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Abstract

Pension policy has gone through an intense period of reform over the past few decades. However, further changes are likely to take place in the near future. Major global trends, not only population ageing but also globalisation, technological innovation and climate change, are going to shape socio-economic and labour organisation and influence macroeconomic trends and will thus have an impact on the adequacy and long-term sustainability of pension policy. This paper focuses on the challenges of the green transition for pensions. We first examine its possible effects on economic growth and productivity, labour markets and the financial sector. We then investigate the potential consequences of the future ecological transition on the financing of old-age protection, future benefits and their adequacy, and the changing role of trade unions in approaching the complex dilemma of supporting the green transition on the one hand, while defending the short-term interests of their rank and file (in terms of tax, labour market and social policies) on the other.

1. Introduction

The present paper sheds light on the major potential consequences of the 'green transition' – i.e. the transition towards a climate-neutral economy – for pension policy. This policy, as well as broader social policies, is largely shaped by the economic and social context, mostly because of the impact of the latter on macroeconomic trends, economic structure and the labour market. It is not necessary to embrace a functionalist or structuralist approach in order to recognise that socio-economic transformation has an impact on social policies. This is also the case for old-age protection.

While there are many studies that investigate the implications of an ageing population (e.g. European Commission 2021) and several that focus on the impact of technological change on pensions (Natali and Raitano 2022; Nullmeier 2022), to the best of our knowledge, none have as yet analysed the potential impact of climate change and the green transition on how pension systems are organised. This paper aims at qualitatively assessing possible consequences for pension systems – and their capacity of being financially sustainable and providing adequate benefits – associated with expected trends in the economic system and the labour market engendered by green growth.

In what follows, we first look at the pension systems in Europe and their recent evolution. The summary set out in Section 2 provides an understanding of pension reforms and the paradigm at their base. It is also the first step in assessing the capacity of pension systems to address the major challenges of the green transition and whether the pension policy inherited from the past (two to three decades of austerity and cost-containment) is well equipped to address the main socio-economic effects of the same transition. Section 3 explicitly evaluates the challenges for the economic system due to the green transition through a literature review which focuses on the different potential effects on economic growth and productivity, labour markets and the financial sector. These three policy dimensions are all concerned with the future of pensions, and the related challenges are likely to shape reforms aimed at ensuring that pension financing and benefits are sustainable and adequate, respectively. Sections 4 and 5 focus on the main policy and political challenges in the pension field: we investigate the reform options for European policy-makers and the political dynamics at stake. As for the latter, we first refer to the main political challenges for the trade union movement across Europe. Finally, Section 6 offers some conclusions.

2. Pension systems in Europe and their recent evolution

In this section, we provide a summary of the most popular pension models proposed in contemporary literature, outlining their limits to deal with the challenges related to the green transition.

Contemporary literature has widely proposed various pension clusters in Europe – *social insurance vs. latecomers* (Hinrichs 2000) and *social insurance vs. multi-pillar* systems (Bonoli 2003) – consistent with two different paradigms.

In s*ocial insurance* systems, the State provides the greater part of pension benefits through mandatory public schemes that are basically earnings-related (e.g. France and Germany). The financing method is on a PAYG (pay-as-you-go) basis. Current contributions paid by both employers and employees (or revenues coming from current taxation, mostly from income taxes, especially when contributions for active workers are not enough to finance pension spending) are not accumulated in individual accounts but are instead used immediately for financing current benefits. The main goal of such pension programmes (which represent the 'first pillar') – usually achieved by applying an earnings-related formula based on workers' final/best years average salary – is to ensure maintenance of the living standard enjoyed by pensioners prior to their retirement. Hence, these schemes mostly aim at guaranteeing the adequacy of pensions to insure workers against possible negative events during their working life. As a result of their higher level of generosity and coverage and their comprehensive character, public pensions are assumed to have crowded out fully funded private schemes.

