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The impact of climate change mitigation policies on European labour markets

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The impact of climate change mitigation policies on European labour markets*

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Abstract

We study the impact of climate change mitigation policies intended to reach the 2-degree target set in the Paris Agreement on the structure of European labour markets. Employing a three-sector macro-econometric model with a rich labour market extension, we show that measures targeted at shrinking the use of fossil fuels in electricity generation and road transport sector, which has an overall modest positive impact on GDP and total employment, can make occupational structure less unequal and polarised in 2030 in more than half of the Member States of the European Union, particularly, where the industries most affected by the transition to a low-carbon economy (i.e., mining and quarrying, utilities, and manufacturing of coke and refined petroleum products) remain relatively most important.

JEL classification: J21, Q52.

Keywords: Europe, polarisation, labour market, climate change, 2-degree target.

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1. Introduction

Although there is a wide agreement on the convenience of addressing the challenges posed by global warming, climate change mitigation policies might harm some segments of the population in the short term. Determining the impact of any sort of public sector intervention is not only in the best interest of citizens but also it helps to deal with the potential resistance of the sectors most affected by these actions. The Yellow Vests' protests in France, partly associated to a remarkable hike in fuel taxes, bring up the convenience of addressing the political economy of the measures for carrying out the so-called ecological transition (Milanovic, 2018).[1]

The aim of this work is to shed light on the effects of climate policies intended to achieve maintain the increase in global temperature below 2 °C in 2030 on the labour market structure of labour of the European Union (EU) plus the United Kingdom.[2] Measures targeted at reducing CO_2 through shrinking the use of fossil fuels in electricity generation and road transport sector might imply a process of creative destruction, with employment losses and gains located at different places of the occupational distribution. Projecting these kinds of consequences becomes essential for designing compensatory mechanisms that can improve the political feasibility of these mitigation policies.

Actually, ensuring a just transition to a low-carbon economy represents one of the main concerns of the International Labour Organization (2015). A wide range of studies, inspired by very different modelling strategies, explores the im-

[1] In fact, the European Union Just Transition Mechanism aspires to mobilise €100 billion over the period 2021–2027 in the most affected regions, to alleviate the socio-economic impact of the transition.

[2] At the time of performing this research the UK was still part of the EU. Hereafter, for brevity, when using the term EU, the group of states included also comprises this country.

plications of this shift on both income and employment; they mostly suggest the existence of overall modest positive effects on both magnitudes due to the ecological transition.[3] Nevertheless, there is a remarkable scarcity of studies addressing issues like the quality of jobs or gender equality (García-García et al., 2020). To the best of our knowledge, there is no previous research addressing the same outcomes as ours, i.e., labour market inequality and polarisation. Nevertheless, we have several examples of works addressing inequality concerns using a wide range of methodologies. For instance, various studies highlight the regressive impact of higher electricity prices (Frondel et al., 2010; Frondel et al., 2015), network charges (Schlesewsky & Winter, 2018), or public subsidies for renewables (Andor et al., 2015) due to the ecological transition in Germany. Bernardo and D'Alessandro's (2016) systems-dynamics analysis for Italy shows that the shift to a low-carbon economy might increase the labour share at the expense of output and wages growth. Lastly, it is worth mentioning the results of D'Alessandro et al. (2020), whose dynamic macrosimulation model forecasts a widening of income inequality among total population in France by 2050 unless market-based incentives of green growth come together with radical redistributional policies like a job guarantee or working time reduction. Given the great and growing importance given by the European citizens to the climate change (European Commission, 2019), the widening economic disparities (European Commission, 2014), and the limited empirical evidence on the topic, the distributional concerns about the measures required for carrying out the transition to a low-carbon economy constitutes a hot topic

[3] García-García et al. (2020) provides a very comprehensive survey of this literature, which covers, among others, Earth system models, Computable General Equilibrium models, Input-Output analysis, macro-econometric models, Integrated Assessment Models, and models of Keynesian and Post-Keynesian inspiration.

nowadays.

This work makes use of a global macro-econometric model integrating a range of social and environmental processes, a set of modules that allow translating the impact of these types of measures into employment implications by occupation and sector of activity, and a ranking of jobs derived from labour force surveys—a simple and rough way of approaching to job quality—to explore how these global warming mitigation interventions affect labour market inequality and polarisation by country.[4] The main finding of the paper is that the overall impact on employment is generally positive and the impact on occupational structure, limited. Overall, in those countries where mining and quarrying, utilities and manufacturing of coke and refined petroleum products still hold a relevant weight nowadays (i.e., some Eastern Europe states), the transition to a low-carbon economy might make the labour market less unequal and polarised.

The contribution of this paper is twofold. The first one is of a substantial nature: it enlarges our understanding of the consequences of policies aiming at curbing global warming on the labour market. Particularly, it focuses on the changes in occupational structure, identifying the niches where job creation and destruction occurs. This rather crude approach to job quality allows evaluating the impact of energy transition on both inequality and polarisation on the European labour markets. In the second place, to the best of our knowledge, this study represents the first work that applies rigorous measures of ordinal inequality and polarisation to explore changes in occupational structure.

The rest of the paper unfolds as follows. In the second section, we describe the

[4]Labour market polarisation and inequality have attracted much attention in other domains, such as the assessment of the impact of technological change (see, e.g., Barbieri et al. [2019] and Jerbashian [2019], among many others).

main features of the model used to estimate the impact of the climate change mitigation policies implemented to reach the 2-degree target and the tools employed for measuring ordinal inequality and polarisation. Section 3 presents and discusses the main findings of the analysis. In the last section, we draw several conclusions from this modelling exercise and summarise the main implications of this research work.

2. Methodology

2.1. Modelling strategy

The simulation of climate change mitigation policies draws on the European Centre for the Development of Vocational Training (Cedefop in its French acronym) skills forecasting model (Cedefop, 2009, 2012; Cedefop & Eurofound, 2018). It intends to provide comprehensive projections on the future trends in the labour market structure (Figure 1). In its 2018 projections, among other outcomes, the Cedefop model anticipates the number of jobs by occupation and sector of activity until 2030. This forecasting exercise involves the use of the Energy-Environment-Economy Global Macro-Economic (E3ME) multi-sectoral macro-econometric model and six modules, forming the Cedefop Skills Forecast framework, to translate its results into implications for skills supply and demand (Cedefop, 2009).

Overall, the forecasting exercise draws on data from Eurostat, including population projections (with specific forecasts on migration and ageing), national accounts, and the European Labour Force Survey (EU-LFS). The first module consists in the E3ME model, developed and maintained by Cambridge Econometrics, and allows forming projections of labour demand by industry and labour supply by demographic group. Modules 2–7 are not full models in the sense of the E3ME model and they make use of the EU-LFS microdata to estimate trends of changes in occupations within sectors or for qualifications. Modules 2, 3, and 4 cover the demand for skills. Their forecasting draws on fitting trends of aggregate qualification patterns among the population and labour force, combined with more sophisticated approaches based on econometric analyses of microdata on individuals (mainly, using the EU-LFS). Modules 2 and 3 deals with employment levels and expansion demand for occupations (EDMOD) and qualifications (QMOD), respectively. The forecasting module designed to calculate changes in employment (expansion demand) by occupation (EDMOD) draws on trends of occupations within each industry derived from the EU-LFS microdata. Using econometric techniques, it estimates such trends by economic activity and applies them to the E3ME sectoral employment results. The estimation of employment by qualification level (QMOD) follows a similar approach.

The fourth one focuses on replacement demand (RMOD), job openings due to workers leaving a job because of retirement, migration, or mortality. The population stocks are used to ascertain trends in the data. The estimation of replacement demand draws on stocks of age-cohorts by occupation and qualification, and it excludes transitions from one occupation to another. The EU-LFS allows analysing the demographic composition of each occupation and, consequently, specific rates of retirement for each occupational class. This data source also makes possible to estimate rates of outflow. This module applies models and information on the probability of leaving employment (owing to retirement, migration, or other reasons) to the output of the two previous modules in order to forecast job openings by qualification and by occupation. The modelling of skills supply corresponds to

