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Exploring policy responses to labour-saving technologies: An assessment of basic income, job guarantee, and working time reduction

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Abstract

This study examines policy responses to labor-saving technologies, focusing on employment and income inequality. Using the EUROGREEN model, we assess three scenarios: basic income, job guarantee, and working time reduction. The job guarantee scheme effectively reduces unemployment but raises the fiscal deficit, while working time reduction improves wage share, cuts deficits, and reduces inequality. Basic income has a moderate impact on unemployment but significantly reduces inequality but is accompanied by higher deficits. A wealth tax could help finance these policies and contribute to inequality reduction. This research provides novel insights to policymakers by demonstrating how a strategic mix of labour policies can improve socio-economic outcomes in the face of technological-induced job disruptions.
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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 policymakers. Most of the available literature is concerned with assessing the possible impacts of technological change and innovation on a wide range of variables such as labour demand (Chiacchio et al., 2018; Frey & Osborne, 2017), the labour share (Acemoglu & Restrepo, 2020; Autor & Salomons, 2018), labour productivity (Salvatore, 2021), power and control (Fana & Villani, 2023) and income inequality (Acemoglu & 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 explores the economic feasibility of different policy measures in response to the challenges posed by labour-saving technologies. We simulate the effects of three policy measures -Basic Income (BI), Job Guarantee (JG), and Working Time Reduction (WTR) with equal pay- against a scenario of rapid technological change. Some of these policies are relatively unconventional, but they are gaining traction in recent academic discussions and policy recommendations (Caamal-Olvera et al., 2022; Cárdenas & Villanueva, 2021; La, 2023; Magnani & Piccoli, 2020; Nandy et al., 2021; Theurl & Tamesberger, 2021, among others).

We assess the impact of these three 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. While different contributions analyse each one of these policies separately, to the best of our knowledge, there are no papers that compare simultaneously the three policies in a context of labour-saving technological progress.

We find that BI, JG and WTR could potentially offset some of the negative effects related to rapid technological change, namely growing unemployment and inequality. These effects, however, are not uniform. As it will be presented below, JG effectively lowers unemployment but increases the fiscal deficit, while BI has a moderate effect on unemployment, significantly decreases inequality, but leads to higher deficits. Working time reduction boosts the wage share, decreases public deficits, and reduces inequality. The combination of two or three policies combines the virtuous effect of each, generating scenarios with better performance in terms of socioeconomic indicators.

The paper is structured as follows. The next section briefly reviews the relevant literature on the impact of new technologies on employment, income distribution, and inequality. Moreover, it presents the three policy measures analysed in this study. The main features of the EUROGREEN model are outlined in Section 3, while Section 4 describes the scenarios used in the simulations and their calibration. The results of the simulations are presented in two parts, following a "sequential scenario" framework designed to isolate the impacts of each labour

policy and evaluate their cumulative effects. Initially, the outcomes for each policy measure are presented individually, set against a backdrop of rapid technological change with no policy intervention, to ascertain the distinct effects of each policy. Subsequently, a second round of simulations integrates various policy measures to explore their potential interactions and combined impact. Section 5 concludes with a summary of the main findings and discusses their implications for policy.

2. 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.[2]As Mokyr et al. (2015) observed, technological anxiety has consistently accompanied the evolution of capitalism. Historical attempts by economists to evaluate the impacts of technological change and explore potential policy responses are exemplified by Burtle (1957). Burtle specifically investigated how the reduction of working hours and the introduction of a job guarantee program could serve as responses to automation. Pasinetti (1981), analysed the relationship between technical change on labour demand using an input-output framework and stressed that the final effect on the unemployment rate would depend from the evolution of final demand as well as working time.

Hence, the current discussions surrounding the rise of automation and other new technologies echo previous debates. However, a novel aspect of the current discourse is the extent to which this wave of technological change might be more disruptive than those in the past. In this respect, Acemoglu and Restrepo (2019) provide a theoretical framework explaining the relationship between the rise of new technologies and labour demand. The introduction of new technologies enables firms to substitute labour with capital, as an increasing array of tasks can now be performed by machines. This results in what is termed the displacement effect, which negatively impacts labour demand. However, this effect is mitigated by two countervailing forces: 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.