In *multi-pillar* systems, by contrast, the State has responsibility for basic entitlements with the aim of preventing poverty – in particular by providing flat-rate or means-tested benefits to all retirees/elderly people – while additional benefits are provided by fully funded private supplementary occupational and/or individual schemes (e.g. Denmark, the Netherlands and the UK). The financing methods thus vary: on the one hand, public pension programmes (first pillar) are PAYG financed, while, on the other hand, supplementary occupational schemes (second pillar) and pension funds (third pillar) are fully funded (i.e. current revenues are saved and then used to finance future benefits). The strengthening of the role played by the private pillar – with a decreasing role of the public pillar – is often proposed in order to achieve multiple aims, e.g. reduce public spending on pensions; deal with ageing populations attributing a larger role to funded schemes that should be

less exposed than PAYG to 'demographic risks'; increase the saving rate and the development of financial markets that should foster economic growth; increase mean returns on contributions if the rate of return guaranteed by funded schemes is higher than that obtainable on PAYG schemes; or reduce the risk on expected pensions, since PAYG and funded schemes offer individuals different levels of coverage against various sources of risks (e.g. PAYG are more exposed to demographic and political risks, while contributions accrued in funded schemes are highly exposed to financial risks).

More recent attempts to map pension systems in Europe have started from the assumption that the dominant privatisation paradigm (Orenstein 2013) has led to the progressive convergence of pension systems at least in terms of reform efforts. Ebbinghaus (2012), for instance, identified three groups of countries in Western Europe. The Bismarckian systems (Continental and Southern European countries) are characterised by the persistent key role of earnings-related public pensions. They are described as latecomers in the implementation of the multi-pillar model. Nordic countries (Sweden, Finland and Norway) are part of the emergent multi-pillar systems with public PAYG schemes supplemented by fully funded schemes. Denmark, Switzerland, the UK and the Netherlands are among those countries with mature multi-pillar systems where privately funded schemes that were introduced decades ago now play a key role in old-age security.

Natali (2017) subsequently proposed a further classification of pension systems in Europe, with the identification of five clusters. In line with Bonoli (2003), he identifies two main groups of countries: those with social insurance systems (according to the Bismarckian tradition) and those with multi-pillar systems. However, he further divides each group into different sub-clusters. There are three generations of social insurance countries: those belonging to the first generation introduced public earnings-related schemes between the end of the 19th and the beginning of the 20th century; the second generation consists of the Nordic countries that introduced the same schemes after WWII; the third generation is represented by Eastern European countries that reversed the multi-pillar model in recent years in the aftermath of the Great Recession. In the multi-pillar camp, the first generation is represented by Western European countries that partly privatised their pension system in the early (or during the second half of the) 20th century, while the second generation includes Eastern European countries that introduced private contribution-based and earnings-related schemes in the last decade of the 20th century and/or at the beginning of the 21st century.

These classifications are relevant but seem of limited interest when we try to assess the potential impact of climate change on pension policy. Firstly, all the countries are now based on the pension policy mix where both public and private schemes coexist, even if the relative roles of the two pillars differ across countries.

In the past few decades, most European countries have shared the reform line consistent with the containment of pension spending through a stronger link

between contributions and benefits, more meagre indexation of pensions, an increase in the number of years of contributions required for a full pension, a higher pensionable age and stricter regulation of early retirement (Ebbinghaus 2017).

Both public and private schemes have, in many countries, moved to strengthen the link between contributions paid throughout the working life and expected pensions, with the aims of containing costs and monitoring the trend of public spending for pensions, especially in a context of ageing populations, providing better incentives for a longer working life, thus 'making contributions pay' to increase future pensions, and reducing the heterogeneity of actual returns on past contributions associated with pension formulas where only final/best years matter (Holzmann and Palmer 2006).