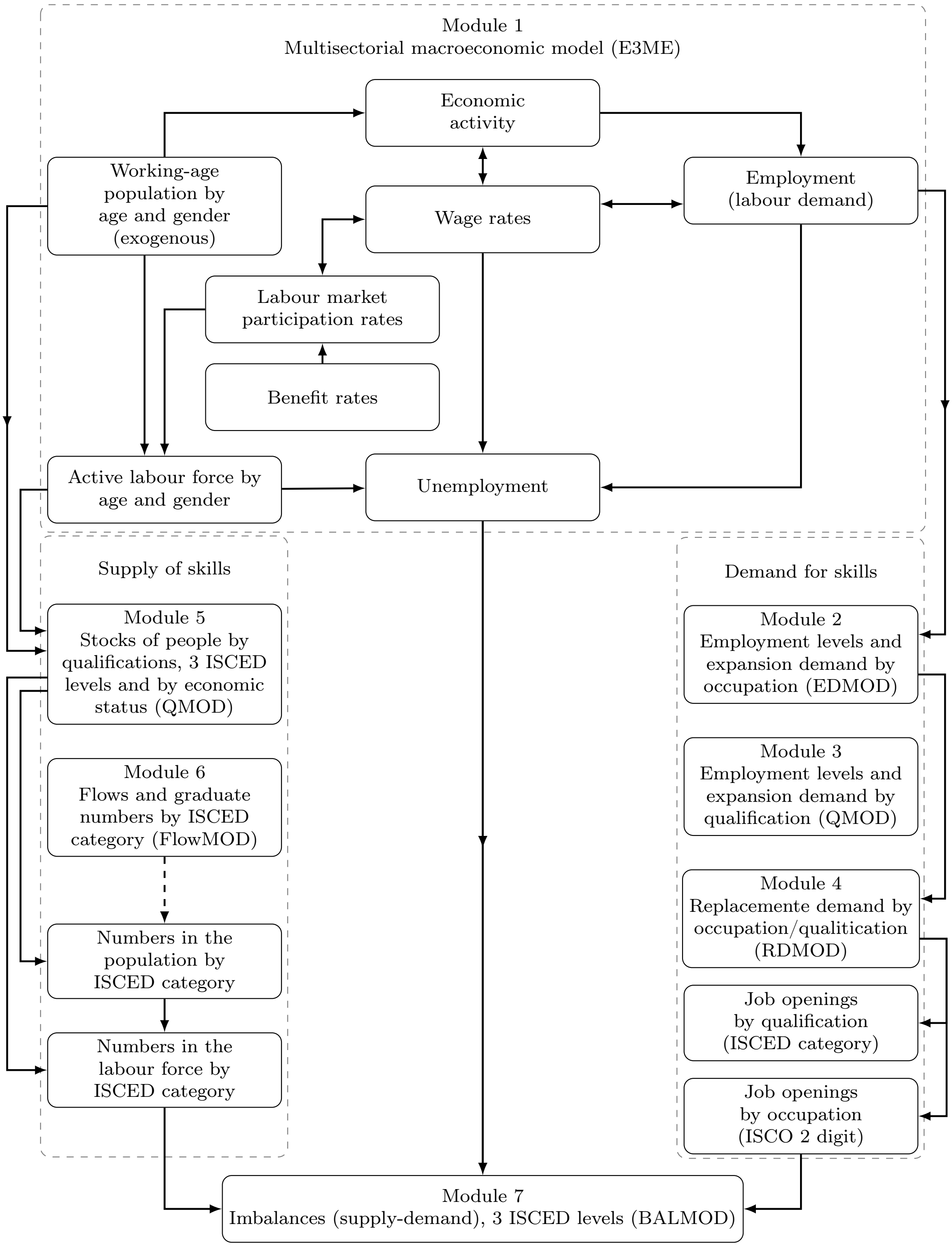
Modules 5 and 6, which analyse working-age population stocks and flows by the highest level of qualification held, respectively. The E3ME model includes a demographic module for estimating active labour force by age group and gender from the effect of economic activity, real wage rates, unemployment, and benefit rates on the working-age population stocks projected by Eurostat. Forecasting focuses on stocks, and it comprises from rather simple models that fit trends of aggregate qualification patterns among population and/or labour force to more sophisticated econometric strategies based on the exploitation of individual level data (mainly, from the EU-LFS) (Cedefop, 2012).

The last module reconciles skills supply and demand, exploring the resulting imbalances. A group of individual country experts review and validate the results of the model.

In order to explore the consequences of the ecological transition on inequality and polarisation in the labour market, we extend this framework in two ways. In the first place, departing from 2015, the model is able to project employment until year 2030 by occupation and sector of activity, so it is possible to integrate them with the jobs-based framework of the European Job Monitor (EJM) developed by the Eurofound. The EJM provides a ranking of jobs, defined as combinations of occupations and industries, based on the mean hourly wage by country. It makes possible to carry out an exhaustive assessment of employment changes across the earnings distribution. Secondly, we explore the consequences of policies aimed at holding the global average temperature below the 2 °C above pre-industrial levels, achieving the target set in the Paris Agreement (United Nations, 2015) (hereafter, the energy scenario).

E3ME is a global macro-econometric Energy-Environment-Economy (E3) model

Figure 1. Cedefop skills forecasting model



Source: Authors' elaboration.

widely used for the evaluating the impact of climate and energy policy during two decades (Barker et al., 2016; Barker et al., 2007; Ekins et al., 2012; Foley et al., 2016; Mercure et al., 2018a; Mercure et al., 2018b; Mercure, 2012; Mercure et al., 2019; Pollit et al., 2015). It represents one of the most advanced models of its kind, since it allows for an integrated treatment of national economies, energy systems, emissions, and material demands, capturing two-way linkages and feedback among these components, and provides highly disaggregated results by country and industry (Cambridge Econometrics, 2014). It has some features of Post-Keynesian inspiration, since it does not assume that economies work at their full capacity (with not totally flexible pries and output determined by aggregate demand) and agents' behaviour does not come from optimization under perfect information but from parameters estimated from macro-econometric analyses of historical time-series.[5]

The so-called energy scenario consists in achieving a level of global CO_2 emissions in 2030 associated to a 66% probability of limiting the temperature increase to below the 2-degree-target (Intergovernmental Panel on Climate Change, 2014), whose achievement requires stronger climate change mitigation policies and a different technological trajectory than those currently in place.[6] Such a policy scenario includes some carbon pricing mechanisms already in place (e.g., the EU Emissions Trading System), as well as continued support for renewables and energy efficiency, an expansion of carbon pricing, and a partial removal of fossil fuel subsidies. The E3ME is a suitable tool for simulating the impact of these kinds of policies, be-

[5]See Pollit et al. (2015) for a thorough comparison between Computable General Equilibrium models and this sort of strategy in this area of research.

[6]The Nationally Determined Contributions of the states, including the 40% reduction in CO_2 emissions committed by the EU are not enough for achieving this target.

cause it computes energy demand by sector and sort of fuel. Overall, this scenario targets those sectors responsible of most of CO_2, electricity generation and road transport, trying to shrink the use of fuels with a high content of carbon. The implementation of this strategy in the modelling develops in an iterative way, with the establishment of additional measures until achieving the 2-degree target. Specifically, the model in this scenario deploys the following policies:[7]

— A carbon emission price of $155 in constant 2012 values in 2050. Such a carbon price is set globally but applied at a national level through cap-and-trade systems and/or carbon taxes.

— Public programmes, funded by the revenues from carbon pricing, to improve the energy efficiency in households, industry, and commerce consistent with the recommendation of the International Energy Agency (2016).

— A biofuel mandate applied to aviation with the effect that about 18% of fuel in this sector will come from this sort of fuel by 2050.

— Power generation policies aimed at promoting renewables, particularly, wind and solar power, that comprise feed-in tariffs (which guarantee the price received by producers) and direct subsides decreasing over time (around 10–15% of the additional investment costs and up to 60% in some circumstances).

— Road transport policies for promoting the shift to low-carbon vehicles that include a proportional tax on vehicles depending on carbon emissions per kilometre, higher road fuel taxes, regulation after 2018 to phase out the

[7]This range of measures applies to the 59 global regions covered by the E3ME model, although some countries (e.g., China, Russia, Ukraine and some nations from Latin American and the Association of Southeast Asian Nations) demand further regulations to reduce the use of coal outside the power generation sector.

least fuel efficient vehicles, limitation after 2020 of high-polluting luxury vehicles in some countries, electrification of the public vehicle fleet (as a way of fostering charging facilities), setting higher emissions standards for new cars after 2018, and a biofuel mandate in several countries in order to reach the emissions reduction target.