Research is increasingly identifying which jobs are most impacted by new technologies such as automation, which is linked to job polarization and a decline in routine jobs, while some studies argue elementary occupations are more susceptible to automation (OECD, 2019). However, examining the broader impact of technology on national employment is crucial. Studies from various regions show mixed effects, with some indicating job losses due to automation (Chiacchio et al., 2018; Frey & Osborne, 2017, among others) while others suggest automation may not necessarily reduce employment (e.g. Domini et al., 2021; Kromann et al., 2020; Lee & Lee, 2021).

While these findings are often industry-specific, the broader debate on technology's impact on employment continues. A more pessimistic view, supported by much of the current literature (Acemoglu & Restrepo, 2021; Autor et al., 2020; Lankisch et al., 2019), suggests that rising productivity could contribute to declining labour share and increased income inequality. This

[2] An extensive literature review on these topics goes beyond the scope of our paper (for an in depth discussion on the topic, see Mondolo, 2022).

synthesis highlights the dual effects of technological progress and emphasizes the need for comprehensive policy responses to mitigate potential negative outcomes.

In short, technological advancements and the substitution of human labour by machines have been constants throughout history. However, the transformative impact of the current technological wave on the economy is causing increasing concern. Many scholars contend that this wave could automate a significantly larger number of jobs without adequately compensating through new job creation. This trend is expected to result in a sustained decline in labour demand, a decrease in the labour share of income, and a widening of inequality. Given these potential outcomes, it is crucial to analyse the disruptive effects of significant technological shocks and to discuss the role that various policy measures can play in mitigating these impacts. In this paper we address these issues studying the impact of three policies using the EURO-GREEN model (D'Alessandro et al., 2020). These policies can be briefly presented as follows.

2.1. Basic income (BI)

BI is a policy where a government provides a regular, unconditional payment to all citizens, regardless of their financial status or employment situation. Originally envisioned as a universal and generous benefit, many current proposals envisage some restrictions and/or offer a lower amount, often insufficient to fully support individuals, thereby not entirely eliminating the need to work. While BI could help address economic vulnerability, reduce inequality, and mitigate the impact of technological advancements, pilot projects like those in Manitoba and Finland have shown mixed results (Kangas et al., 2019; Simpson et al., 2017). Challenges include economic feasibility, funding requirements, and the limited scope of these trials, which may not fully capture the macroeconomic impacts. Different studies indicate that BI could have significant redistributive effects and a progressive impact on tax reforms (e.g. Caamal-Olvera et al., 2022; La, 2023).

2.2. Job guarantee (JG)

A JG scheme entails the government providing employment to anyone willing to work, aiming to reduce unemployment and poverty while expanding public sector job opportunities. JG is designed as a policy tool to lower unemployment, alleviate poverty and contrast mounting inequality (Tcherneva, 2020). Moreover, instrument that the government can employ to reach socially desirable objectives such as the creation of "green jobs" that are intended to help reducing polluting emissions (D'Alessandro et al., 2020). While this policy has been recently employed on a local scale (Imai, 2007; Nandy et al., 2021), it is important to assess the potential effects of JB schema at the aggregate level. In this respect, the policy's cost is a critical concern, with estimates suggesting it could be a significant portion of GDP. Some authors argue that the multiplier effect from increased public sector employment, might offset the initial financial burden, making JG a viable tool for managing economic fluctuations and promoting social equity (Theurl & Tamesberger, 2021).

2.3. Working time reduction (WTR)

WTR has been one of the most conventional responses to technological change until the first half of the XX century and implies decreasing the number of hours worked per week without a reduction in wage. With rapid technological advancements and automation, WTR is proposed

as a means to distribute work more evenly across the workforce and potentially reduce unemployment (De Spiegelaere & Piasna, 2017). Evidence from recent reforms and simulations suggests that reducing working hours can lead to job creation, lower unemployment rates, and decreased income inequality (Askenazy, 2013; Cárdenas & Villanueva, 2021). 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). Additionally, WTR may boost productivity, enhance workers' wellbeing, and have positive environmental effects (Cieplinski et al., 2021a, 2021b; Lepinteur, 2019; Pencavel, 2015).

3. Methodology

We adapt the EUROGREEN model (presented in detail in D'Alessandro et al., 2020; Cieplinski et al., 2021a, 2021b; Distefano & D'Alessandro, 2023) to study the labour market effects of technological progress, and explore potential policy responses. EUROGREEN is grounded on three main methodological pillars:

1. *Post-Keynesian Economics*: considers that output level and growth are 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 feedback 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" (Hardt and O'Neill, 2017). 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 representation of the EUROGREEN model can be seen in Fig 1).