To further these aims, on the one hand, in public PAYG schemes, the reference period for computing earnings-related defined benefit pensions has been extended in many countries, and some countries (within the EU, Sweden, Italy, Poland and Latvia) have replaced a defined benefit (DB) formula with a notional defined contribution (NDC) formula.[1] On the other hand, to reduce risks for sponsors of private funds and monitor spending trends, occupational pension funds have also often moved from a DB formula (where, implicitly, a guaranteed rate of returns on contributions exists and financial risks are, to a certain extent, shared between workers and fund sponsors) to a defined contribution (DC) formula, where workers' expected pensions strictly depend on the success of the financial investments financed by their contributions.

As a consequence, reforms have brought about an evident process of progressive 'individualisation' of old-age risks, where the capacity of pension schemes to guarantee the stability of individuals' living standard before and after retirement has been strongly reduced, and, thus, individuals are no longer protected against possible negative events that may occur during their working life (e.g. periods of being unemployed or earning very low wages), since their entire working life history matters for calculating future pensions. Redistribution across generations and within cohorts of pensioners has been restricted in many countries, in the same years when post-industrial labour markets became more flexible (Hinrichs and Jessoula 2012). Furthermore, the social norms behind the fairness associated with pension benefits have changed if pensions are often considered fair in the current debate only when – apart from the provision of social assistance and a minimum income benefit for the elderly poor – they strictly mirror the contributions paid by the individual over the course of his or her working life. Therefore,

1. Benefits depend on the accrual of contributions paid during the working life, and, according to actuarial rules, annuities are computed taking into account expected longevity at retirement, according to the number of years that a pension is expected to be paid. In the pension economics literature, the concept of 'actuarial fairness' has then been used recently as a benchmark (Borsch-Supan 2006). Note that the actuarial rules of an NDC allow policy-makers to stabilise pension spending even in a context of sustained population ageing, since its technicalities allow the public system to pay a rate of return on contributions able to balance the intertemporal budget of the pension system (Natali and Raitano 2022).

according to recent reform trends, due to pressures in public balances and an eagerness for individuals to shoulder more responsibility for the accrual of contributions – often shown by the EU and international institutions – the several objectives pursuable through a pension scheme are increasingly being reduced to the simple need to smooth individual resources over the various phases of a person's life.

In the following sections, we assess the implications of these trends for the capacity of a pension system to deal with the new challenges related to the possible scenarios that might be triggered by the green transition. As we see, the increased individualisation of old-age risks seems at odds with the need to address the new inequalities originated by the ecological transition.

3. Economic and social challenges of the green transition

According to the targets set by the Paris Agreement, global greenhouse gas (GHG) emissions need to decrease in order to keep the global mean temperature increase below 1.5°C or well below 2°C compared to 1990. In this connection, the European Union plays a leadership role in climate policies and mitigation action, submitting the most ambitious NDCs (nationally determined contributions), recently updated in 2020, and the European Green Deal targets for 2030. The European commitment is set to achieve climate neutrality (net-zero emissions) by 2050, and an emissions reduction of at least 55% by 2030 (German Presidency of the Council of the European Union 2020).

Several concerns arise from climate policies about the economic costs and distributional effects of undertaking the transition, such as the impact on global GDP growth, the employment effect, firm competitiveness and savings management (see Tables 1 to 4 below for a summary of the main findings emerging from the literature, discussed in detail in the following paragraphs).

These changes occur in and add to a context of technological transformation, new forms and relations of work, and population ageing (Speck and Zoboli 2019), and are thus relevant for understanding future potential dynamics in the sustainability of pension contributions and the adequacy of transfers.

3.1 Economic costs, growth and productivity

Achieving climate goals requires a structural transformation of the economy, with a shift in production, energy consumption, transport, construction and individual behaviour (Edenhofer et al. 2014). This profound change will give rise to both winners and losers among different sectors, regions and workers (Fankhaeser et al. 2008).

