decline in demand due to reduced consumption among top-wage workers coupled with a more gradual increase in labour productivity. As a consequence, the employment rate is almost not changed with respect to the baseline. The impact of the policies on other macroeconomic indicators are reported in the Appendix.



(a) Employment Rate

(b) Labour Productivity

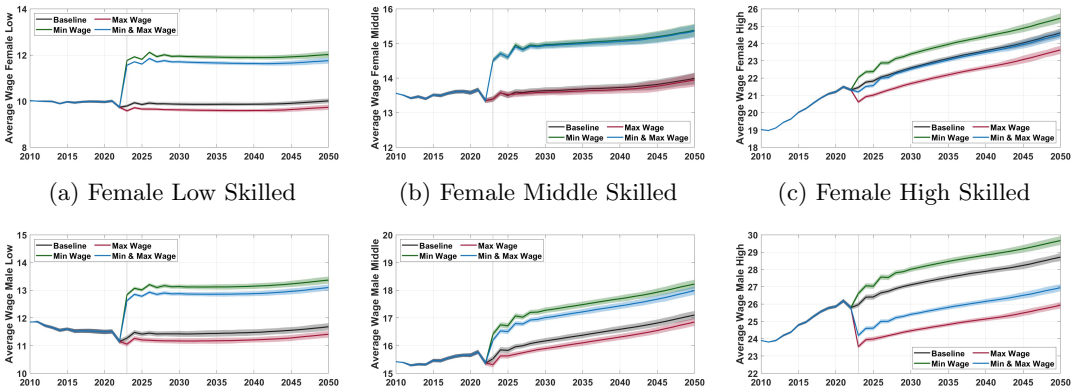
Figure 6: Macroeconomic Indicators

Note: Simulation results for selected macroeconomic indicators. For each scenario, the figures report the median value of 1000 simulations varying the seed of the random component of the model. The shaded areas depict two median absolute deviations around the mean. The vertical gray line defines the period of the introduction of the policy (2023) in the three policy-scenarios.

4.2.2 Wages

The fall in wage inequalities observed in the policy scenarios results from the impact on wages according to the characteristic of workers (gender and skill level) and the decrease in the inequalities across industries of activity. Figure 7 reveals how average wages of each group evolve in the baseline scenario and how they respond to the policies. We can see how the minimum and maximum reduce wage inequality, through their different effect in each group. The Minimum wage substantially increases the wages of low skilled female and male workers. The maximum wage, in turn, shows a

strong effect for high skilled workers, especially among male workers. Note also that the net effect of both policies is negative only for male high-skilled workers, while it is neutral for female high-skilled, and positive for the other groups.



(a) Female Low Skilled (b) Female Middle Skilled (c) Female High Skilled

(d) Male Low Skilled (e) Male Middle Skilled (f) Male High Skilled

Figure 7: Average Wage per Gender and Skill level

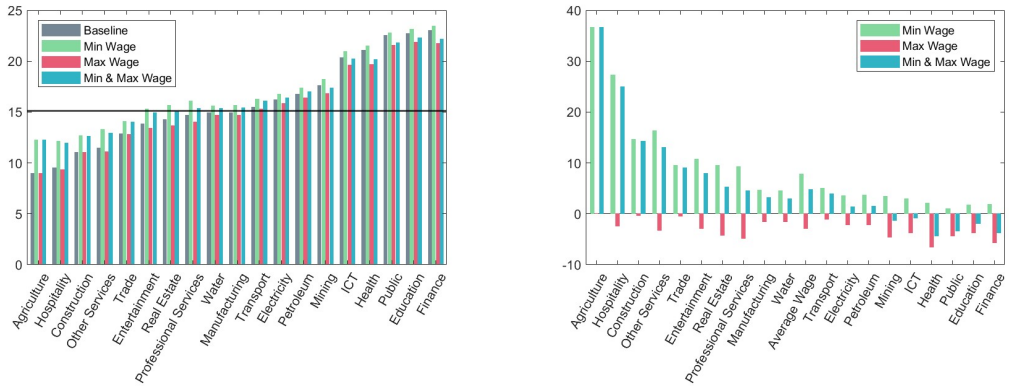
Note: Simulation results for average wage for gender-skill groups. For each scenario, the figures report the median value of 1000 simulations varying the seed of the random component of the model. The shaded areas depict two median absolute deviations around the mean. The vertical gray line defines the period of the introduction of the policy (2023) in the three policy-scenarios.

Figure 8 displays the median outcomes of the policy intervention on wages across the 19 industries included in the Eurogreen model. The analysis at the industry level allows us to understand how the policy effects are heterogeneous for workers in different activities. Results show that the Minimum and Maximum wage policies reduce the wage dispersion across industries. As expected, the strongest effect appears in the scenario that combines the two policies.

The compression of the wage structure following from the policies is also observed in the industry level. Figure 8a reports the hourly wages by industry in the period of the policy implementation, with industries ordered from the lowest (Agriculture) to the highest (Finance) average wage in the Baseline scenario. The figure 8b reports the relative change in wages observed in each policy scenario with respect to the Baseline for the same period. We can see in both figures how the minimum wage leads to notable wage increases at the lower end of the wage spectrum. This effect decreases as the average wage increases. In contrast, the Maximum Wage scenario exhibits a relatively mild negative impact on the average wage of the top wage industries. The net effect of the two policies (scenario Min & Max Wage) decreases as the Baseline wage level of the industry increases. For industries with an Baseline wage considerably above the average (Mining, ICT, Health, Public, Education, and Finance), the net effect of the two policies becomes negative, further contributing to the reduction in the payment gap across industries. The three policy scenarios compress the wage structure, in spite of roughly preserving the hierarchy among industries.