3.1. Innovation process

The core of the model is represented by the input-output approach, grounded on national accounts. Given $i = 1, \ldots, s$ 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:

$$\boldsymbol{A} = \boldsymbol{Z} \cdot \hat{x}^{-1} \tag{1}$$

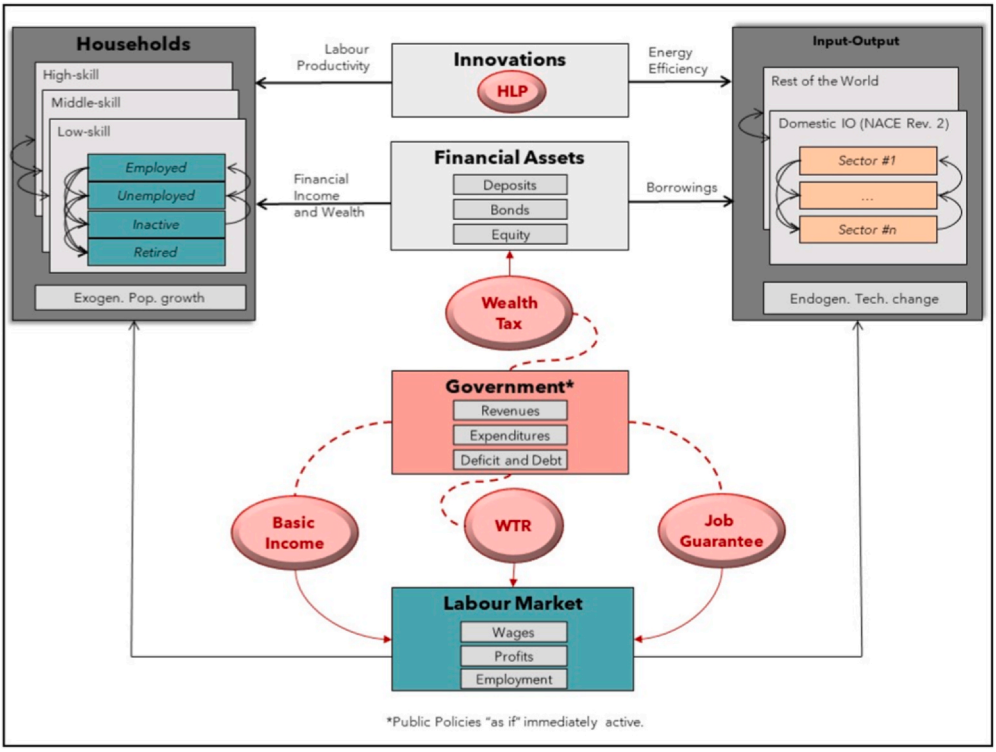


Fig 1. Macroview. Note: Macroview adapted from the EUROGREEN model (D'Alessandro et al., 2020; Distefano and D'Alessandro, 2023), to highlight the main impacts of the labour policies here introduced, namely Job Guarantee (JG), Working Time Reduction (WTR), Basic Income (BI), plus a Wealth Tax (WT). These policies are compared against the hypothesis of technology-induced high labor productivity (HLP). Red buttons represent the policies implemented in the policy mix scenarios.

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:

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

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

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 $\mathbf{A}$. Indeed, the model assumes that firms adjust their intermediate demand ($\mathbf{Z}$) 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 $\bar{\lambda}$ labor productivity, with weights defined by new investments in fixed capital (I_t) and the stock of older fixed capital after depreciation $K_{t-1}(1-\delta)$.,[3] respectively:

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

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

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

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 focus on three single 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 yearly benefit to all working-age adults that substitute or reduces other social transfers.
3. **Working time reduction** (WTR): We assume that the weakly working full-time gradually reduces, in five years, from 35 to 30 h without loss of total salary.

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" framework (Distefano and D'Alessandro, 2023; Nieto et al., 2020) in order to isolate the impacts of each different labour policy and evaluate their cumulative effects. Since policies may generate mixed outcomes on several, a combination of policies can be more effective for a general improvement of labour market outcomes. We, therefore, test alternative policy packages composed of a combination of two or more single policies listed above. The list of policy mix addressed in the paper are presented in table 1.

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. Therefore, we compare scenarios based on the median value for 500 simulations. The figures report median values for each

Table 1
List of policy combinations.