As reported by the IPCC AR5-WGIII, in cost-effective scenarios, the aggregated cost of mitigation to keep the increase in global average temperature below 2°C ranges between a 1.5% and 4.2% reduction in global GDP by 2050. It means an annual GDP growth reduction of between -0.03% and -0.13% (Edenhofer et al. 2014).

More recent studies (Vrontisi et al. 2018) are consistent with these estimates. The economic cost of the low-carbon transition, in terms of the annual

GDP growth rate between 2020 and 2030, implies a maximum reduction of 0.1 percentage point in the intended nationally determined contributions (INDC) scenario, no more than 0.3% in the 2°C scenario and a maximum of 0.5% (median value of 0.36) in the 1.5°C one. These estimated reductions in annual GDP growth rates are low compared to the fluctuation to which the GDP growth rate in the reference scenario is subjected across models, which ranges between 2.8% and 4.4%.[2]

The same studies converge in their assessment of this economic impact on different countries. Looking at the distribution of mitigation costs across regions, the EU 28 scores below the global average, while fossil fuel-exporting countries are most adversely affected (Edenhofer et al. 2014).

The distribution of mitigation costs is also studied by Fragkos and Kouvaritakis (2018). They analyse the extent to which the percentage loss of GDP due to the low-carbon transition differs across the world's major economies. Specifically, they look at the CO_2 reduction needed to fill the gap between the reference and the 2°C scenarios in the period from 2010 to 2050. It emerges that the cumulative mitigation costs are the lowest for the EU (0.4% of GDP), which would face only an additional 20% reduction in emissions compared to the reference scenario. Meanwhile, the other major economies considered in the analysis (US, China and India) have a wider gap to fill, which in turn corresponds to a higher cost (up to 1.9% of GDP). Inequality in the costs of mitigation policies among countries is also highlighted by Tavoni et al. (2015). They show that, in a cost-effective scenario, OECD countries would be subject to lower than average global GDP losses, a finding that is consistent across different models.

The estimates become worse in scenarios characterised by delayed actions or limited technological availability. Moreover, results are generated by models that often assume the perfect implementation of climate policies, the existence of a unique emissions trade system, the absence of transaction costs, transparent markets, optimal behaviour, technological diffusion, and the absence of labour and capital market imperfections (Guivarch et al. 2011).

Moreover, owing to the complexity involved in calculating co-benefits, these are not included in the overall estimates produced by models. Finally, we should consider the aggregated benefits of avoiding the damage caused by climate change (Vrontisi et al. 2018), which are estimated to exceed the total cost of mitigation in the cost-effective scenarios (Edenhofer et al. 2014).

The low-carbon transition interacts with other structural changes in society and the economy, and some results will depend on the combined effect of

2. When comparing the INDC scenario with the cost-effective ones, it emerges that high-income economies, such as the EU, would experience a more consistent fall in GDP growth. This result derives from the bigger contribution to cutting GHG emissions proposed in INDCs compared to that proposed by the emerging economies.

these forces. A glaring example is a technological innovation that supports and affects the impact of climate policies in terms of both GDP and employment.

Overall, the green transition raises more concerns about the distribution of costs than about its overall impact (see Table 1).

Table 1 **Potential economic challenges of the green transition**

GDP growth	Overall expected impact: low aggregated costs (loss of a few GDP points by 2050). Aggregated net costs of mitigation depend on: • technological progress • timing of action • policy mix and co-benefits • benefits in terms of damage avoided

Source: Authors' own elaboration

3.2 Labour market and employment dynamics

The green transition is expected to have an impact on both the economy and the labour market. Therefore, different scenarios to estimate net employment, job reallocation rates, wage dynamics, and sectoral and regional shifts could arise and play a role in determining welfare challenges, including requirements on the adequacy and sustainability of pension systems.

One of the main concerns raised by policy-makers over climate policies is the net employment impact. The topic is widely debated by the literature, an analysis of which shows controversial results.

