European Commission

Policy Responses to Labour-Saving Technologies: Basic Income, Job Guarantee, and Working Time Reduction

JRC Working Papers Series on Social Classes in the Digital Age
2023/09

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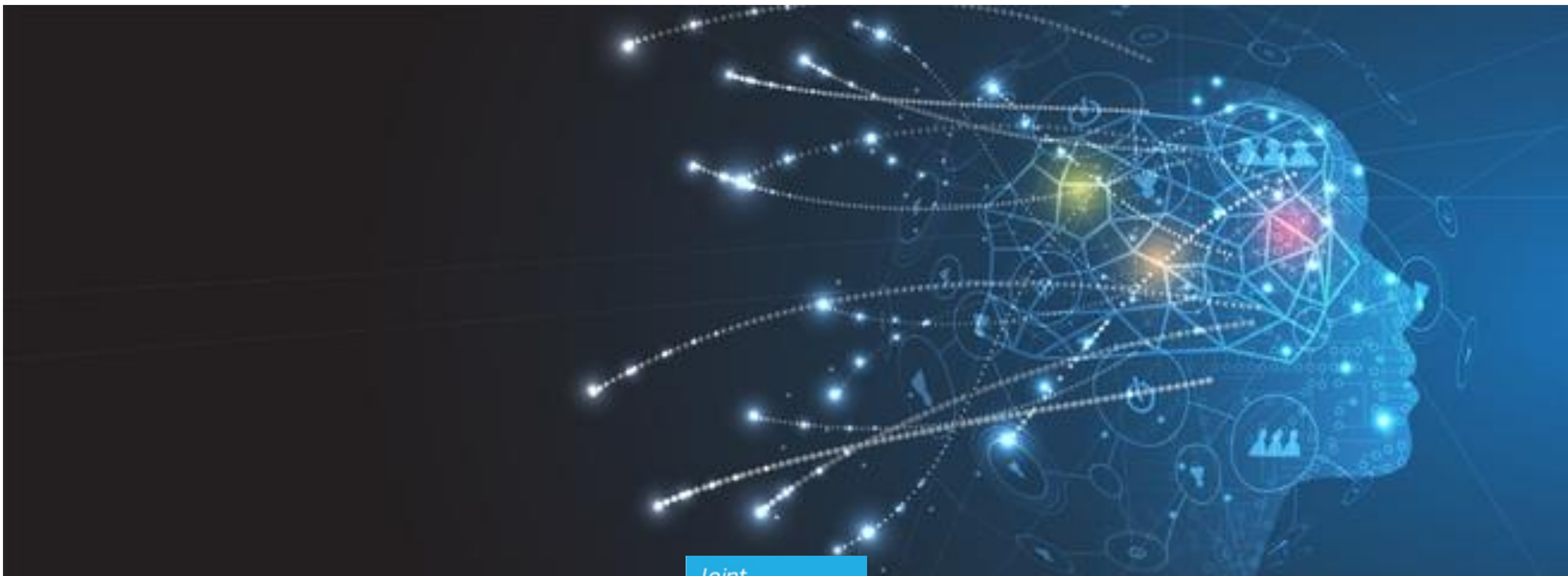

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JRC134452

Seville: European Commission, 2023

How to cite this report: D'Alessandro, S., Distefano, T., Spinato Morlin, G., Villani, D. *Policy Responses to Labour-Saving Technologies: Basic Income, Job Guarantee, and Working Time Reduction*, European Commission, Seville, 2023, JRC134452.

Policy Responses to Labour-Saving Technologies: Basic Income, Job Guarantee, and Working Time Reduction

Simone D'Alessandro (University of Pisa), Tiziano Distefano (University of Florence), Guilherme Spinato Morlin (University of Pisa), Davide Villani (Joint Research Centre, Seville – European Commission)

Abstract

Several studies argue that the latest advancements in technology could result in a continuous decrease in the employment level, the labour share of income and higher inequalities. This paper investigates policy responses to the rise of labour-saving technologies and their potential negative effects on employment and inequality. Using EUROGREEN (an Input-Output-Stock-Flow model), we assess how three different policy measures – basic income (BI), job guarantee (JG), and working time reduction without loss of payment (WTR) – could affect the economy in the wake of a technological shock. We build different scenarios in which the effects of these policies are implemented against a reference setting of high labour productivity growth. We evaluate the impact of these policies on per capita GDP, the Gini coefficient, the labour share, the unemployment rate, and the deficit-to-GDP ratio. We find that these policies could be effective in counterbalancing some of the negative effects of labour-saving technologies. JG reduces the level of unemployment significantly and permanently, whereas BI and WTR only temporarily affect the unemployment rate. WTR effectively increases the wage share and generates the lowest deficit-to-GDP ratio in the long run. The introduction of a wealth tax further reduces inequality and helps to offset the increase in public spending associated with JG and BI. A mix of these policies delivers the highest per capita GDP, lowest unemployment rate, and best distributive outcomes.

Keywords: Labour-saving technologies; input-output; inequality; policy scenario analysis

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Acknowledgements: The authors would like to thank Alejandro Buesa Olavarrieta, José Bruno Fevereiro and the participants of the International Input-Output Association Conference 2023 for useful comments and suggestions. The usual disclaimers apply.

Joint Research Centre reference number: JRC134452

Contents

1 Introduction

Technological progress has long been regarded as a driver of economic growth and social prosperity. However, there is growing concern about the effects that the current wave of technological change can have on our societies. Automation technologies, robots, artificial intelligence and digitalisation are some of the processes that characterise the current wave of technological change and that could have disruptive effects in our society. While these changes offer many benefits, they also pose several challenges that must be addressed.

The diffusion of these technologies is attracting a lot of attention from academics and policy makers. Most of the existing literature is concerned with assessing the possible impacts of technological change on a wide range of variables such as labour demand (Arntz et al., 2016; Chiacchio et al., 2018; Frey and Osborne, 2017, among others), the labour share (Acemoglu and Restrepo, 2020b; Autor and Salomons, 2018) and income inequality (Acemoglu and Restrepo, 2021). However, there is more scarcity of contributions that try to establish what policies could be implemented to counterbalance some of the undesired effects of technological change.

This paper seeks to contribute to filling this gap by exploring the economic feasibility of different policy measures in response the challenges posed by labour-saving technologies. To this end, we simulate the effects of three policy measures -Basic Income, Job Guarantee, and Working Time Reduction with equal pay- against a scenario of rapid technological change. We assess the impact of these policies using the EUROGREEN model (D'Alessandro et al., 2020), a dynamic macro-simulation model based on an input-output and stock-flow consistent structure. The model, estimated for the French economy, builds on data from a wide set of sources such as Eurostat, EU KLEMS, the World Input–Output Database, the OECD and the International Energy Agency. Therefore, EUROGREEN is a valuable tool for analysing the propagation effects of technological changes throughout the economy's productive structure, as well as their impact on sectoral employment and carbon emissions.

The indicators chosen for this study are some of the most debated in the literature, given their exposure to technological change. We start by focusing on the potential impact of innovation on long-term economic growth, analysing the evolution of per-capita GDP. Another set of indicators analyses the impact of the policy measures on labour market demand. Specifically, we examine the rate of unemployment and labour market participation, which are crucial indicators of the health of the labour market. Next, we focus on income distribution and inequality, assessing the evolution of the labour share of income and the Gini coefficient. Finally, to account for the economic feasibility of the policy measures, we also examine the simulations for the evolution of the public deficit, since one common criticism leveled against the policies analysed in this paper is their high cost. Thus, policy makers must balance the policy effectiveness to address the challenges posed by technological change with the need to maintain fiscal sustainability.