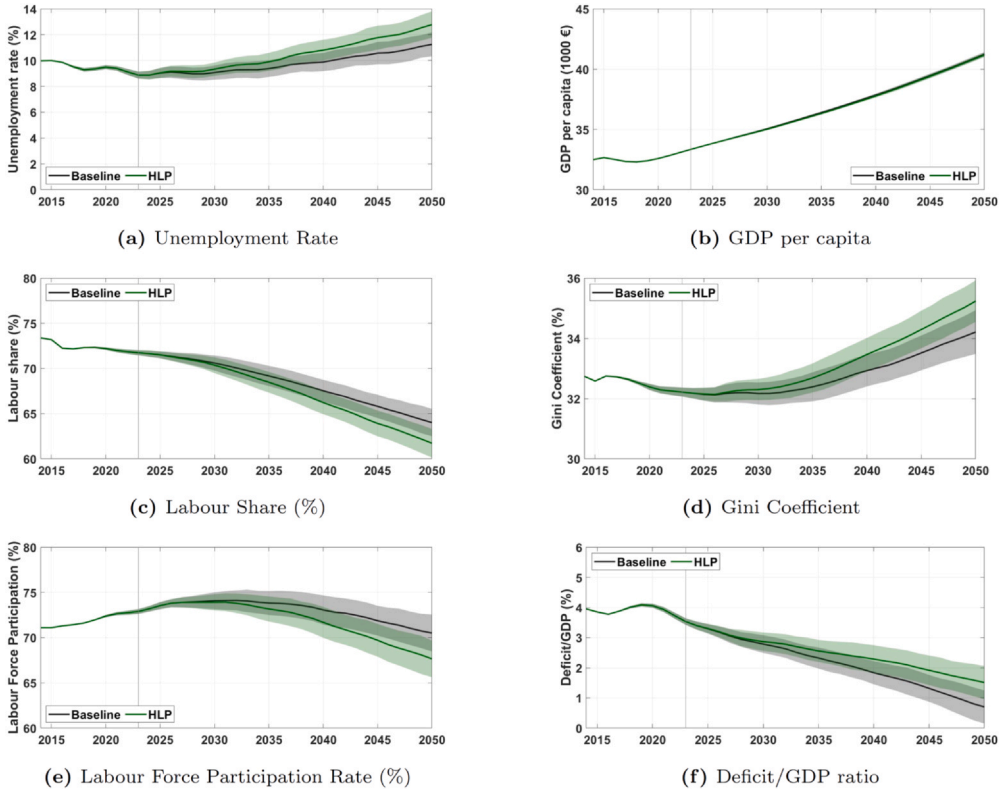
Scenario	Active Policies
HLP	Labour-saving technologies, no policy
Policy Mix 1	BI, JG, and WT
Policy Mix 2	JG, WTR, and WT
Policy Mix 3	BI, WTR, and WT
Policy Mix 4	BI, JG, WTR, and WT

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

Fig 2 compares the dynamics of the baseline scenario with a scenario of fast labour-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.

Although both scenarios follow similar trends for GDP per capita, they substantially differ in terms of inequality and labour market indicators. 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 2.3 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



(a) Unemployment Rate (b) GDP per capita

(c) Labour Share (%) (d) Gini Coefficient

(e) Labour Force Participation Rate (%) (f) Deficit/GDP ratio

Fig 2. Labour saving technologies.

skilled workers. 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 0.8 percentage points (see Fig. 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. In this section we analyse how policy responses can counterbalance these effects. Fig 3 shows how the selected indicators change after the introduction of each policy (BI, JG and WTR).

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 per capita working hours also has a positive effect on employment. By increasing employment and workers' earnings,