According to Fankhaeser et al. (2008), the net effect on the labour market is multifaceted and likely to evolve over the short, medium and long term. In the *short term*, the direct employment effect occurs, because of adjustments among sectors directly affected by mitigation and the relative job disruption and creation. The shift from carbon-intensive activities to low-carbon ones that are more labour-intensive should initially determine a rise in employment. In the *medium term*, the economy-wide effects of climate policy take place. They are determined by behaviour shifts and value chain changes and might partially offset the increase in employment if climate actions are adopted unilaterally, causing a loss in competitiveness, carbon leakage and job migration. In the *long term*, the research and development of low-carbon technologies and their deployment should increase the demand for skilled labour, causing 'dynamic' effects (Table 2).

Focusing on the direct employment effect, Berman and Bui (2001) found that, when environmental regulations address capital-intensive industries (oil refineries, chemicals, cement, transportation, heavy manufacturing), the effect on net employment is almost zero. In broad terms, they affirm that the outcome depends on the elasticity of industry demand with respect to price and the factor substitutability between capital and labour. The first

condition is also investigated by Morgenstern et al. (2002), who found that environmental regulation does not have a significant effect on employment within an industry when market power is high, and thus the elasticity of demand is low, as demonstrated in their analysis of the plastics and petroleum sectors.

Table 2 **Potential employment challenges of the green transition**

Net employment effect is positive, but only by a small extent	*Short term* Low-carbon technologies are more labour intensive
	Medium term Risk of loss in competitiveness, carbon leakage, job migration
	Long term Technological change • demand for skilled labour increases • product-driven: increase in the demand for labour • process-driven: decrease in the demand for labour
	Revenue recycling from carbon pricing: • double dividend hypothesis: shift in taxation from labour (high distortionary) to emissions (internalise externalities) • financing other policies (e.g. retraining process) contributes to the net effect on employment
	Multiple targets (emissions reduction, renewables share, energy efficiency improvements) increase net employment

Source: Authors' own elaboration

On the other hand, the typology of technology and solutions introduced by environmental and climate policies can influence the outcome with regard to net employment. In the long term, shifting to abatement technologies can become less labour- and more capital-intensive due to innovation. In this connection, Marin and Vona (2017) found that environmental regulation, proxied by energy prices, has a negative impact on employment. They also observed that this effect is more pronounced for those sectors that are more energy-intensive and exposed to international trade. This negative outcome can be particularly severe if adequate labour market policies are not implemented to mitigate the adverse consequences and encourage the reallocation of jobs.

As for the dynamic effects occurring in the long run, innovations are expected to bring about an increase in the demand for labour when they are product-driven (Harrison et al. 2014), but those that involve process innovation may have a negative impact on the level of employment, leading to improvements in labour productivity (Cainelli et al. 2011). Moreover, the impact of innovation on welfare largely depends on whether the investments across low-carbon and non-energy sectors will be substitutable or complementary. Indeed, a higher degree of substitutability might cause a crowding-out effect in investments.

More recently, Pollitt et al. (2015) use a modelling approach to estimate the impact of a 40% reduction in GHG emissions by 2030 on employment in the

EU. They analyse two alternative mitigation pathways, the first based on a unique carbon pricing system across EU Member States and sectors, and the second grounded on multiple objectives, including targets on renewables and energy efficiency. The findings for both options reveal a positive impact on employment but highlight a substantial difference in the range of the results, showing a higher potential for job creation when additional targets are set. This is the case of the EU which, in the last NDC submitted (2020), claims to improve energy efficiency by more than 32.5% compared to the historical baseline and increase the renewable contribution to at least 32% of the final energy consumption by 2030 (German Presidency of the Council of the European Union 2020).