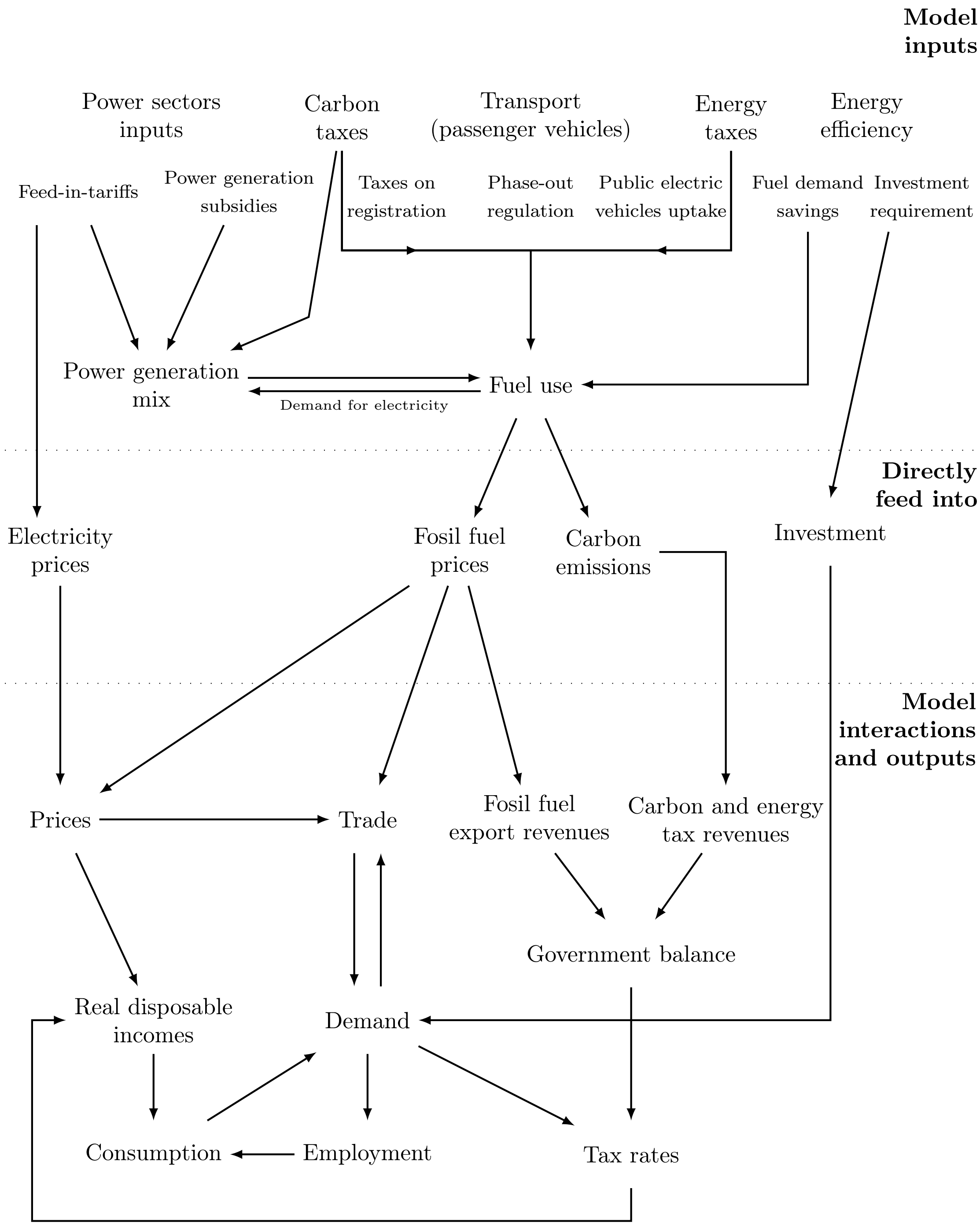
The E3ME models all this battery of policies through its inputs, as Figure 2 illustrates. The seven policies detailed above unfold on power sector inputs, carbon taxes, transport, energy taxes, and energy efficiency. They induce a decline in the demand for coal, oil, and gas, lowering the global prices of fuels and reducing of carbon emissions. The model allows for a feedback between energy prices, carbon revenues, and investment, affecting real disposable incomes, and consumption expenditure.

Power sector inputs (feed-in tariffs and subsides) foster a shift of the power generation mix towards renewables, leading, at least initially, to an increase in electricity prices unless greater degrees of adoption of this technology result in cost reductions. This composition change leads to a decrease in the demand for conventional fuels, with an impact on electricity prices.

Carbon taxes drive the price of carbon-intensive fuels up, which lowers their demand and affects the power-generation mix. The transport sector interventions described above, which favours the uptake of more efficient or electric vehicles, reduce the demand for petrol and diesel by road transport in favour of electricity.

The target of publicly funded energy efficiency policies (e.g., better household insulation and more efficient appliances) is to shrink the demand for fuels. This scenario is neutral in terms of the fiscal budget balance in all countries through adjustments in the income tax, the value added tax, and social security contribu-

Figure 2. Model inputs and links



Source: Authors' elaboration.

tions when needed. If the revenues raised by carbon pricing measures do not cover the whole cost of those policies, the model allows the governments to the use of the mentioned tools to fill such a gap. If the resources collected exceed investment costs, the E3ME model assumes the usage of the surplus in reducing taxes.

The investment in energy efficiency and the electricity supply sector stimulates the demand for domestic and foreign goods and services, raising production, employment, disposable income, and consumption expenditure.[8] Conversely, large fossil-fuel-exporting countries might require tax hikes to compensate for the loss of fiscal resources. The model allows price changes to affect differently the competitiveness of the countries—thus impacting the demand for its production—and the outcome of carbon taxation translates into tax rate changes that, in turn, alter consumer spending and the demand for goods and services.

The overall effect of this set of policies is complex, with different implications from country to country. On the one side, one expects that a higher investment associated to renewable technologies and energy efficiency will foster economic growth when countries carry out the production of the capital goods associated to this strategy domestically (and no stimuli if the economy has to import them). On the other side, these measures are very likely to drive energy prices up, with a negative impact on consumer disposable income and external competitiveness. This probably leads to a decrease in the demand for fossil fuels, inducing a reduction in both the extraction and processing associated activities and their global demand. Given that the EU—plus the UK—represents a net importer of fossil fuels, the overall impact of this change on GDP and employment might well end

[8]Note that the E3ME considers direct, indirect and economy wide rebounds effects, i.e., the decrease in savings due to efficiency measures because of the reduction in energy prices (Colmenares et al., 2020).

being positive. Nevertheless, there can exist non-negligible differences across states depending of their economic structures.

2.2. Inequality and polarisation measurement

The key output provided by the model outlined above regarding the aim of this paper consists in a large matrix comprising the distribution of employment across 41 occupations and 63 industries by each EU country.[9] In this context, as mentioned above, the definition of a job corresponds to a combination of an occupation and an economic activity, which results in almost 2,600 potential categories. This number is much smaller in practice, as many occupations only exists in certain industries. The next step is to order this set of jobs according to an ordinal wage ranking built by the Euforound (2021) for year 2015 drawing on several EU-level databases.[10]. As a result, the main output of interest in terms of labour market structure consists in a distribution of employment across such an ordinal ranking. There is a large body of literature in Economics and Sociology making use of this type of approach, with slight variations, to monitor middle- and long-term changes in job quality (see, among many others, Autor et al. [2003], Fernández-Macías [2012], Goos and Manning [2007], or Oesch and Rodríguez Menés [2011]). The translation of the measures due to the transition to a low-carbon economy into consequences on the occupational structure will depend not only on the countries' sectoral composition but also on the position of the jobs affected by the climate change mitigation policies across the wage distribution. The Eurofound's database also provides two additional rankings we use for assessing the robustness of the

[9]The taxonomies of occupations and sectors of activity consist in a slightly aggregated version of the International Standard Classification of Occupations 2008 and the Statistical classification of economic activities in the European Community Revision 2 at the two-digit level.

[10]See Eurofound (2019b) for details on the construction of the ranking.

main results. The first one considers the average educational level by cell and the second relies on a non-pecuniary job quality index based on 38 variables capturing the amenities in different dimensions of work (Eurofound, 2013).

As argued by Jenkins (2021), it is inappropriate to use tools developed for measuring cardinal inequality and polarisation to analyse data of this nature. Therefore, in order to evaluate the labour market implications of the measures adopted to achieve the 2-degree target, we draw on measures of ordinal inequality and polarisation proposed in the Welfare Economics literature. The indicator of inequality employed here comes from Cowell and Flachaire (2017), whereas we select the polarisation index proposed by Apouey (2007). These two measures allow comparing distributions whose medians might differs (Jenkins, 2020; Sarkar & Santra, 2020), as it is the case of the job distributions in 2015 and 2030 under two different scenarios that represents the inputs of the analysis. Specifically, the indicator of inequality we employ hereafter displays as follows (Cowell & Flachaire, 2017):

$$I(\alpha) = \begin{cases} \frac{1}{\alpha(\alpha-1)} \left(\frac{1}{N} \sum_{i=1}^{N} s_i^{\alpha} - 1 \right), & \text{if } 0 < \alpha < 1 \\ -\frac{1}{N} \sum_{i=1}^{N} \log s_i, & \text{if } \alpha = 0 \end{cases} \tag{1}$$

where s_i is the share of population/sample with a job ranked less than or equal to individual i (the downward-looking status of individual i), N denotes the population/sample size and and $0 \leq \alpha < 1$ is a parameter that captures the sensitivity of the inequality index $I(\alpha)$ to different parts of the distribution. The larger that α is, the smaller is the weight put on highly ranked jobs relative to low ranked ones.