The paper is structured as follows. After this introduction, Section 2.1 revises the literature on new technologies and their relation with employment, income distribution and inequality. Section 2.2 briefly presents and discusses the three policy measures analysed in the paper. The main features of the EUROGREEN model are discussed in Section 3, while Section 4 describes the scenarios and their calibration employed in the different simulations. The results of the simulations are presented in two parts. First, we present the outcomes of the simulations for each policy measure individually, comparing them against a scenario of rapid technological change and no policy intervention. Subsequently, another round of simulation combines different policy measures to determine how they might coexist and interact. Section 5 concludes with a summary of the main results and their policy implications.

2 Literature review

This section resumes the recent discussion regarding the rise of new technologies and the expected impact on the demand for labour and inequality. Then it presents the three policy measures analysed in this paper (Basic Income, Job Guarantee and Working Time Reduction) and links them with the debate on labour-saving technologies. Finally, we also explain the rationale for the introduction of a wealth tax as a tool to provide additional funding to the Basic Income and Job Guarantee programmes.

2.1 New technologies, employment and inequality.

The concerns regarding the impact that a technological shock would have on the economy and, more broadly, the society is not new. Notably, the idea of technological unemployment was popularised by Keynes (1930), although the concept was already present since the dawn of capitalism (think, for example, at the Luddist movement). Technological anxiety has always accompanied the development of capitalism (see Mokyr et al., 2015). Examples of how economists have tried to assess the impact of technological change and possible policy responses can be found already in (Burtle, 1957), who specifically enquired on how the reduction of working hours and the introduction of a job guarantee program could be employed to respond automation. Among other contributions we can mention Pasinetti (Pasinetti, 1981), who analysed the effects of technical change on labour demand using an input-output framework.

Hence, the current discussions regarding the rise of automation bears similarities with previous debates. For the sake of simplicity, however, we shall devote most of our attention to more recent contributions, which specifically focus on recent technological developments and its relationship to the demand for labour, income distribution and inequality. Today, a common theoretical explanation of the link between the rise of new technologies and labour demand is that of Acemoglu and Restrepo (2019). The introduction of new technologies allows firms to substitute capital for labour, as an increasing number of tasks can be performed by machines. This is the *displacement effect*, which brings a negative impact on the demand for labour. At the same time, this trend is counterbalanced by two opposite forces, which they call the *productivity effect* and the *reinstatement effect*. The former refers to the higher demand for labour in non-automated tasks that comes from the higher productivity associated with new technologies, while the reinstatement effect refers to the creation of new jobs in which labour has a comparative advantage compared to capital. The net effect on the amount of labour demanded in the economy depends on the interplay between these forces.

There is a mounting body of analyses that try to assess what type of jobs and occupations will be more heavily affected. Part of the literature argues that automation will foster job polarisation (i.e. a reduction of middle occupation and relative expansion of bottom and top occupations) and a reduction in routine jobs. As routine jobs are those more affected by labour-saving technologies, they are more easily replaced by machines (Autor et al., 2003; Autor and Handel, 2013; Goos et al., 2014, 2021). Other findings do not support this hypothesis and find that elementary occupations are more likely to be affected by automation (OECD, 2019).

Regardless the discussion on job polarisation, it is crucial to focus on the aggregate effect that new technologies have on industry and national employment. In this respect, Frey and Osborne (2017) estimate that 47 percent of total employment in the US is at risk of automation. Similar studies provide more conservative, although still remarkable, figures. Arntz et al. (2016) quantify the share of automatable jobs in the US to be 9 percent, while Nedelkoska and Quintini (2018) estimate that this share is 14 percent for OECD countries.

Focusing on six European countries, Chiacchio et al. (2018) find that a higher concentration of robots reduces significantly the employment rate, while Acemoglu and Restrepo (Acemoglu and Restrepo, 2020a) reach similar results for the US. Furthermore, Aghion et al. (2019) show that the rise of robots and automation reduces aggregate employment in France, and Dauth et al. (2021) find similar results for the German manufacturing sector, although this effect is compensated by the creation of new jobs in services. Chen et al. (2022) find that British industries more exposed to robot penetration suffer a significant employment decline.[1]

The interplay between the rising in new technologies and the substitution of capital for labour relates is also employed to explain the decline in the labour share on income, which in the last decades has fallen in all Western countries (OECD, 2015). This reduction tends to be more pronounced in those industries that are more exposed to automation and record high productivity growth (Autor and Salomons, 2018), which often coincide with those sectors highly intensive in repetitive tasks, which are more easily replaced by machines (Dao et al., 2019). This mechanism can be amplified by the fact that technological advancements are concentrated in a few "superstar" firms which benefit from larger productivity gains and are able to obtain a growing share of value added (Autor et al., 2020; Schwellnus et al., 2018). At the same time, some authors link the reduction in the labour share to the drop in prices of equipment and investment goods due to technological change (Karabarbounis and Neiman, 2014). Regardless of the different nuances, this literature shares the idea that new technologies and the rise in productivity associated with them have a direct negative impact on the labour share.

As mentioned, a consistent bulk of literature links the new technologies to the process of occupation polarisation, job destruction, and rising retribution of capital income relative to labour income. These processes lead to higher income inequality which is thereby found to be a direct consequence of the current wave of new technologies (Acemoglu and Restrepo, 2021; Lankisch et al., 2019).

In conclusion of this section, we can claim that while technological advancements and the replacement of human labour by machines have been a constant throughout history, there is an increasing apprehension about the transformative impact of the current technological wave on the economy. Most scholars argue that the current wave of automation may result in a substantially larger number of jobs being automated without sufficient compensation through the creation of new labour-intensive roles compared to the past. Consequently, this trend is projected to lead to a sustained decline in labour demand, a decrease in the labour share, and a widening of inequality.

For these reasons, it is crucial to analyse the potentially disruptive effects of strong technological shocks and discuss the role that different policy measures can play in this context. In what follows, we will assume that there is a consistent technological shock that is highly labour saving.

2.2 Policy measures

2.2.1 Basic Income

Basic Income (BI) can be defined as "an income paid by a political community to all its members on an individual basis, without means test or work requirement" (Van Parijs, 2004: 8). Following this definition, BI was originally conceived to be a universal policy, granted to every citizen regardless of their income or working condition. Over the years, several proposals of BI have been put forward. Most designs consist of a lump sum that is below the living wage, e.g. 600 euros-month. These

[1] For the sake of completeness, we should also mention that another group of studies is more sceptical regarding the disruptive effects of the current technological transformations. Some authors argue that the current wave of innovations should be considered a continuation of the preceding ICT revolution (Lee and Lee, 2021). Other researchers reveal that, despite automation has a significant effect on productivity, it is associated with higher or unchanged employment level (Kromann et al., 2020). In the same fashion, Klenert et al. (2021) do not find evidence that robots reduce employment and the demand for low-skilled workers in Europe. Domini et al. (2021) and Yang (2022) find that automation spikes and AI technology are associated with positive employment creation. Therefore, it is important to mention that the debate on the effects of new technologies on employment is still open. In this paper, the EUROGREEN model designs a significant negative effect of new technologies on employment, aligning with the prevailing findings in the literature. Consequently, our analysis should be regarded as an exploration of a scenario where the more pessimistic outlook materializes.

schemes can be considered a support against economic vulnerability, which, in practice, do not rule out completely the necessity of engaging with work. In some cases, BI schemes include restrictions on the beneficiaries of the allowance (it could be limited to unemployed workers or individuals below a certain income threshold). In this case, BI loses its universal characteristics, becoming closer to more traditional targeted measures in support of more vulnerable individuals. Other BI proposals are more generous, envisaging the basic income cheque to be sufficient to live, hence removing the constraint to engage with salaried relations (see Srnicek, 2016).