The relevant role played by renewable energy is further highlighted by Fragkos and Paroussos (2018), who perform a sectoral analysis, estimating the net effect on employment in different sectors. They found, on average, higher labour intensity and domestic job content in the renewable energy sources sector compared to those in the fossil fuels sector. This result translates into a positive expectation of the effect of the low-carbon transition on the EU's net employment growth (1% increase in the labour force by 2050). The sectors expected to exploit the higher employment increase by 2050 are electricity, agriculture (biofuels production) and construction (building renovation). Specifically, the sharpest increase will be in the construction and installation of solar PV and wind turbines and advanced biofuels. Overall, job reallocation between sectors should be around 1.3% by 2050 in the EU and 1.5% globally. On the other hand, the sectors hardest hit by the transition will be all the traditional energy supply and carbon-intensive industries such as coal mining, refineries and refuelling stations. The authors confirmed a positive change in employment due to climate policies but underlined the sectoral and regional differences in the outcome variables.

The concentration of job losses in the carbon-intensive areas and sectors could compromise the social consensus for climate mitigation. Indeed, the distribution of climate policy costs represents one of the main barriers to the actual implementation of such policies. Therefore, compensation schemes play a key role in garnering the support of fossil fuel-related groups with a view to achieving a *just* transition. Workers belonging to the exposed sectors are likely to take a stand against climate policies if the employment alternatives, in view of their skills, are weak (Tvinnereim and Ivarsflaten 2016). A set of actions, such as the retraining of low-skilled workers (Fragkos and Paroussos 2018), outplacement assistance and labour subsidies (Guivarch et al. 2011), would help shorten unemployment periods and ensure the effective reallocation of jobs.

Fragkos and Paroussos (2018) identified the following conditions as relevant indicators of the impact of climate policies on net employment: (i) change in competitiveness; (ii) financial scheme; (iii) policy mix; and (iv) revenue recycling. The first factor depends on the scale of policy implementation, and any policies that are not implemented worldwide might lead to a decrease in employment due to a loss in market share caused by higher local energy

prices and a shift in business activities to other jurisdictions without GHG regulation. The second condition concerns the degree of substitutability between investment choices in low-carbon and non-energy sectors. If it is high, a crowding-out effect might occur. Thirdly, the net impact on jobs is strongly influenced by the set of complementary policies adopted to attenuate or avoid side-effects, such as retraining programmes for workers employed in high carbon-intensive sectors, measures to increase labour market participation and adequacy of skills supply to meet the green labour demand. Finally, the implementation of a carbon tax revenue recycling scheme further contributes to the overall employment outcome, while also playing a crucial role in achieving policy acceptability and establishing consensus.

The 'double dividend' hypothesis supports a positive outcome for the labour market as a result of shifting taxation from labour to environmental pollution. Indeed, labour taxation might lead to high distortionary effects, whereas carbon taxation should achieve welfare improvements, reabsorbing the relative externalities of the green transition. The pertinent literature does not agree on the feasibility of the double dividend hypothesis owing to different results depending on the type of workers being studied (all workers, skilled or unskilled workers) (Bosello et al. 2001; Dissou and Sun 2013; Fæhn et al. 2009) and contradictory short- and long-term effects (Carraro et al. 1996). Indeed, most of the studies relied on CGE models, the results of which deviate in some measure from the main assumptions and the representation of markets and their imperfections (unvoluntary unemployment, geographical immobility, flexibility in wages, time-consuming job search process, heterogeneity among skilled workers).

As seen so far, the overall employment effects, even though they represent one of the main concerns of policy-makers, are limited in terms of the level of stringency experienced to date, and there are several factors that might play a more influential, if not determinant, role in the employment outcome (see Table 2 above).

On the other hand, more concerns arise from the distributional consequences of the low-carbon transition, producing winners and losers among workers, sectors and regions. In this connection, a qualitative analysis of the employment effect also needs to be conducted.