The study of polarisation in the context of occupational structure has not certainly fulfil very high formal standards when compared to the developments in Public Economics. This literature has tried to determine whether there is a relative decline of jobs in the middle of the wage distribution relative to the top and the bottom. This objective, expressed in a little vague and informal way, has relied on verifying the existence of a U-shaped relationship between the observed employment change and the rank of the job—through the inclusion of a quadratic polynomial in the rank variable in a linear regression and a focus on the estimated coefficient of second-order term—and the graphical visualization of the patterns of employment growth across the job distribution using a certain number of quantiles (see, among many others, Goos and Manning [2007] and Fernández-Macías [2012]). These approaches neither discuss nor state explicitly their value judgements and, at best, only allow determining whether there is a change in the polarisation of labour market structure, since they do not put a number on this phenomenon. Nevertheless, building on the pioneering contributions of Esteban and Ray (1994) and Foster and Wolfson (2010), a several solid proposals for measures of ordinal polarisation has emerged in the field of Public Economics (see, e.g., Jenkins [2021] or Sarkar and Santra [2020] for a review). However, just some few of these indexes allow comparisons between distributions with different medians, a circumstance very likely to be present in the type of data explored here. Therefore, the analysis presented in this paper relies on one of the indexes that is suitable for this task, the $P_2(e)$ polarisation index, proposed by Apouey (2007) and expressed as follows:

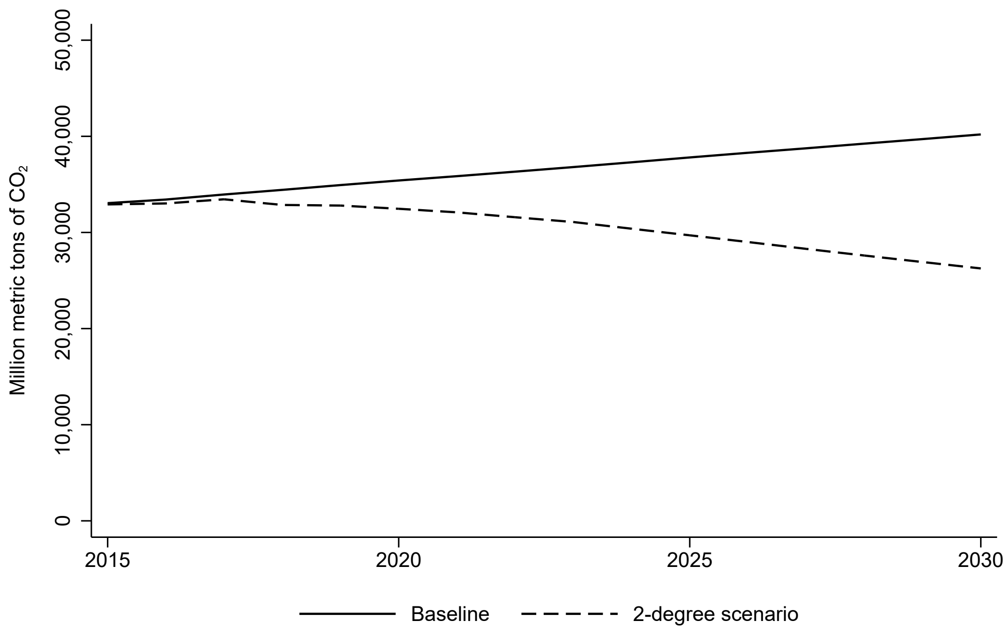
$$P_2(e) = 1 - \frac{2^e}{K-1} \sum_{k=1}^{K-1} \left| F_k - \frac{1}{2} \right|^e \tag{2}$$

where F_k represents the proportion of individuals allocated in the category k or lower, K, the total number of classes and e is a parameter that determines how concentration within the groups below the median and within the categories above the median contributes to polarisation. For instance, the index aggregates the distances between F_k and 0.5 employing the square root of absolute distances if $e = 0.5$, a linear distance function under $e = 1$ or a Euclidean distance metric if $e = 2$ (Jenkins, 2020).

3. Results

The deployment of the measures for curbing global warming described above results in a reduction of more than a third in CO_2 by 2030 compared to the business-as-usual scenario (Figure 3), in line with previous research works like International Energy Agency (2016), Mitchell et al. (2016) or Peters (2016).

Figure 3. Global CO_2 emissions (million metric tons, 2015–2030)



Source: Authors' analysis.

The EU will decrease its level of carbon emissions in more than 20% compared to the baseline, a less marked decline than the one required for China, India, or the United States, more dependent on fossil fuels (Table 1). The higher level of investment necessary to transforming the electricity generation sector and energy efficiency measures will result in a GDP and employment 0.5 and 1.1% higher than in the baseline scenario, a positive modest impact coherent with most of other forecasts in the specialised literature (García-García et al., 2020). Such an outcome is much more positive than, for instance, in the United States, harmed by the decline of production of oil and gas, and smaller than the one in China or India, with a longer way to walk in terms of embracing—and a larger potential of profiting from—renewable energy technologies.

Table 1. CO_2 emissions, GDP, consumption, investment and employment in 2030 (% change over the baseline)

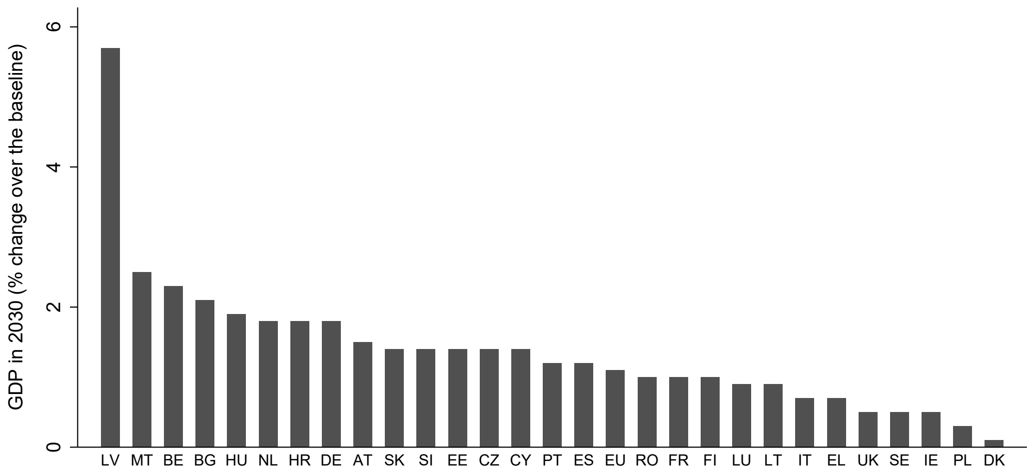
	Global	United States	China	India	European Union plus United Kingdom
CO_2	−34.7	−45.5	−26.5	−53.2	−20.3
GDP	0.1	−3.4	4.7	0.6	1.1
Consumption	0.4	−2.0	11.2	−1.1	0.7
Investment	1.0	−2.5	3.2	1.1	1.7
Employment	0.5	−1.6	2.3	0.1	0.5

Source: Author's analysis.

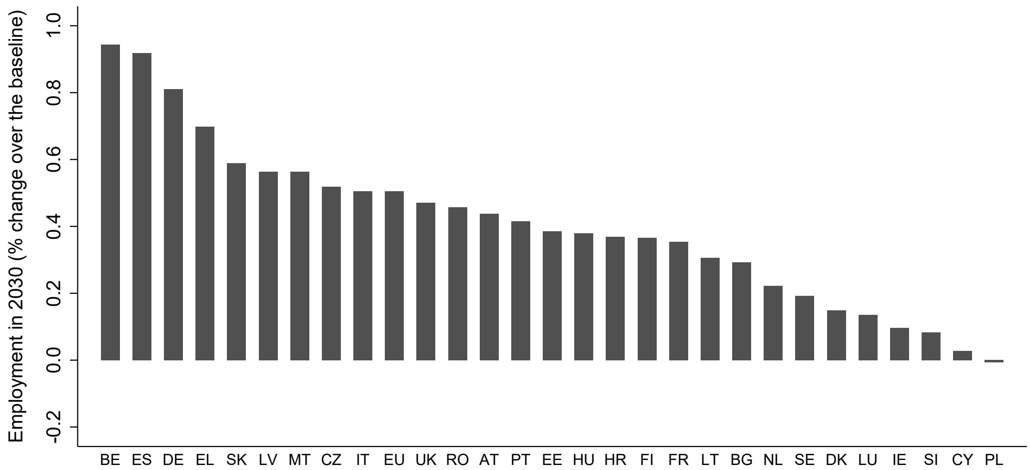
Figure 4 summarises the impact of these policies on GDP and employment in the EU by country. As argued above, the effect on output responds to the investment associated to decarbonization and energy efficiency measures and a lower dependence on fossil fuels imports and their reduced prices. In this line, Latvia experiences the largest economic boost in the EU given to its lag in these sorts of policies and the relevance of fossil fuels imports in 2015. On the opposite side of the spectrum, the Danish case exemplifies that the potential gain will be lower in the most advanced countries in the ecological transition—the level of investment required to meet the decarbonization target is smaller—, but also suggests a more modest effect in those national economies where coal production still plays a non-negligible role, such as Poland or, to a much lower extent, Romania. The effects on employment are of a smaller scale and coherent in most of the cases with the output impact. Nevertheless, there are non-negligible deviations in some countries. The reason for the positive evolution of job creation in Spain is the decrease in energy prices—driven by the development of the photovoltaic sector—that fosters households' incomes and thus the demand for consumer services, largely labour-intensive. In Latvia, the large GDP rise mainly accrues to the much less labour-intensive equipment supply firms. Lastly, decarbonization in Cyprus results in energy prices increases, which negatively affects consumer expenditure and external competitiveness.