The possible effects of BI have been analysed in relation to a wide range of factors, such as inequality and poverty (Wright, 2016), environmental sustainability (André Cieplinski et al., 2021), insecurity and human health (Painter, 2016). BI can also be an effective policy to respond to the rise of new technologies alleviating the negative effects that could derive, for example, from massive of massive job destruction (McAfee and Brynjolfsson, 2016; Yang, 2018).

Although no country has introduced a universal BI scheme, several pilot projects have been carried out. Among the first experiments, in the 1970s the regional government of Manitoba implemented a BI scheme that aimed at guaranteeing between $ 3,800 and $ 5,400 yearly income, depending on the household size (Simpson et al., 2017). Another significant example was recently carried out in Finland, where, between 2017 and 2019, a BI scheme assigned a monthly 560 euros per month benefit to two thousand unemployed individuals (Kangas et al., 2019).

While these experiences and their evaluation provide valuable information on a wide set of indicators, their insights are nonetheless limited. One drawback that commonly affects pilot projects is that, due to their scale, they may suffer from fallacy of composition problems, and their results may not be generalised on a macro scale. In this respect, experiments on BI may be unable to consider the changes in the national tax system that would be needed to fund BI (Van Parijs and Vanderborght, 2017). Moreover, these pilot experiences are often short lived, which prevents from an evaluation of their impact in the long run. Another crucial aspect is the economic feasibility of BI, since providing a universal monthly allowance would imply a heavy economic burden for public finances. Some scholars have highlighted that a generous BI scheme would be economically unfeasible, especially without reducing existing welfare measures (Martinelli, 2017). Hence, BI appears as a very ambitious policy which is likely to affect a wide range of socioeconomic variables, but, nonetheless, it also presents criticalities. Given the state of the discussion, macro-simulation models can help to estimate the aggregate impact of BI, both in terms of financial sustainability and in relation to a large set of indicators.

2.2.2 Job guarantee

Job Guarantee (JG) consists of the direct provision of jobs by the government to anyone who is willing to work. The idea that the state should have an active role in absorbing involuntary unemployment is not new (e.g. Keynes, 1930; Lerner, 1951). However, this proposal is receiving growing interest, especially after the global financial crisis and the Covid-19 pandemic, which have provoked a considerable unemployment surge and evidenced the importance of an active public intervention as economic actor and regulator.

Also in this case, the expected effects of the introduction of JB are numerous. By expanding labour demand, a first natural outcome of the JG is the reduction of unemployment. Another projected result is the fall in poverty and inequality as a consequence rising income of (formerly) unemployed individuals (Tcherneva, 2020). Moreover, JG is often seen as an instrument that the government can employ to reach socially desirable objectives. In this respect, Godin (2012) and D'alessandro et el. (2020) simulate JG schemes that are specifically targeted to the creation of green jobs that are intended to help reducing polluting emissions. From this perspective, JG can be an effective tool not only to reduce unemployment and inequality, but also to govern rapid technical change.

Analogously to BI, the budgetary sustainability is of primary importance since the cost of JG is funded via public spending. Minsky (2008: 334) estimated that a JB program in the US would amount to 1.25

percent of GDP, while Paul et al. (2018) provide larger figures, around 3 percent of American GDP. Theurl and Tamesberger (2021) model a JG scheme for Austria in which the government initially creates 30,000 jobs and increases this number by 1,500 per year. They find that the multiplier effect of the JG scheme can largely offset the economic cost initially imposed on public finances.

2.2.3 Working time reduction

Working time reduction (WTR) is one of the most conventional responses to technological change. Historically, the growth of productivity has created the material conditions to increase wages and to reduce working hours. In fact, since the advent of the industrial revolution, per capita working hours have reduced considerably. Notably, Keynes (1930) envisaged that, thanks to technological advancements, a 15-hours workweek would be sufficient to guarantee a satisfying standard of life by the end of the 20th century. Nevertheless, most Western countries reached an 8-hour workday around a century ago and, since then, working hours have stalled (with only a few exceptions) despite the considerable technological advancements.

Nowadays, the debate around WTR has been revamped following the idea that rapid automation could make possible the reduction of work time (Brynjolfsson and McAfee, 2014; De Spiegelaere and Piasna, 2017; Ford, 2015). In a context of expansion of labour-saving technologies, this policy can be seen as an opportunity to distribute the (decreasing) demand for labour among a higher number of workers, hence reducing the tendency towards higher unemployment (Pasinetti, 1981). In this vein, some studies evaluate the impact of (few) recent WTR reforms that were implemented in Western economies. Research on the outcome of WTR in France finds that the reform contributed to reduce the unemployment rate (Askenazy, 2013; Du et al., 2013). Other scholars find more ambiguous results in which the impact of WTR is weak or non-significant but none of them find negative effects on the employment level (Kapteyn et al., 2004; Sánchez, 2013)

Cárdenas and Villanueva (2021) simulate the reduction of 5 hours of the workweek in Spain and find that this measure would promote job creation and lower the unemployment rate by 2.6 percentage points. Moreover, working time reduction could also help to reduce income inequality while the labour share of income is expected to increase, counterbalancing the decline experienced recently. The effects of WTR go beyond their impact on employment level. Some scholars argue that WTR can help to boost productivity (Owan et al., 2021; Pencavel, 2015), reducing or, in some cases, offsetting the economic burden to employers by higher hourly labour costs. Moreover, WTR has a positive impact on workers' wellbeing (Lepinteur, 2019), could influence gender equality (Cieplinski et al., 2022) and lead to environmental benefits (A. Cieplinski et al., 2021; Jackson and Victor, 2011).