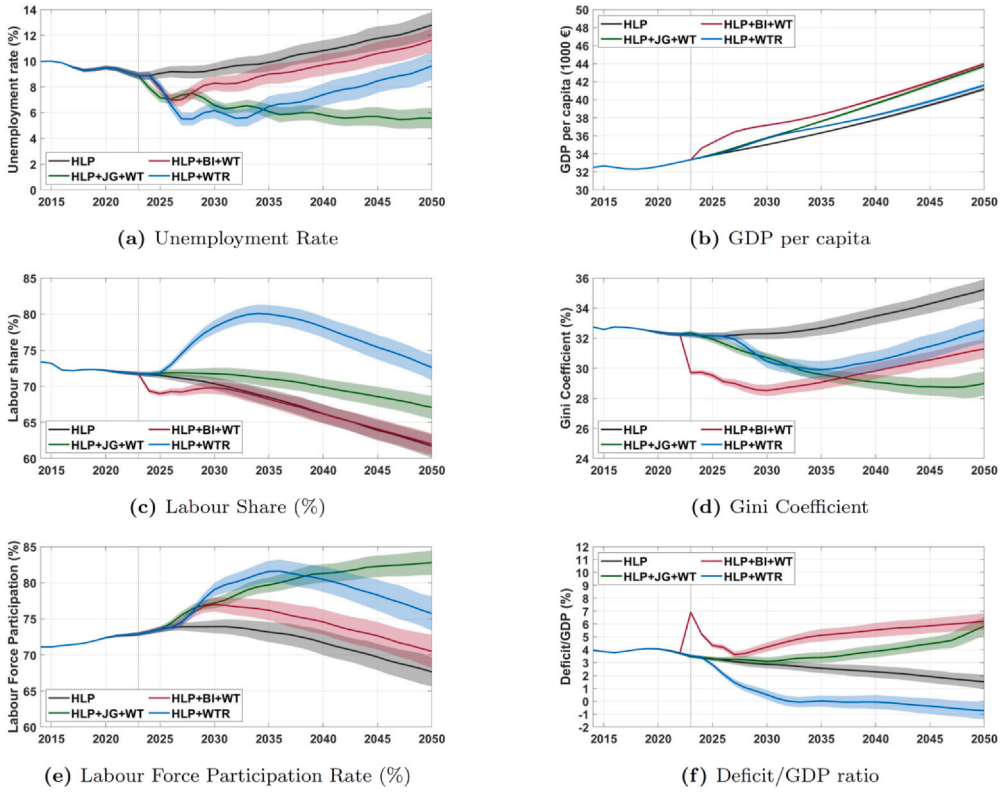


Fig 3. Outcome indicators for single policies.

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.

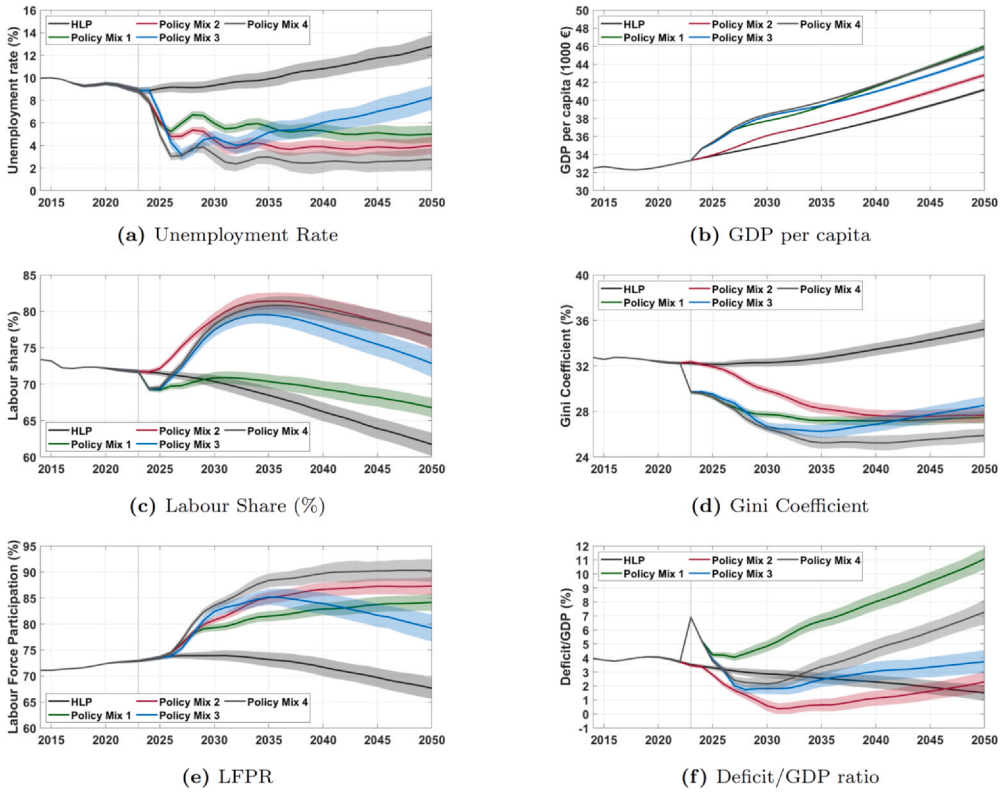
JG is the most successful policy in preventing the increasing trend in unemployment in the long run. JG involves the direct hiring of additional workers up to a maximum of 300 thousand workers, as long as there are involuntary unemployed workers. Since JG starts with a smaller number of workers but gradually increases in 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 5,6 % 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. 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 three policies correct the trend of increasing inequality of HLP. 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. 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 the Gini coefficient by 2030, the most effective policy to reduce inequality in the long run 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

Fig 4 reports the median values for the main indicators over the period 2030–2050 when we combine different policies (*as per* Table 1). 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 (BI + WTR + WT) 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 Fig. 4a).