Figure 4. GDP and employment in the EU in 2030 (% change over the baseline)

(a) % change in GDP over the baseline



(b) % change in employment over the baseline

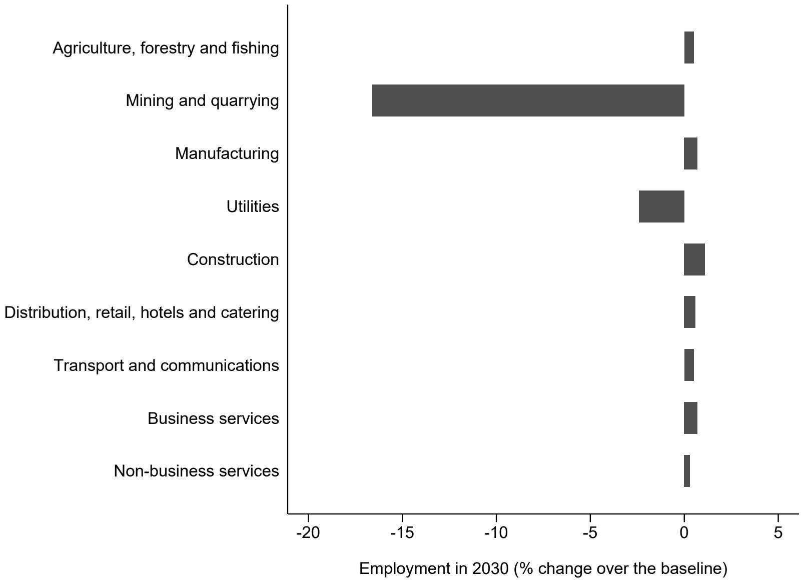


Source: Authors' analysis.

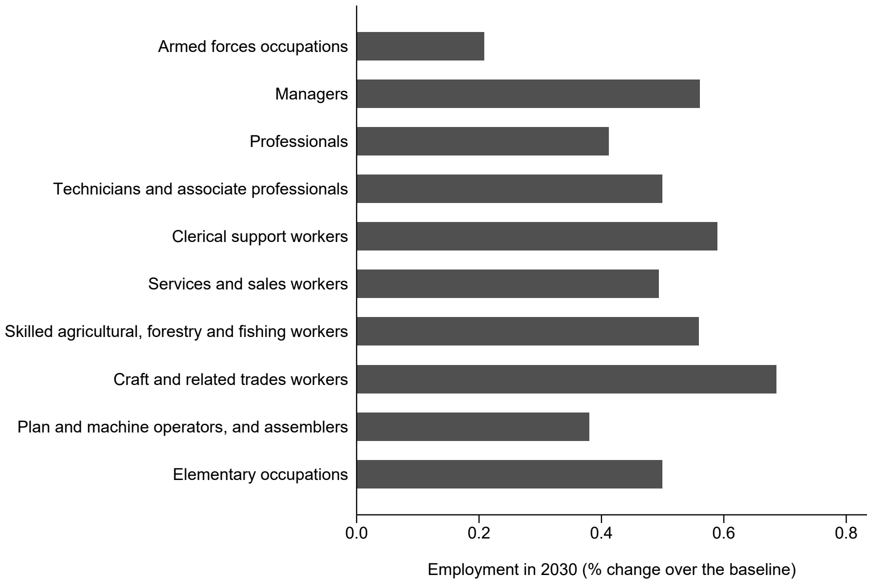
Figure 5 shows the impact of the transition to a low-carbon economy on employment by sector of activity and occupation in the EU as a whole. The industries concentrating the job losses are mining and quarrying and utilities (and a more detailed assessment reveals that manufacturing of coke and refined petroleum products also exhibits a negative evolution). The behaviour of employment in the former sectors reflects the shrinkage of extraction activities, whereas job creation in the latter suffers from the energy efficiency measures that reduces the demand for gas. It is worth commenting on the higher volume of jobs in the construction sector, which benefits from the modernization enhanced by energy efficiency measures and the building of renewable plants. Although many parts of the economy will enjoy a demand boost because of the growth in consumer expenditure, sub--sectors of manufacturing and business services will additionally profit in terms of employment from being part of the supply chain of construction, renewables, and energy efficiency equipment. The outcome in terms of occupation is much less appealing since the differences with the baseline are remarkably small. The most salient finding is the slightly above-average positive impact reported among craft and related trade workers that reflects" the boost of the production of investment goods. In the Annex, we present the same information by country using broad group occupational and sectoral categories (Table A.1) and the top 10 occupation and industries at a very disaggregate level with the highest and lowest growth in the EU (Table A.2).

Figure 5. Employment by sector of activity and occupation (% change over the baseline)

(a) % change in employment by sector of activity over the baseline



(b) % change in employment by occupation over the baseline

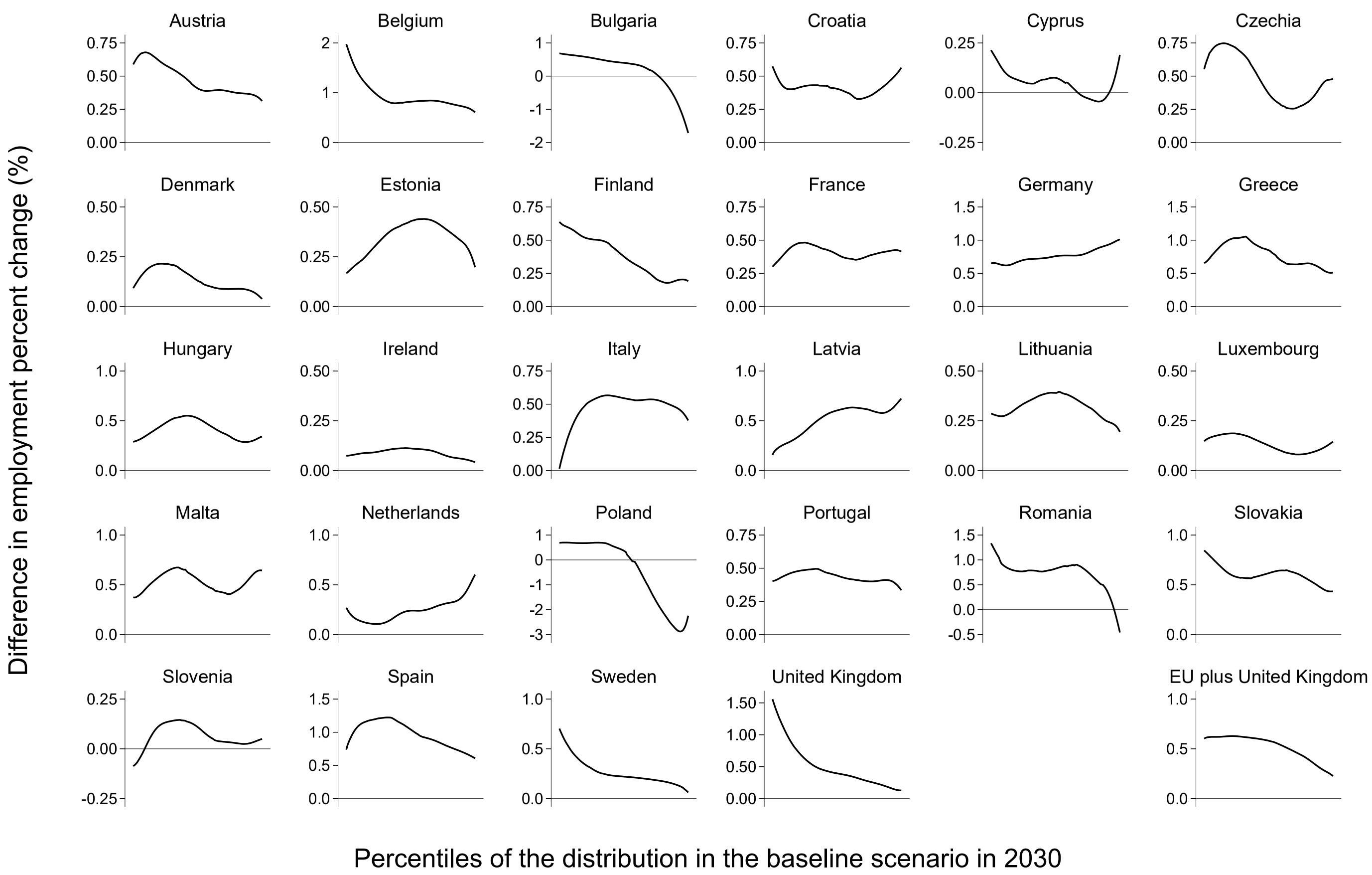


Source: Authors' analysis.