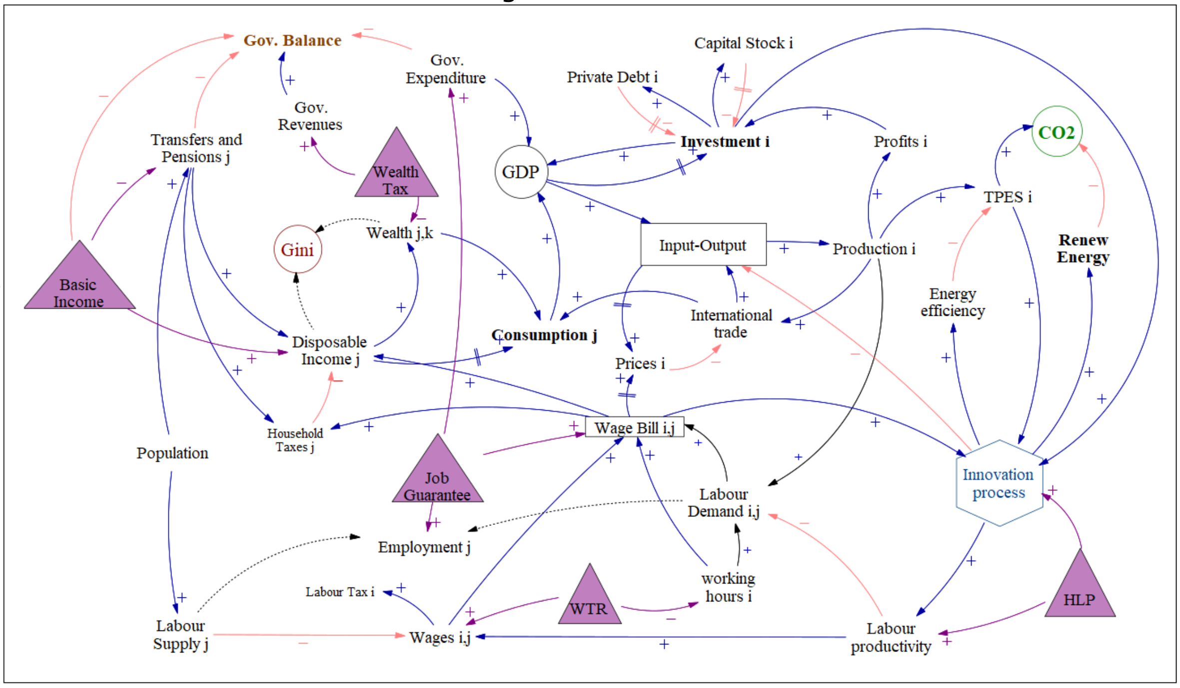
2.2.4 Wealth Tax

Social policies required for supporting workers from the impact of labour-saving technologies may lead to considerable government deficits. This, in our case, is the case of BI and JG. Increases in taxation may become fundamental to avoid increases in public debt ratios. In this context, tax policy should also be concerned with the targets of reducing inequality and protecting workers earnings and wellbeing. Taxation of wealth can be an instrument to reduce the inequality of income and wealth (Piketty et al., 2013), whereas financing social policies. Wealth taxation are more progressive than income taxes, as data shows wealth to be much more concentrated than income (Piketty and Zucman, 2014). Wealth inequality increased dramatically in the United States in the last decades, where the top 1% wealth share increased from 25-30% in 1980 to nearly 40% in 2016 (Zucman, 2019). Since 1980, the top 1% wealth share combining China, Europe, and the United States has surged from 28% to 33% today. Meanwhile, the bottom 75% share has stagnated at around 10% (Zucman, 2019). The ratio between wealth and income follows an increasing trend in advanced economies (Piketty and Zucman, 2014).

Apostel and O'Neil (2022) show that a wealth tax has a revenue potential of potential of 5.9 to 43.1 billion euros in Belgium, suggesting that the revenue potential is strongly underestimated by other studies. However, they argue that a small wealth tax would have little effect on changing wealth distribution. Nevertheless, when fiscal resources are employed to improve the living standards of low-income households, the distributional effect of a wealth tax may alleviate the pressure for economic growth and prove particularly advantageous in the context of the green transition (Apostel and O'Neil, 2022). Wealthy taxpayers however may potentially use sophisticated tax evasion strategies, such as offshore accounts (Alstadsæter et al., 2019). A growing strand of literature thus estimate how wealth taxes affect taxable wealth (Brulhart et al., 2016; Zoutman, 2015).

3 Model

Figure 1. Macroview.



Note: It presents the main variables and connections of the EUROGREEN model (D'Alessandro et al., 2020; Distefano and D'Alessandro, 2023), with a focus on the main impacts of the policies here introduced. Violet triangles represent the policies implemented in the scenarios (see subsection 2.2). Double-marked arrows mean one-period lagged effects, while positive (negative) relations are denoted by the sign + (-) and are blue (red). Subscript j stands for skill (high, middle, low), i for industry (29 NACE sectors), and k for financial assets (deposits, bonds, and equities). All the tax variables presented in the Figure enter Gov. Revenues.

As described in detail in D'Alessandro (2020), the EUROGREEN model is grounded on three main methodological pillars:

1. *Post-Keynesian Economics*: considers that output is driven by effective demand and the economy does not show any spontaneous tendency towards full employment of factors of production, prices are determined as a markup over average costs of production. Moreover, the distribution of the product among the social classes is not determined entirely by technological variables but reflects their relative bargaining power, in a process influenced by the historical evolution of nominal incomes and employment rates.
2. *System Dynamics* (SD): approach to analyse the interconnections and feedbacks among the socio-economic and environmental components. SD has a high degree of flexibility and a graphical structure that allows the identification of feedback mechanisms.
3. *Environmentally Extended Social Accounting Matrix and Input-Output*: that provides a consistent economic framework, coherent with the official national accounts, to study inter-industry connections. This includes the composition of the labour force (skills, working time, and wages) and the resource uses (e.g., energy) by sector.

The combination of these approaches stands also at the core of "Ecological Macroeconomics". For the sake of clarity and given the purpose of the current study -- i.e., exploring the effects of automation in the labour market -- we describe in detail the module of technological progress that characterizes the EUROGREEN model (a graphical picture of the whole EUROGREEN model can be seen in Figure 1).

3.1 Innovation process

The core of the model is represented by the input-output approach, grounded on national accounts. Given *i = 1, …, s* sectors, we can build the matrix of intermediate trade $\mathbf{Z}_{(sxs)}$ where each row (column) represents the selling (buying) sector, and the associated vector $f_{(sx1)}$ of final demand (consumption, government expenditure, investments) and exports $e_{(sx1)}$. So, by doing the row sum of $\mathbf{Z}$, f, and *e* we can find the total vector of sectoral total output $x_{(sx1)}$.

Also, we can calculate the matrix of technical coefficients as:

$$\boldsymbol{A} = \boldsymbol{Z} \cdot \hat{x}^{-1} \qquad (1)$$

where the hat stands for diagonal matrix. Each entry $a_{(j,k)}$represents the share of input bought from sector *j* to produce a unit of output in sector *k*. This matrix is crucial because it shows the distribution of input factors required by each sector which indirectly reflects the technology of production. Moreover, from matrix $\mathbf{A}_{(sxs)}$, we can calculate the Leontief inverse $\mathbf{L}_{(sxs)}$which returns the overall (direct and indirect) effect in the economic system (i.e., $\mathbf{Z}$) due to a change in the final demand. Namely:

$$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1}, \qquad (2)$$

$$x = \boldsymbol{L} \cdot (f + e). \qquad (3)$$

Most of the models available in the literature adopt a constant matrix **A** which is not realistic when running long-run simulations. In order to fill this gap, the EUROGREEN model includes a specific "Technological Innovation" module which allows for an endogenous update of matrix **A**. Indeed, the model assumes that firms adjust their intermediate demand (**Z)** based on changes in final prices and input costs. Therefore, $\Delta a_{j,k}$ can be considered a proxy for technological change. An increase (decrease) in $\Delta a_{j,k}$ indicates that sector *k* needs more (less) input from sector *j* per unit of production.

The process of technological change in the EUROGREEN model also affects labour productivity and energy efficiency. One of the unique features of our model is that innovation is *endogenous* and depends on the relative costs of labour and intermediate inputs. As described in D'alessandro et al. (2020), the innovation process is partly based on a stochastic process and partly driven by firms' investments. We assume four possible cases for innovation: no innovation (T_1) a new technology that is either material-saving (T_2) or labour saving (T_3), and an innovation that allows for both labour and primary input savings (T_2). The probability of each case depends on the direction and volume of investments, with the lowest probability for the most optimistic case (T_4). The model also incorporates stochasticity in the innovation process, calibrated on real data from national accounts. Once a firm decides which technology to adopt, it is gradually implemented in line with fixed capital renovation.

The key modelling procedures regarding the innovation process can be summarised in three steps:

- Random selection of available technologies from the set {T_1, T_2, T_3, T_4},
- Calculation of the magnitude of change in technical coefficients and labour productivity associated with each new technology,
- Firms choose the technology that minimizes their costs and implement it.

This framework allows us to capture the endogenous nature of innovation in our model and to investigate how it affects various aspects of the economy, such as labour productivity, energy efficiency, and production costs.