Nevertheless, the policy mixes including BI and JG impose a burden in the form of greater debt-to-GDP ratio due to the high increase in terms of deficit-to-GDP. 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. Therefore, any policy scenario which includes WTR (Policy Mix 2 and Policy Mix 3) record lower deficit-to-GDP ratios, with median values between 2.3 % and 3.7 %. These represent 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



(a) Unemployment Rate (b) GDP per capita

(c) Labour Share (%) (d) Gini Coefficient

(e) LFPR (f) Deficit/GDP ratio

Fig 4. Outcome indicators for policy mixes. Note: 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.

is seen in the Policy Mix 1 (11 %). Again, this is because JG and BI imply additional public spending, whereas WTR increases taxation and does not involve public spending.

The different policy mixes 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 more gradual reduction of inequality.

5. Summary and policy implications

We applied the EUROGREEN model (D'Alessandro et al., 2020) to explore policy responses to the disruptive effect of technological progress on the labour market. Our analysis

focused on the potential effects of universal basic income (BI), working time reduction (WTR), and a job guarantee program (JG). We also examined scenarios that combined these policies to assess their integrated impacts. We found that all the three policies effectively mitigate the growth of technological unemployment.

As expected, the JG stands out as the most effective instrument in reducing the unemployment rate, which is consistent with the findings of similar literature (D'Alessandro et al., 2020; Godin, 2012). Satisfactorily results in reducing the unemployment rate are obtained also via the WTR, although in the long term the reduction in unemployment tends to reverse due to the persistence of technological change.

As to income distribution and inequality, the introduction of a JG and, notably, WTR could result in a less severe reduction or even an increase in the labour share of income compared to a scenario without these interventions. Additionally, all three policies demonstrated potential to mitigate levels of personal inequality, yielding outcomes more favourable than those in the baseline scenario. These findings complement the simulations regarding BI performed for other countries (Caamal-Olvera et al., 2022; La, 2023).

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. Our results showed a mild increase in the public deficit in the long run for those policies (i.e. BI and JG) that involve higher public spending. The wealth tax, introduced to offset the spending increase associated with BI and JG policies, proved to be an additional tool to reduce inequality, as recently argued by various scholars (Apostel & O'Neill, 2022; Piketty et al., 2023). The growth in fiscal deficit is more problematic for BI than it is for the JG scheme, where the increase in public spending is more gradual. The implementation of these policies brings the fiscal deficit to about 6 % for BI and JG at the end of the period. On the other hand, the public deficit decreases in the WTR scenario, since this policy does not require public disbursement while tax collection tends to increase.

A synergistic combination of these policies could significantly enhance their impact on key economic variables. The policy packages here assessed are projected to reduce unemployment rates and the Gini coefficient and increase the labour share of income over the long term. However, there is a trade-off as these policy mixes tend to exert additional pressure on public finances, particularly when the JG and BI are implemented concurrently. To mitigate this, combining WTR with BI and JG could stabilize or even reduce the deficit-to-GDP ratio, offering a balanced approach to fiscal sustainability while still reaping the social benefits of these policies.

Overall, we conclude that BI, JG and WTR could be effective tools to counterbalance the 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. These findings contribute to the ongoing debate about the potentially disruptive role of new technologies. Public policies can actively mitigate undesirable effects of technological change and promote a more equitable distribution of economic benefits, ensuring that the gains from technological progress are shared across all societal segments.

Our results do not consider other effects of the three policies analysed in this paper (Owan et al., 2021; Pencavel, 2015), workers' wellbeing (Lepinteur, 2019) and environmental benefits (Cieplinski et al., 2021a, 2021b). To provide a more comprehensive evaluation of the effects of the policies studied, future research should consider the dimensions that, for the sake of parsimony, have not been addressed in this paper. This broader approach will help in understanding the full impact of these measures, enhancing our ability to craft policies that address the multifaceted challenges posed by rapid technological advancements.

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