Using locally weighted scatterplot smoothing, we show the pattern of job creation and destruction across the occupational structure by country as a consequence of the climate change mitigation policies (Figure 6). Not only there are remarkable differences in the scope of the changes in employment, as shown above, but there is also a wide diversity in the way that the transition to a low-carbon economy shapes the labour market. Whereas employment change decreases across the wage distribution in states like Austria, Belgium, Bulgaria, Finland, Slovakia, Sweden or the UK, other countries like Malta or Slovenia exhibits a sort of increasing pattern. One observes a roughly uniform pattern in Germany, Latvia or Luxembourg and a rough inverted-U relationship in Estonia, Italy or Lithuania, with a number of cases hard to characterise just through eyeballing. Therefore, the use of tools for measuring ordinal inequality and polarisation becomes particularly attractive considering the limited magnitude of the changes, the existence of so diverse—and not-as-easy-to interpret—national profiles, and the appeal of making comparisons across countries. One should also bear in mind that the impact of those changes on these magnitudes depends not only on where job creation and destruction occur but also on the initial distribution of workers across jobs.

The application of such types of measures (Figure 7), described in Sub-section 2.2, confirms the reduced size of the effect of the policies associated with the achievement of the 2-degree target on ordinal polarisation and, particularly, on ordinal inequality. Decarbonization seems to raise inequality in the labour market in the case of Estonia, Slovenia, Hungary, Lithuania, Sweden, Portugal, Italy, Spain, France, Greece, and Romania and to augment polarisation in Croatia, Austria, the Netherlands, Sweden, Denmark, Luxembourg, France, the UK, Czechia, and Belgium. Interestingly, the EU as a whole experiences a decrease in the levels of

Figure 6. Changes in employment across the occupational structure by country (% change over the baseline)

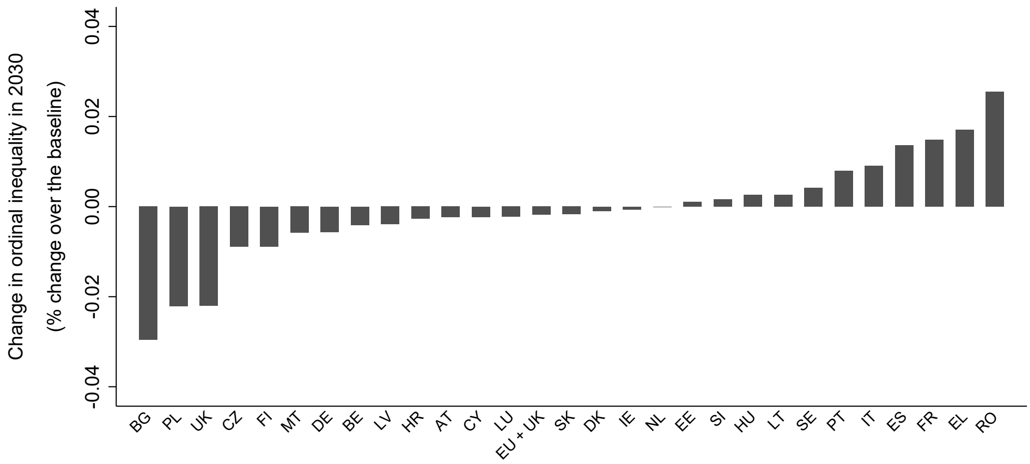


Note: Locally weighted scatterplot smoothing with a bandwidth of 0.75.
Source: Author's analysis.

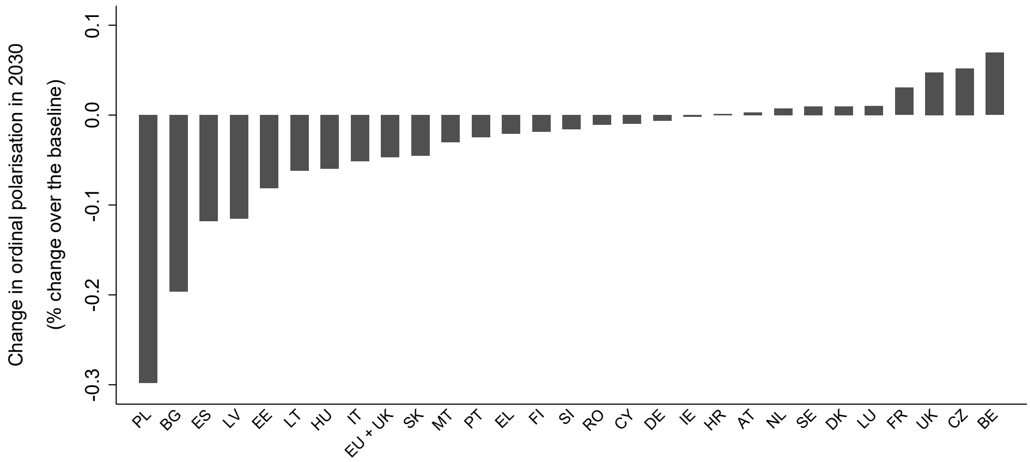
ordinal inequality and polarisation. The existence of a far from perfect, though remarkable, correlation between the variation in both indicators (the Pearson correlation coefficient, ρ, equals 0.33) and the change in the position of many countries depending on the measure considered indicates that one stands in front of different phenomena. This issue is probably worth mentioning given that those terms (inequality and polarisation) are (imprecisely) used as interchangeable terms in a certain share of the labour market literature.

Figure 7. Change in inequality and polarisation in 2030 (% change over the baseline)

(a) % change in ordinal inequality, $I(0)$, over the baseline



(b) % change in ordinal polarisation, $P_2(1)$, over the baseline



Source: Authors' analysis.

Since the model includes a wide set of mechanisms of linkages and each national economy possesses its own peculiarities within industries (e.g., different intensities in the use of fossil fuels), it is inherently quite difficult to determine the drivers of these outcomes. Nevertheless, several findings arise. The first one is that the larger is the share of employment in the most affected sectors (mining and quarrying, utilities, and manufacturing of coke and refined petroleum) in the baseline, the lower is the increase in ordinal inequality and polarisation ($\rho = -0.31$ and -0.49, respectively). There are not so large differences in the position of the jobs associated with these activities across the labour market structure in the baseline: they are mainly concentrated in the upper part of the earnings distribution (see Figure A.1 in the Annex). Nevertheless, whereas the proportion of employment in these industries located in the top quintile of the job structure exhibits a weak correlation with inequality ($\rho = -0.02$), the relationship with the evolution of polarisation seems stronger ($\rho = -0.19$).[11]

There are cases that do not fit this pattern, like Romania—which, unlike the Bulgarian or Polish economy, with the most affect sectors also meaning more than 3% of total employment—, where the job decline observed in these industries is less marked ($-2.8\% - \textit{change}$ in the former compared to more than -10 and almost -8% in the latter countries). There is actually a positive correlation between the change in employment in those industries and the variation in ordinal inequality and polarisation ($\rho = 0.53$ and 0.51, respectively).

In order to assess the stability of the results presented above, we perform two types of robustness checks. The first one refers to the specification of different values for the parameters embedded in the indexes of ordinal inequality and polarisation that capture the sensitivity to inequality in different parts of the distri-

[11]The initial proportion of employment in these sectors in the middle tercile of the distribution only shows a weak relationship with both inequality and polarisation ($\rho = -0.01$ and -0.08, respectively).

bution (α) and how concentration within the groups below and above the median contributes to polarisation (e), respectively. The evolution of both magnitudes remains basically unchanged when varying the values for the mentioned parameters (Table A.3).

My second sensitivity analysis consists in evaluating how the main results in terms of inequality and polarisation vary when using an alternative measure of job quality. With that purpose, we redo the previous calculations considering a job ranking based on the mean educational level and the mean value of an index of non-monetary job amenities by cell. Reassuringly, the main results seem to hold in both qualitative and quantitative terms (Tables A.4 and A.5).

4. Conclusions

While both EU citizenship and international organizations have expressed a large and growing concern on both climate change and economic disparities, our knowledge on the impact of policies intending to curb global warming on labour market inequalities still remains limited. The aim of this paper has been to contribute to fill this gap. Using a three-sector macro-econometric model linked to a rich set of labour market modules and equipped with new inequality and polarisation measures, this research has found that the effects of the measures aimed to achieve the 2-degree target on the EU labour markets is overall modest and should not represent a wide source of concern. The EU-wide impact on both GDP and employment is positive and these actions slightly reduce inequality and polarisation in employment. Nevertheless, the outcomes remarkably differ by country. They mainly depend on the economic structures of national economies and their current levels of progress towards low-carbon ones. Overall, those countries most affected by the shrinking of the industries associated with the production fossil fuels are also those that would profit from the largest declines in ordinal inequality and polarisation in their labour markets. These findings are robust to a wide series of robustness checks regarding the value judgements embedded in the measurement indexes of these magnitudes and the way of ranking jobs within domestic labour markets.