Once a technology is implemented, the actual labour productivity of a sector is given by a weighted average between the new $\hat{\lambda}$ and previous $\bar{\lambda}$ labour productivity, with weights defined by new investments in fixed capital (I_t) and the stock of older fixed capital after depreciation $K_{t-1}(1-\ \delta)$.,[2] respectively:

$$\lambda_t^i = \frac{\hat{\lambda} I_t + \bar{\lambda} K_{t-1}(1-\delta)}{K_t} \qquad (4)$$

The level of investment determines how fast new technologies are implemented and have an effect on employment and wages. A similar reasoning applies to intermediate input-saving innovations T_2 that will affect the total demand and output of all other industries. The process of technological change here described generates non-trivial dynamics across and within industries in the simulated economy. Labour-intensive (intermediate input-intensive) industries are more prone to adopt technology $T_3(T_2)$ if available.

However, the adoption of intermediate input-saving technologies has consequences for other industries. While it may increase the value added per unit of output in the industry that adopts it, it may also reduce the output of the industries whose goods and services are used as input in the production processes of that industry. This dynamic will change the composition of industries in the economy.

As labour-saving technologies become more prevalent, labour-intensive industries may face reduced demand for their products and services, which can lead to lower profits and slower adoption of new technologies. A new technology that increases labour productivity (i.e., HLP) will reduce the number of workers hired per unit of output. However, it will also increase hourly wages and, consequently, aggregate demand. This can lead to higher profits and faster adoption of new technologies in those industries, which can ultimately drive productivity gains and economic growth. At the same time, the growth in aggregate demand can counterbalance (at least partly) the negative employment effects that spread from high productivity growth.

Overall, the process of technological change is complex and dynamic, with significant implications for employment, wages, and economic growth. The adoption of new technologies can lead to productivity gains and increased profits, but it can also have negative consequences for other industries and workers. Understanding these dynamics is essential for policymakers and business leaders as they navigate the challenges and opportunities of technological change in the 21st century.

4 Scenario setting and results

Scenario analysis is used to compare alternative plausible futures by defining specific “what-if” questions, i.e. by varying the values of specific parameters or by adding a new variable that proxies a policy intervention. In particular, we define four single labour policies:

1. **Job Guarantee** (JG): Government hires a maximum of 300,000 unemployed workers per year that perform either services or environmental work and are paid minimum wages.
2. **Basic Income** (BI): Government introduces a 5580 euros yearly benefit to all working-age adults. This proposal is in line with different experiments carried out recently (see section 2.2

[2] Note that in the equation below $K_t = I_t + K_{t-1}(1-\ \delta)$.

above) and is universal, since it is awarded to any adult person independently from other characteristics. Other public expenditures are not affected, except for unemployment benefits that are removed.

3. **Working Time Reduction** (WTR): We assume that the weakly working full-time gradually reduces, in five years, from 35 to 30 hours without loss of total salary. This implies a growth in hourly wages that is paid by the employers.
4. **Wealth Tax** (WT): given that the BI schemes and JG policies require additional expenditures from the government, we include the possibility to apply a wealth tax to compensate for the negative effect on public finance of these two policies. Wealth tax is proportional to spending in BI and JG (up to a tax of 5%, considered an upper limit for the wealth tax).

Moreover, we follow a "sequential scenario" (Distefano and D'Alessandro, 2023; Nieto et al., 2020) in order to isolate the impacts of each different labor policy and evaluate their cumulative effects. We also test alternative policy packages composed of a combination of two or more single policies listed above.

Since policies may generate mixed outcomes on several, a combination of policies can be more effective for a general improvement of labor market outcomes. We, therefore, test the effect of different combinations of policies.

Scenario	Active Policies
HLP	Labour-saving technologies, no policy
Policy Mix 1	BI, JG, and WT
Policy Mix 2	JG, WTR, and WT
Policy Mix 3	BI, WTR, and WT
Policy Mix 4	BI, JG, WTR, and WT

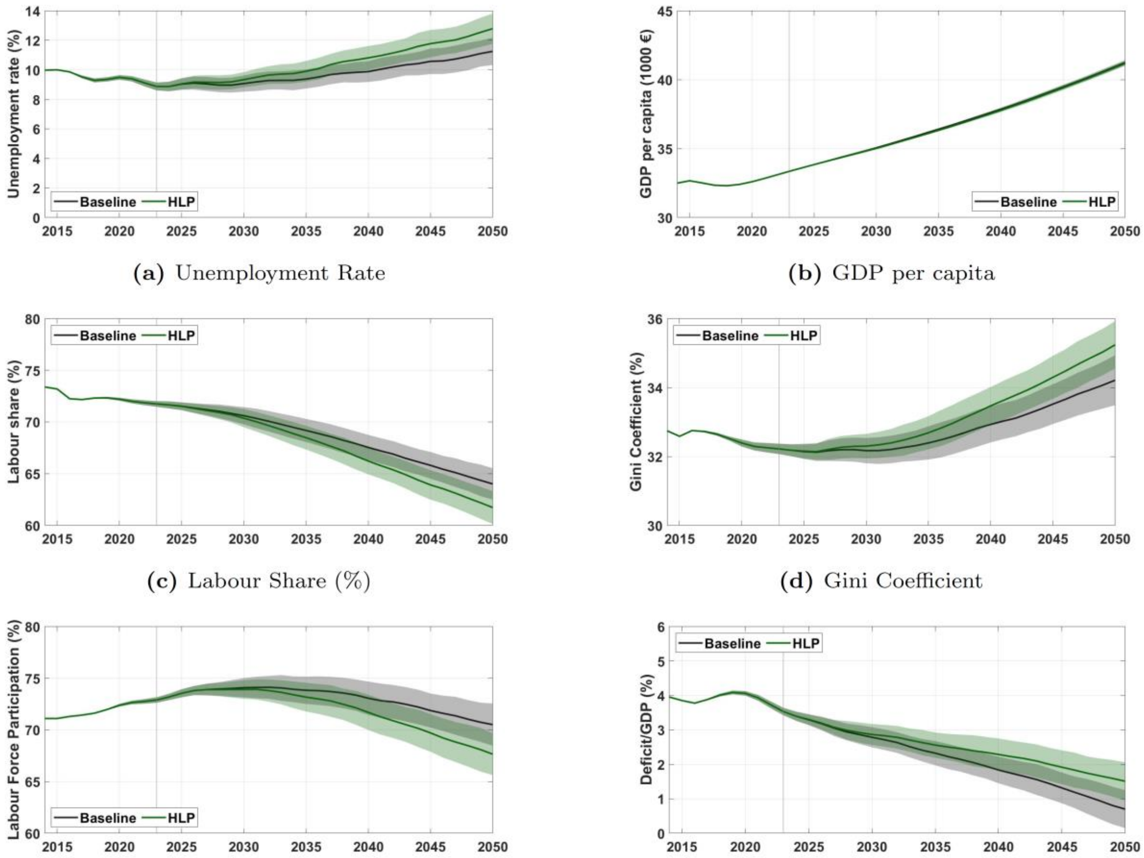
We compare four scenarios of different policy mixes with the scenario of a fast increase in labour productivity (HLP).

Simulations in EUROGREEN include a random component related to the availability and efficiency increases of new technologies. Innovation affects economic variables through the reduction of technical coefficients, an increase in labour productivity, or both. Therefore, we compare scenarios based on the median value for 500 simulations. The figures report median values for each scenario and confidence intervals built with two median absolute deviations, approximately 95% under a normal distribution. All simulations follow the baseline scenario until the period 2023, where the structural change or policy intervention particular to each scenario is introduced.