The heterogeneity of earnings across industries in Eurogreen reflects the disparity in the initial data for the Italian economy and the modelled trends related to the composition of the labour force

and productivity gains. While the initial wages, specific to each industry, gender, and skill level, are calibrated based on data, their trajectories diverge due to the characteristics of employees. These differences provide insight into the results discussed above. Industries such as agriculture not only exhibit lower average wages but also have a higher proportion of low-skilled workers within their work force. Conversely, sectors like Finance concentrate higher wages owing to the strong representation of male and highly skilled workers.



(a) Hourly Wage Level

(b) Policy Effect (%)

Figure 8: Wages by Industry in Baseline and Policy scenarios

Note: Hourly wage (current euros) across industries in the period of the policy activation (a); Relative change (%) in the wage level across industries with respect to the Baseline scenario in the period of the policy activation (b). Industries are ordered from lower to higher mean wage in the baseline. The horizontal line in (a) represents the average wage in the baseline.

5 Discussion and Final Remarks

We apply the Eurogreen model to simulate the introduction of minimum and maximum wage policies in Italy, assessing their effects on labour market inequalities and key macroeconomic indicators. Eurogreen includes 19 economic sectors and 114 employee groups differentiated by gender, skill level, and industry. This high level of heterogeneity accounts for a significant portion of labour market inequality, as demonstrated by a comparison with wage inequality indices (Gini and Theil) and provides a useful starting point to examine wage inequality dynamics. Moreover, the Eurogreen model captures different dimensions of inequality, including the gender wage gap and sectoral wage disparities—two crucial challenges in the Italian economy.

We found that minimum and maximum wages effectively reduce labour market inequalities. The minimum wage substantially decreases the Gini and Theil indices of wages, proving to be more effective at reducing inequality than the maximum wage policy. However, the maximum wage policy has a much stronger impact on the gender wage ratio, which reveals that this policy is essential for addressing gender inequality. This happens because the discrepancy between female and male earnings is more pronounced in higher-paying occupations levels. As a result, the maximum wage

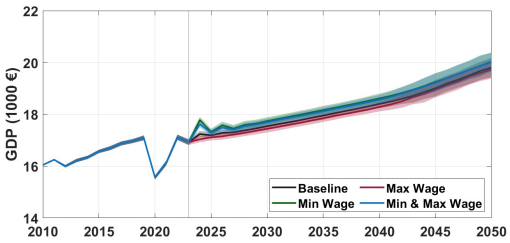
policy exerts a stronger impact on reducing top male wages, thereby narrowing the income gap between men and women. An analysis of the gender wage ratio by skill level within the Eurogreen model reveals that, at the time of policy introduction, the baseline scenario shows a gender wage ratio of 0.88 for low-skilled workers, 0.87 for middle-skilled workers, and 0.83 for high-skilled workers. This indicates that although gender disparities exist across all skill levels, they are most pronounced among high-skilled workers.

Overall, our findings reveal that the most effective results in reducing inequality are observed when the two policies are combined, highlighting their complementary nature in addressing different sources of inequality. The success in reducing inequality occurs without undesirable side-effects on macroeconomic outcomes. In particular, the employment rate and labour productivity are weakly affected by the policy scenarios. Their stability is attributed to the balance between positive aggregate demand effects and negative technological effects on employment, which are related to cost-induced changes in labour productivity.

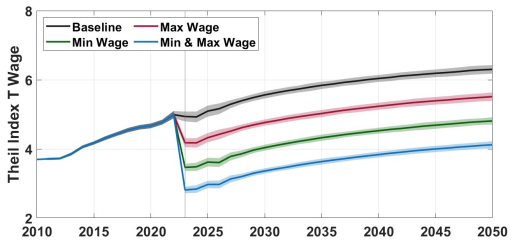
Our paper, therefore, provide a substantial contribution to the current debate on wage policy intervention. Overall, our results highlight that the statutory approach could overcome some of the limitations of the collective agreement approach. Specifically, fixing *ex-ante* a minimum standard appears more effective in protecting workers from shocks in the structure of production and in adjusting for income inequality across sectors. In these conditions, the introduction of a statutory minimum wage could even increase the bargaining power of unions – and not the opposite as it is often claimed by the opponents of statutory interventions. On the other hand, introducing a statutory maximum wage stands as a powerful tool to boost the redistribution of economic resources within the whole economy. However, such a measure typically faces political resistance based on the observation that income caps could represent a barrier to labour-productivity growth and displace high-skill workers. Discussing these counter-arguments is beyond the scope of our analysis, and we must acknowledge a limitation of our study in this regard. However, the impact of the maximum wage on the considered macro variables reveals that its introduction is not incompatible with economic growth and does not decrease overall employment.

Naturally, other factors contributing to inequality among individuals include disparities in other sources of income than wages. Profit accumulation, dividend payments, public transfers and taxation all are included in the determination of individual disposable income in Eurogreen. Profits and dividends are negatively affected by the minimum wage policy, but tend to be positively affected by a maximum wage. On the other hand, we did not analyse the key role of transfers and taxation in fighting inequality which has been explored elsewhere (Villani et al, 2023). Nevertheless, even when we focus on overall income inequality, the minimum wage shows a favorable effect, as evidenced by a decrease in the Gini coefficient of disposable income. We conclude thus that the effect of this policy goes beyond labour market inequality.

A Appendix



(a) GDP



(b) Theil T Wages

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