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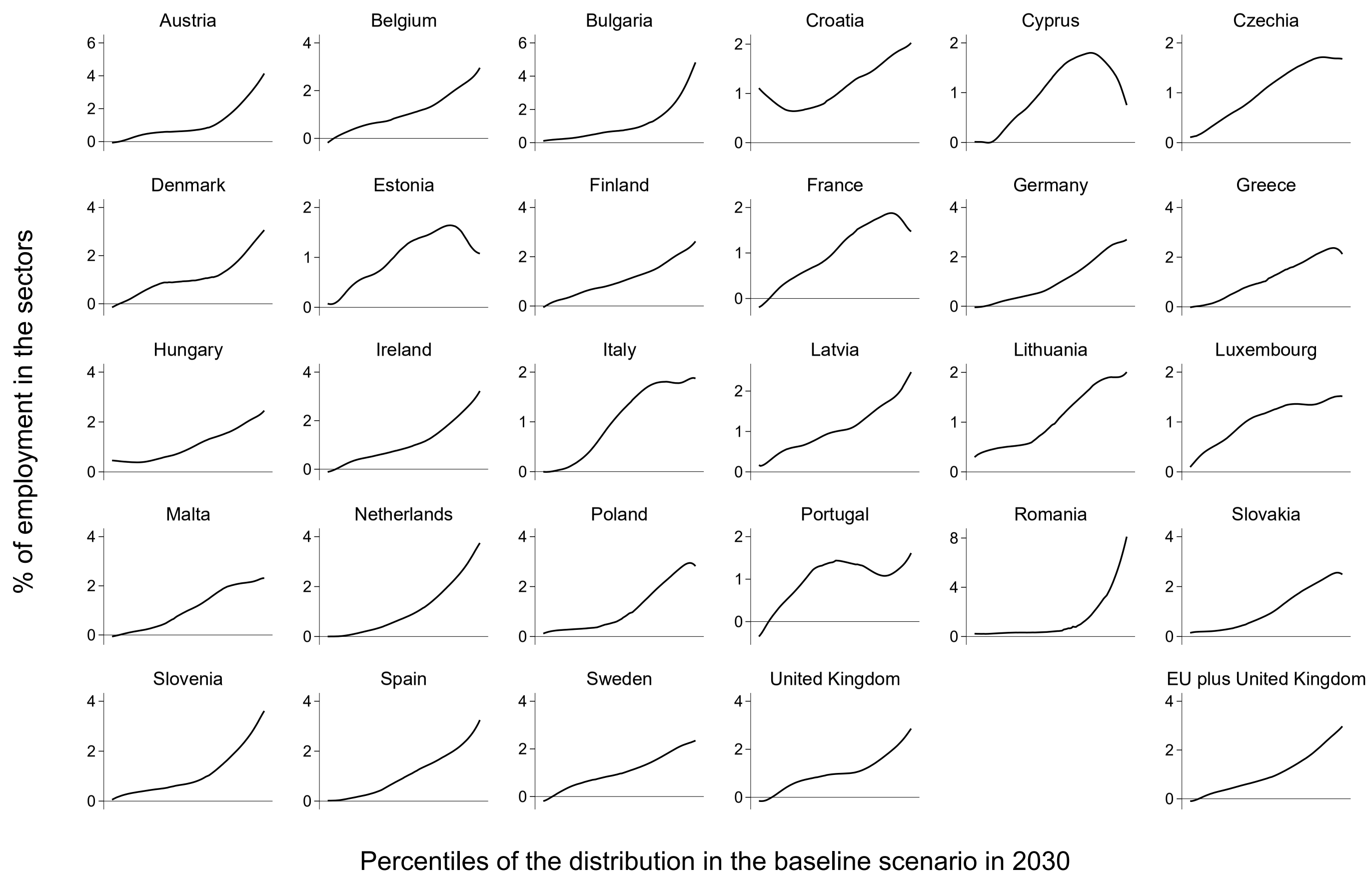
Annex

Figure A.1. Distribution of employment in mining and quarrying, utilities, manufacturing of coke and refined petroleum products across the occupational structure in 2015 (% total employment in the sectors)



Note: Locally weighted scatterplot smoothing with a bandwidth of 0.75.
Source: Authors' analysis.

Table A.1. Change in employment in 2030 under the 2-degree scenario compared to the baseline by country, occupation and industry (% change deviation from baseline)

	Occupation					Sector of activity						
	Total	High-skilled white collar	Low-skilled white collar	High-skilled blue collar	Low-skilled blue collar	Agriculture, forestry and fishing; Mining and quarrying	High-technology industry	Low-technology industry	Construction	Knowledge intensive services	Less knowledge-intensive services	Non-manufacturing industries
AT	0.46	0.43	0.38	0.55	0.58	0.29	0.60	0.82	0.55	0.40	0.49	−2.35
BE	0.98	0.95	1.17	1.00	0.76	0.24	1.21	0.10	2.49	0.89	1.17	−2.43
BG	0.31	0.05	0.31	0.58	0.45	1.05	−0.48	0.52	1.05	0.49	0.41	−12.65
CY	0.06	0.04	−0.02	0.20	0.12	0.40	0.06	−0.12	0.80	0.19	−0.06	−3.87
CZ	0.52	0.56	0.43	0.92	0.15	−5.20	0.79	1.17	2.56	0.46	0.57	−1.99
DE	0.84	0.82	0.71	1.27	0.75	0.03	0.12	0.33	3.12	0.63	1.00	1.62
DK	0.15	0.14	0.08	0.33	0.19	−0.42	1.28	0.79	0.53	0.11	−0.01	−0.94
EE	0.38	0.32	0.36	0.53	0.45	0.13	0.44	0.25	1.16	0.28	0.54	−1.94
EL	0.69	0.85	0.76	0.35	0.72	0.02	−0.15	0.39	0.99	0.82	0.86	−3.21
ES	0.91	0.81	0.88	1.42	0.84	0.02	0.33	1.98	2.34	0.63	0.86	−0.06
EU + UK	0.51	0.47	0.53	0.65	0.45	−0.56	0.62	0.72	1.05	0.42	0.65	−2.35
FI	0.37	0.15	0.32	0.54	0.92	0.10	0.84	0.98	0.91	0.01	0.83	−7.06
FR	0.35	0.34	0.31	0.61	0.26	2.03	0.68	1.46	−0.20	0.12	0.51	−0.39
HR	0.37	0.29	0.22	0.82	0.41	1.76	1.93	0.32	0.38	0.15	0.39	0.00
HU	0.38	0.26	0.23	0.67	0.60	0.17	0.78	1.27	1.34	0.26	0.24	−4.14
IE	0.08	0.09	0.08	0.06	0.10	−0.03	0.32	0.23	0.00	0.09	0.10	−1.03
IT	0.50	0.59	0.43	0.51	0.41	0.89	1.98	0.27	0.50	0.62	0.33	−1.23
LT	0.31	0.27	0.25	0.44	0.33	0.00	1.09	0.27	1.16	0.20	0.31	−1.30
LU	0.13	0.10	0.07	0.38	0.17	0.80	0.15	0.24	0.66	0.04	0.09	−0.63
LV	0.57	0.47	0.45	0.54	0.90	0.48	0.46	0.19	1.42	0.47	0.78	−2.44
MT	0.57	0.55	0.65	0.59	0.47	0.20	0.17	0.39	0.32	0.64	0.66	0.00
NL	0.23	0.32	0.15	0.08	0.22	−0.10	−0.06	0.23	0.16	0.57	−0.16	−1.43
PL	−0.07	−0.18	0.22	0.48	−0.76	−4.02	0.76	1.08	1.02	0.32	0.60	−6.82
PT	0.41	0.40	0.46	0.39	0.39	0.09	0.54	0.23	0.87	0.50	0.38	−0.37
RO	0.47	0.49	1.02	0.07	0.45	−0.09	0.51	0.38	0.00	0.55	1.17	−2.59
SE	0.22	0.15	0.17	0.26	0.53	0.15	0.10	0.43	0.12	0.12	0.47	−1.07
SI	0.08	0.03	0.04	0.11	0.21	−0.08	−0.08	0.36	0.05	0.00	0.14	0.00
SK	0.59	0.42	0.51	0.75	0.95	0.00	0.62	0.40	1.60	0.40	0.84	−1.74
UK	0.46	0.40	0.52	0.23	0.64	−0.92	1.32	0.66	0.13	0.33	0.78	−5.31

Source: Authors' analysis.