4.1 The impact of labour-saving technologies in EUROGREEN

Figure 2 compares the dynamics of the baseline scenario with a scenario of fast labor-saving technical change (High Labour Productivity - HLP). The HLP scenario differs from the baseline by an increase in the probability that a new technology increases considerably labour productivity starting in the year 2023.

Figure 2. Labour saving technologies.



(a) Unemployment Rate

(b) GDP per capita

(c) Labour Share (%)

(d) Gini Coefficient

(e) Labour Force Participation Rate (%)

(f) Deficit/GDP ratio

Although both scenarios follow similar trends for GDP per capita, they substantially differ in terms of inequality and labour market. Labour-saving technologies present an overall worsening in indicators of labour market and inequality. HLP increases the unemployment rate in about 1.53 percentage points in 2050. The increase in unemployment and the decoupling of wages from productivity growth reduce the labour income share. Therefore, the median labour share of HLP scenario is smaller by 2.28 percentage points by the end of the simulation period. Income inequality as measured by the Gini coefficient also increases after the introduction of labour-saving technologies, due to the increase in the profit share and the increase in inequality among high skilled and medium and low skilled workers. Therefore, by 2050, Gini coefficient reaches 34.2 points in the baseline scenario, whereas it reaches 35.2 in the HLP. The data presented in these figures align closely with the literature discussed in Section 2, which illustrates a trend of increased unemployment and inequality following the adoption of new labour-saving technologies. Thus, this model serves as a reliable benchmark for capturing the changes described in the literature. Finally, the increase in unemployment and the fall of the labour share have a negative effect on government tax revenue and a positive effect on public spending (due to unemployment benefits). Hence, deficit-to-GDP ratio is higher in the HLP scenario by an amount of 0.81 percentage points (see Figure 2f).

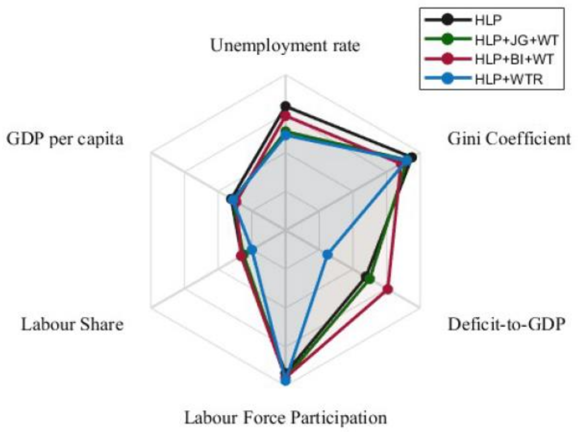
4.2 Policy proposal: Basic Income, Job Guarantee, Working Time Reduction

4.2.1 Single policies

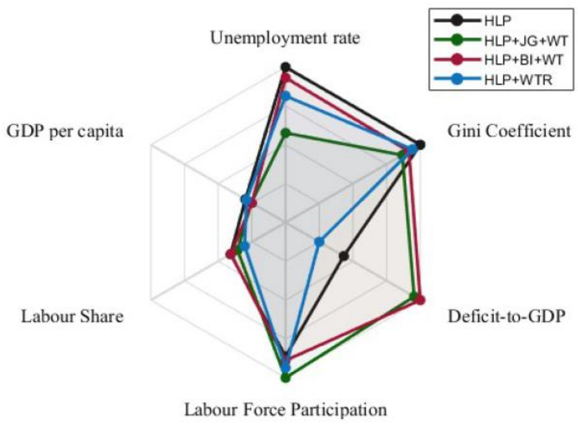
When implemented in the EUROGREEN simulated environment, labour-saving technologies generate negative effects on labour market and inequality. This section describes the effects that BI, JG and WTR would impact on these spheres.

Figure 3 shows how the selected indicators change after the introduction of each policy. Since policies are introduced in period 2023, we compare outcomes in 2030 (Figure 3a) and 2050 (Figure 3b). Before 2023, the scenarios differ only due to the random component of the simulations. All three policies result in higher GDP per capita compared to the baseline, although BI and JG present the best performance in terms of per capita GDP. WTR effectively increases the labour share since it reduces working hours but increases the hourly wage. The reduction in working hours also has a positive effect on employment. By increasing employment and workers' earnings, WTR permanently increases the level of taxation. Hence, WTR has strong and permanent negative effect on the Deficit-to-GDP ratio, since it does not require additional expenditures from the government.

Figure 3. Outcome indicators for single policies.



(a) 2030



(b) 2050

Note: Comparison of scenarios based on key indicators. Indicators are standardised: for each indicator, the scenario-period with the highest value is given a score of 1, and all other scenarios are scored in proportion to that value. For Unemployment Rate, Gini coefficient, Deficit-to-GDP, LFPR, the highest score is represented by the outermost point of the radar chart, while the lowest score is at the center. For the indicators of Labour share and GDP per capita the axis is inverted, with the highest score represented by the center and the lowest score at the outermost point. Therefore, a smaller area of the plot implies a better scenario in terms of outcomes for the selected indicators.

JG is the most successful in preventing the increasing trend in unemployment in the long run. JG policy involves the direct hiring of additional workers up to a maximum of 300 thousand workers, as long as there are unemployed workers. Since JG starts with a smaller number of workers but gradually increases on time, it can effectively reverse the unemployment trend caused by labour-saving technologies. At the end of the simulations, unemployment is kept at a (median) rate of 5,56% in the JG scenario. Note that the other policy scenarios reduce unemployment with respect to the HLP scenario, but they do not revert the trend of increasing unemployment in the long run (see Figure A1.1 in Appendix for the dynamics of each variable in different scenarios). WTR leads to a median unemployment rate of 9,6% by the end of simulation, while scenario with BI leads to a rate of % 11.6%.

The scenario without policies (HLP) presents increasing inequalities, manifested in an increase of around 32.7 to 35.2 in the Gini coefficient between 2014 and 2050. The three policies correct this trend, with a notable reduction in income inequality. BI reduces the Gini coefficient immediately after its introduction. The success of this policy comes from its direct income transfer and the high level of wealth taxation. The BI scenario achieves a wealth tax of 5% in period 2027 (after a few years of implementation). In contrast, JG achieves the top rate for the wealth tax only by period 2047, since it starts with a lower level of expenditure which gradually increases in time. Figure A1.2 in Appendix shows the evolution of the wealth tax rate after the introduction of BI and JG. Naturally, the wealth tax reduces the Gini coefficient and contributes to reducing the impact of both BI and JG on public deficit-to-GDP ratio. However, both policies comprise a level of spending (in the case of JG, this happens only after 2047) that cannot be fully funded by the wealth taxation (given the maximum rate of 5%). Although BI has the strongest effect on GINI by 2030, the most effective policy to reduce inequality, by the end of the simulation, is JG. By the end of the simulations, JG results in a median Gini of 29,0, while BI presents a median of 31,3 and 32,5 in the scenario with WTR.

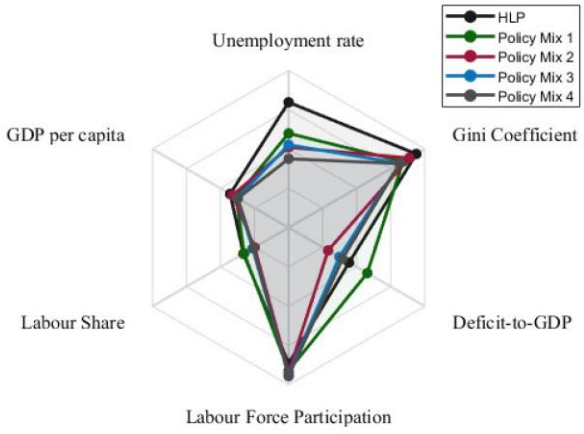
4.2.2 Combination of policies

Figure 4 reports the median values for the main indicators in period 2030 (Figure 4a) and 2050 (Figure 4b). The detailed evolution for the outcome variables can be seen in Figure A1,3 in the Appendix.

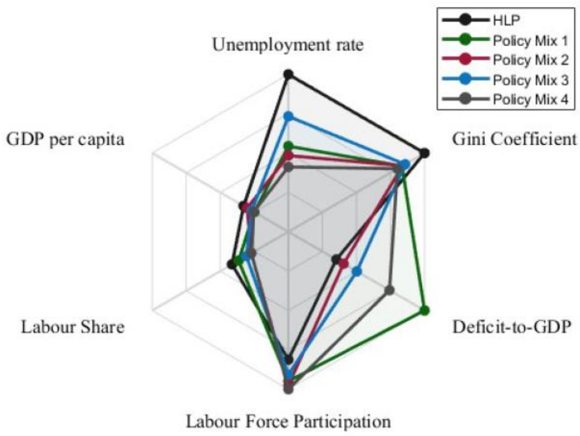
Overall different combinations of policies effectively correct the perverse trends of labour-saving technologies on the labour market and inequality. All scenarios including policy proposals substantially reduce the unemployment rate both in period 2030 and 2050. The presence of JG in the policy mix is fundamental to permanently revert the increasing trend of unemployment caused by labour-saving technologies. Therefore, scenarios Policy Mix 1, 2, and 4 present the lowest unemployment rates by the end of the simulation, with median values between 2.8% and 5.0%. Scenario Policy Mix 3 reduces unemployment in the first years of implementation but cannot persistently avoid the increase in unemployment in the long run. Still, this scenario has an unemployment rate 4.5 percentage points lower than the HLP scenario by 2050 (see Figure 4b).

Nevertheless, the policy mixes including BI and JG impose a burden in the form of greater debt-to-GDP ratio. The scenario combining BI and JG therefore presents the highest deficit-to-GDP ratio both in 2030 and in the end of the simulations. As discussed in the previous section, WTR has a negative effect on public indebtedness, since the increase in hourly wages are funded by the private sector. In fact, all scenarios including the policy WTR have a deficit-to-GDP ratio lower than the scenario HLP in the period 2030. However, by the end of the simulation time horizon, it becomes clear that social policies require greater public spending, resulting in higher deficit ratios compared to the HLP scenario. Among the policy scenarios, Policy Mix 2 and Policy Mix 3 have lower deficit-to-GDP ratios, with median values between 2.3% and 3.7%. These represents values of the deficit-to-GDP ratio that, in the long run, are lower than in 2023. At the end of the period, the scenario with all policies (Policy Mix 4) presents a deficit-to-GDP ratio of 7.3%, while the highest ratio is seen in the Policy Mix 1 (11%). Again, this is because JG and BI imply additional public spending, whereas WTR increases taxation.

Figure 4. Outcome indicators for policy mixes.



(a) 2030



(b) 2050

Note: Comparison of scenarios based on key indicators. Indicators are standardised: for each indicator, the scenario-period with the highest value is given a score of 1, and all other scenarios are scored in proportion to that value. For Unemployment Rate, Gini coefficient, Deficit-to-GDP, LFPR, the highest score is represented by the outermost point of the radar chart, while the lowest score is at the center. For the indicators of Labour share and GDP per capita the axis is inverted, with the highest score represented by the center and the lowest score at the outermost point. Therefore, a smaller area of the plot implies a better scenario in terms of outcomes for the selected indicators.

The different policy mix succeed in reducing inequality and increasing the labour share in the long run. The mix combining all policies (Policy Mix 4) generates the best distributive outcomes as measured by the labour share (76.7%) and the Gini Coefficient (25.9).The combination BI and WTR (Policy Mix 3) produces a faster effect on GINI than the policy combining JG and WTR (Policy Mix 2). The policy mixes including WTR (2, 3, and 4) resulted in a higher labour share. Therefore, Policy Mix 2 achieved a labour share of 76.6% and Policy Mix 3 of 72.8% by period 2050. On the other hand, Policy Mix 1 resulted in a labour share of 66.7%, a little above the scenario without any policy intervention (61.7%). Policy Mix 4 achieved the lowest Gini coefficient by period 2050. The other scenarios of Policy Mix presented a final Gini coefficient between 27.5 and 28.5 by the end of the simulations, well below the HLP scenario (35.2). Policy Mixes including BI (Policy Mix 3 and 4) present a faster fall in inequality, while Policy Mix 2 presents a gradual reduction of inequality.

5 Summary and policy implications

The current wave of technological developments is generating a lively debate among economists and policymakers about the potential disruptive effects that new technologies may have on the labour market, inequality, and our societies as a whole. Public policies have always played an active role in regulating technological change, and this role remains crucial today given the significant impact that new technologies can create. This paper contributes to this debate by evaluating the role that basic income (BI), working time reduction (WTR) and the job-guarantee programme (JB) can play in the context of rapid labour-saving technological change.

To this purpose, we apply the EUROGREEN model (D'Alessandro et al., 2020) to assess if and how much each policy would be able to offset the expected increase in income inequality and unemployment generated by fast and wide automation.

The first point to emphasize is that all the policies analysed in this paper are effective in mitigating the growth of technological unemployment. Given its nature, the JG stands out as the most effective instrument in reducing the unemployment rate.

These policies are also expected to impact on the functional distribution of income. The introduction of a JB scheme and, especially, WTR would implicate a lower reduction or an increase in the labour share of income compared to a scenario without policies. Furthermore, all three measures would also help to reduce the level of personal inequality, which is expected to be lower than in the baseline scenario.

A common critique of these policy measures has to do with their fiscal sustainability. For this reason, the EUROGREEN model accounts for the effects on public finances. The results emerging from our simulations indicate only a mild increase in the public deficit in the long run for those policies (i.e. BI and JG) that involve higher public spending. On the other hand, the public deficit is expected to decrease in the case of WTR, as there it does not involve public disbursement associated with this measure.

A synergistic combination of these policies could amplify the effects on the variables of interest. All the policy packages assessed are expected to reach lower unemployment rates, a higher labour share of income and lower Gini coefficients in the long run. The other side of the coin is that policy mixes tend to increase the pressure on public finances, especially when JG and BI are implemented at the same time. Hence, the combination of WTR with BI and JG would guarantee a reduction or steady level of deficit-to-GDP ratio.

Overall, we conclude that BI, JG and WTR could be effective tools to counterbalance the possible negative effects brought by rapid technological change. When comparing these policies, we find that WTR and JG demonstrate more significant improvements in the indicators analysed, although WTR has the notable advantage of not imposing pressure on public finances.

We also underline that the EUROGREEN model is capable to account for uncertainty in the evolution and spread of technological innovations (see section 3) as it is crucial in any evaluation of future events. Hence, we are confident that, although our projections are not precise forecasts of what will happen in the future, they provide reasonable and robust -- tested via sensitivity analyses -- indications of the sign and magnitude of every single policy and policy mix on the main macroeconomic indicators.

More generally, these findings nurture the debate regarding the debate on the potentially disruptive role of new technologies. Public policies can play an active role in correcting the more undesired effects of technological change and promote a more equitable distribution of economic benefits ensuring that the fruits of technological progress are shared by all members of society.