Table A.2. The 10 occupations and industries with the highest and lowest growth in the European Union in 2030 (% change deviation from baseline)

Occupation	%Δ	Industry	%Δ
Stationary plant and machine operators	−0.09	Mining and quarrying	−16.56
Armed forces	0.21	Manufacture of coke and refined petroleum products	−6.91
Personal care workers	0.22	Electricity, gas, steam and air conditioning supply	−4.92
Street and related sales and service workers	0.25	Veterinary and other professional, scientific and technical activities	−0.58
Teaching professionals	0.25	Wholesale and retail trade and repair of motor vehicles and motorcycles	−0.54
Subsistence farmers, fishers, hunters and gatherers	0.29	Other service activities	−0.02
Science and engineering professionals	0.36	Water collection, treatment and supply	−0.00
Health professionals	0.37	Sewerage and waste	−0.00
Refuse workers and other elementary workers	0.37	Insurance, reinsurance and pension funding	0.04
Other clerical support workers	0.39	Water transport	0.05
...	...	...	...
Numerical and material recording clerks	0.62	Manufacture of other transport equipment	0.86
General and keyboard clerks	0.63	Construction	1.05
Assemblers	0.65	Legal and accounting and management activities	1.18
Personal service workers	0.68	Accommodation, food and beverage service activities	1.19
Information and communications technicians	0.70	Manufacture of rubber and plastic products	1.22
Information and communications technology professionals	0.73	Rental and leasing activities	1.28
Food processing, wood working, garment and other craft and related trades	0.75	Security and investigation, service to building and landscape and office activities	1.43
Hospitality, retail and other services managers	0.84	Computer and information service activities	1.44
Building and related trades workers, excluding electricians	0.89	Manufacture of basic metals	1.46
Food preparation assistants	1.07	Manufacture of textiles, clothing and leather	2.12

Source: Authors' analysis.

Table A.3. Robustness checks (I): Change in inequality and polarisation in 2030 using alternative measures (% change over the baseline)

	$I(0.25)$	$I(0.5)$	$I(0.75)$	$P_2(0.5)$	$P_2(2)$
AT	−0.001	−0.000	−0.000	0.008	0.001
BE	−0.006	−0.005	−0.003	0.024	0.070
BG	−0.025	−0.020	−0.016	−0.165	−0.202
CY	−0.002	−0.002	−0.002	−0.007	−0.005
CZ	−0.009	−0.008	−0.007	0.097	0.024
DE	−0.003	−0.002	−0.001	−0.003	−0.011
DK	−0.000	−0.000	0.000	0.032	0.000
EE	−0.000	−0.001	−0.001	−0.098	−0.057
EL	0.009	0.005	0.002	−0.015	−0.030
ES	0.008	0.005	0.003	−0.157	−0.085
EU + UK	−0.002	−0.001	−0.001	−0.043	−0.039
FI	−0.006	−0.004	−0.003	−0.068	0.003
FR	0.009	0.006	0.004	0.044	0.016
HR	0.000	0.002	0.003	−0.025	0.018
HU	0.002	0.002	0.001	−0.099	−0.034
IE	−0.001	−0.000	0.000	−0.002	−0.001
IT	0.005	0.002	0.001	−0.048	−0.047
LT	0.001	0.001	0.000	−0.071	−0.043
LU	−0.001	−0.001	−0.000	0.003	0.007
LV	−0.005	−0.006	−0.006	−0.137	−0.069
MT	−0.004	−0.002	−0.001	−0.045	−0.013
NL	0.002	0.002	0.001	−0.030	0.018
PL	−0.021	−0.019	−0.017	−0.049	−0.239
PT	0.005	0.003	0.002	−0.033	−0.019
RO	0.025	0.024	0.022	−0.008	−0.018
SE	0.005	0.004	0.003	−0.017	0.014
SI	0.001	0.001	0.000	−0.011	−0.017
SK	−0.001	−0.001	−0.001	−0.062	−0.028
UK	−0.009	−0.004	−0.001	0.064	0.029

Source: Authors' analysis.

Table A.4. Robustness checks (I): Change in inequality and polarisation in 2030 using a ranking based on educational attainment (% change over the baseline)

	$I(0)$	$I(0.25)$	$I(0.5)$	$I(0.75)$	$P_2(0.5)$	$P_2(1)$	$P_2(2)$
AT	−0.004	−0.002	−0.001	−0.000	0.016	0.003	0.002
BE	−0.006	−0.005	−0.004	−0.003	0.108	0.059	0.015
BG	−0.053	−0.037	−0.026	−0.019	0.233	0.104	0.024
CY	−0.005	−0.004	−0.003	−0.002	0.036	0.030	0.024
CZ	−0.013	−0.011	−0.009	−0.008	−0.032	−0.025	−0.020
DE	−0.009	−0.005	−0.003	−0.002	−0.022	−0.020	−0.018
DK	−0.000	−0.000	0.000	0.000	0.021	0.012	0.007
EE	−0.011	−0.008	−0.005	−0.003	−0.019	0.010	0.016
EL	0.025	0.015	0.008	0.003	−0.039	−0.028	−0.021
ES	0.009	0.006	0.004	0.003	−0.105	−0.090	−0.061
EU + UK	−0.003	−0.002	−0.002	−0.001	−0.003	−0.007	−0.012
FI	−0.010	−0.008	−0.006	−0.004	0.015	−0.000	−0.006
FR	0.010	0.008	0.006	0.004	−0.031	−0.023	−0.016
HR	−0.008	−0.003	0.000	0.003	0.067	0.054	0.038
HU	0.001	0.001	0.001	0.001	0.081	0.062	0.028
IE	0.004	0.002	0.001	0.000	−0.002	−0.003	−0.003
IT	−0.001	−0.000	0.000	0.001	0.043	0.035	0.023
LT	0.001	0.000	−0.000	−0.000	0.032	0.023	0.016
LU	−0.003	−0.002	−0.001	−0.000	0.033	0.023	0.015
LV	−0.016	−0.013	−0.011	−0.008	0.082	0.045	0.006
MT	0.013	0.004	0.001	−0.001	−0.033	−0.020	−0.032
NL	0.006	0.004	0.002	0.001	−0.007	0.009	0.007
PL	−0.037	−0.030	−0.024	−0.019	0.144	0.088	0.043
PT	0.009	0.006	0.004	0.002	0.034	0.032	0.026
RO	0.073	0.055	0.040	0.028	−0.042	−0.037	−0.038
SE	0.000	0.002	0.002	0.003	0.010	0.008	0.017
SI	0.002	0.001	0.001	0.000	0.005	0.007	0.003
SK	−0.013	−0.008	−0.005	−0.003	0.066	0.046	0.019
UK	−0.001	−0.001	−0.001	−0.001	−0.017	−0.022	−0.028

Source: Authors' analysis.

Table A.5. Robustness checks (I): Change in inequality and polarisation in 2030 using a ranking based on a non-pecuniary job quality index (% change over the baseline)

	$I(0)$	$I(0.25)$	$I(0.5)$	$I(0.75)$	$P_2(0.5)$	$P_2(1)$	$P_2(2)$
AT	0.001	0.001	0.000	0.000	0.030	0.018	0.008
BE	−0.012	−0.009	−0.006	−0.004	0.115	0.086	0.041
BG	−0.039	−0.029	−0.022	−0.018	0.003	−0.041	−0.040
CY	−0.004	−0.003	−0.003	−0.002	0.034	0.027	0.018
CZ	−0.004	−0.009	−0.009	−0.008	−0.069	−0.052	−0.063
DE	−0.004	−0.003	−0.002	−0.001	0.094	0.066	0.036
DK	0.000	0.000	0.000	0.000	0.013	0.017	0.019
EE	−0.009	−0.007	−0.005	−0.003	0.028	0.018	0.004
EL	0.000	0.000	0.001	0.000	0.005	−0.001	0.002
ES	0.010	0.008	0.006	0.004	−0.093	−0.085	−0.074
EU + UK	−0.004	−0.003	−0.002	−0.001	−0.005	−0.009	−0.016
FI	−0.010	−0.008	−0.006	−0.004	−0.040	0.024	0.027
FR	0.007	0.006	0.005	0.004	0.061	0.060	0.052
HR	0.001	0.002	0.003	0.004	0.061	0.036	0.025
HU	−0.001	0.000	0.001	0.001	0.017	0.043	0.037
IE	0.000	0.000	0.000	0.000	0.004	0.003	0.003
IT	0.001	0.001	0.001	0.001	0.014	0.014	0.013
LT	−0.003	−0.002	−0.001	−0.001	−0.012	0.012	0.010
LU	−0.003	−0.002	−0.001	−0.000	0.018	0.014	0.012
LV	−0.022	−0.017	−0.013	−0.009	0.097	0.073	0.040
MT	0.005	0.001	−0.000	−0.001	−0.056	−0.039	−0.039
NL	−0.000	0.001	0.001	0.001	0.018	0.029	0.033
PL	−0.002	−0.017	−0.020	−0.019	−0.147	−0.169	−0.199
PT	0.001	0.001	0.001	0.001	0.031	0.024	0.017
RO	0.036	0.031	0.028	0.024	−0.047	−0.029	−0.017
SE	0.002	0.003	0.003	0.003	0.108	0.062	0.050
SI	0.002	0.001	0.001	0.000	0.018	0.009	0.002
SK	−0.011	−0.008	−0.005	−0.003	0.019	0.007	−0.000
UK	−0.004	−0.002	−0.002	−0.001	−0.003	−0.010	−0.008

Source: Authors' analysis.