At the same time, we should also mention that the benefits spreading from the introduction of the policies analysed in this paper are not limited to the indicators analysed in this paper. Other authors have highlighted how these policies are likely to impact also other spheres, such as workers' wellbeing (Lepinteur, 2019), gender equality (Cieplinski et al., 2022), insecurity and human health (Painter, 2016). Further research may try to take on board these areas of evaluations to have a more comprehensive picture of the effects of the policy analysed in this paper.

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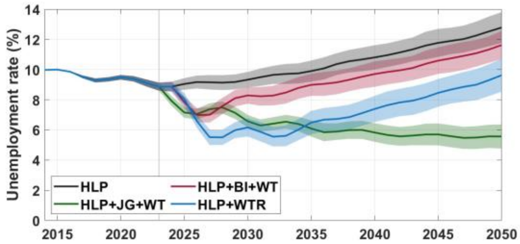
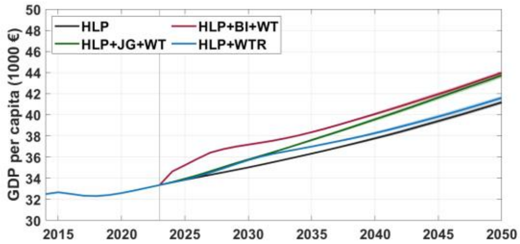
7 Appendix

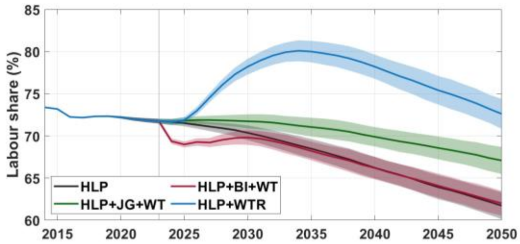
Figure A1.1. Single policies



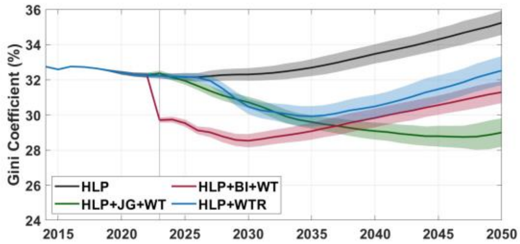
(a) Unemployment Rate



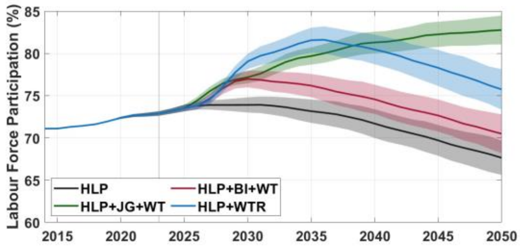
(b) GDP per capita



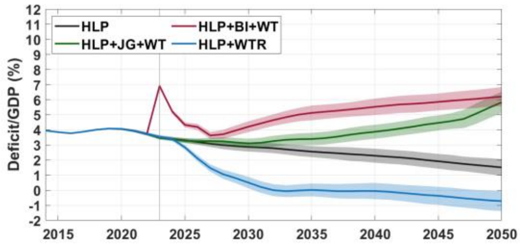
(c) Labour Share (%)



(d) Gini Coefficient



(e) Labour Force Participation Rate (%)



(f) Deficit/GDP ratio

Figure A1.2. Wealth tax

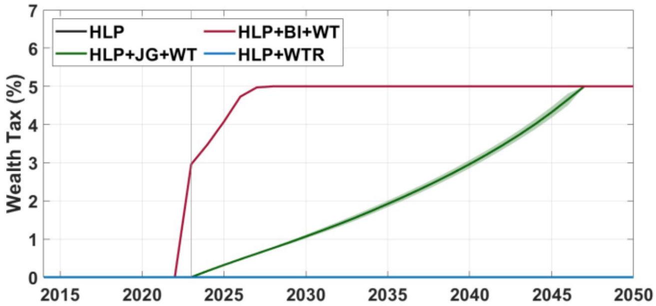
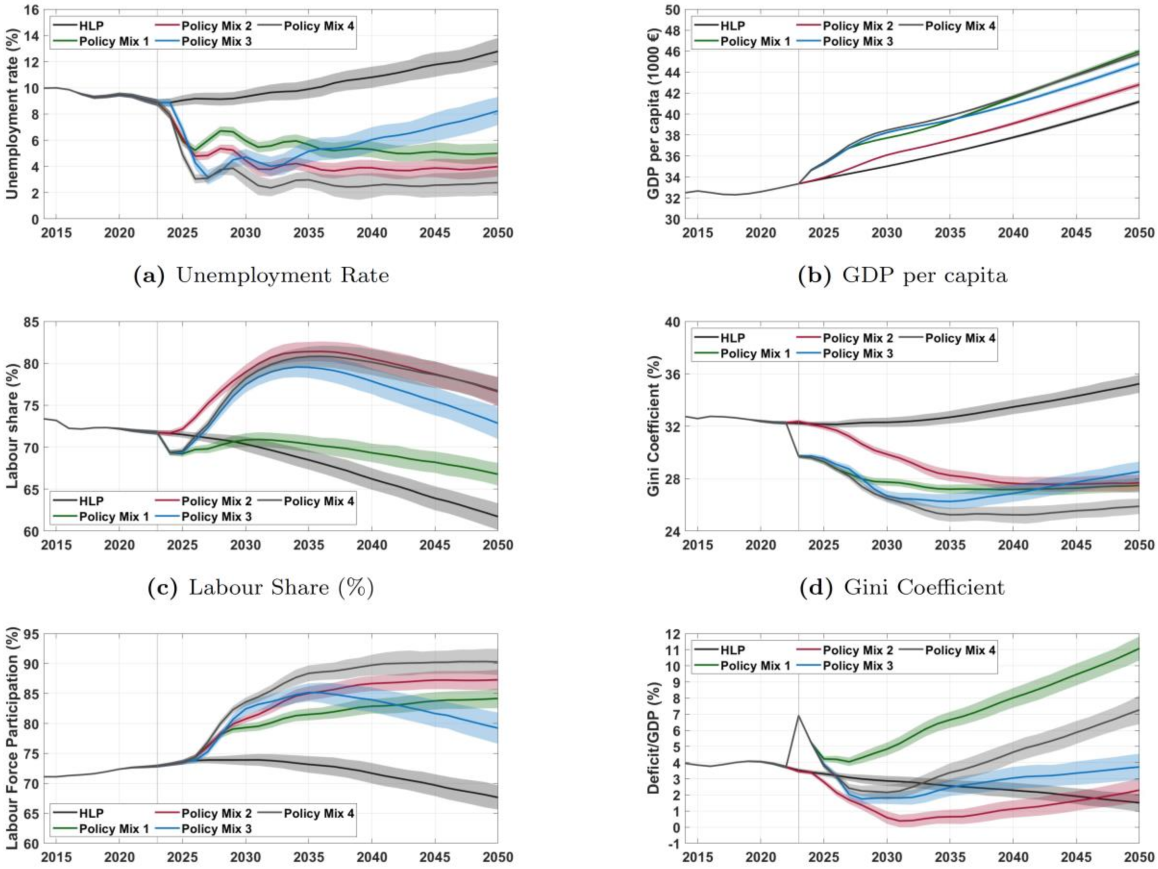


Figure A1.3. Policy Mixes



(a) Unemployment Rate

(b) GDP per capita

(c) Labour Share (%)

(d) Gini Coefficient

(e) LFPR

(f) Deficit/GDP ratio

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