The Occupational Information Network (O*NET) programme, under the sponsorship of the US Department of Labour/Employment and Training Administration, makes the distinction between 'green occupations' and 'green tasks', one that is often blurred in the literature (Dierdorff et al. 2009). The diffusion of green technologies and activities might have effects both on the demand for already existing occupations and for new ones characterised by new skills or tasks. These circumstances and their consequences determine the greening of occupations. On this basis, three occupation-based groups are defined:

1. The *green increased demand* group comprises occupations that already exist but are expanding (e.g. chemical technician, forest and conservation technician, hydrologist). The policy change does not affect the work or workers' requirements, i.e. the skills and tasks performed, but demand for them.
2. The *green enhanced skills* group is represented by pre-existing occupations that are undergoing task changes and consequently require new skills and knowledge (e.g. environmental engineer, construction and building inspector, plumber). This group does not necessarily experience an increase in the labour demand for workers in these occupations.
3. The *green emerging* group supplies new occupations and tasks for new needs and requires new skills (e.g. wind turbine service technician, biomass plant engineer, solar power plant technicians). The rising demand for this group of occupations is expected to increase employment levels.

Vona et al. (2015) further developed a measure to understand the greenness of skills. They found that green skills require a high degree of analytical and technical expertise in all areas of knowledge linked to technology adoption: design, production, management and monitoring. With the exception of managerial competencies, the other activities require robust technical, engineering and scientific skills, highlighting the importance of enhancing investments in formal education.

Further distinctions between tasks can be drawn by looking at the routine intensity of occupations and workers' analytical, interactive, manual and cognitive endowment. Consoli et al. (2016) found that green jobs[3] are marked by a higher content of non-routine analytical tasks. Beyond confirming the need for more formal education, the study results underline the importance of work experience and on-the-job training. More specifically, the study shows that, for the green emerging jobs, on-the-job training is crucial. This evidence highlighted the importance of justifying the learning-by-doing approach (on-the-job training) in the design of labour market policies geared towards transition and the involvement of sector consortia and inter-firm associations in this process.

As already mentioned, one of the main concerns is the actual feasibility of job reallocation and its cost. To this end, it is salient to understand differences in the skills needed for green and brown jobs. Empirical research (Vona et al. 2018) analysing the skills distance between different occupations identified a

3. Green jobs can be defined by two main approaches (Vona 2021): one that looks at the process and the other that looks at the output. The first definition considers the production process and the related pollution and emissions generated, while the output definition defines green jobs as activities that produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. These jobs contrasted with those in polluting industries (known as 'brown jobs').

narrow gap between green and brown jobs, warning that a wider dissimilarity can be seen between other jobs. The most significant skills gap identified by the literature is in green engineering skills in architecture, construction and extraction (Table 3).

Table 3 **Distribution of the potential employment challenges of the green transition**

Job reallocation winners and losers among sectors and regions	*Higher employment losses in carbon-intensive areas and sectors:* • higher job losses in traditional energy supply and carbon-intensive sectors *Green vs. brown jobs:* differences in tasks and skills • closer in terms of skills compared to other jobs • higher content of non-routine analytical tasks • time-consuming process • on-the-job training
Wage dynamics	Income redistribution: • green industries vs. brown industries: *green wage premium* • labour vs. capital: green jobs are more *labour-intensive* • Different jobs: *manual labour* has the lowest benefits in terms of wages

Source: Authors' own elaboration

A number of policy implications arise from these results. First, in view of the similar level of complexity between green jobs and brown jobs, targeted technical programmes and training can be more effective than a general increase in post-secondary education. Second, the small skills gap generates positive but overall muted expectations for net employment. This conclusion is in line with other findings on the green stimulus effect on the economy and employment. It is likely to be both effective and valuable in reshaping the economy from the brown to the green sectors but less likely to provide the economic stimulus necessary to get people back to work quickly in order to restart and recover the economy after the Covid-19 pandemic crisis (Chen et al. 2020). Indeed, the jobs and occupations suffering the most from the effects caused by Covid-19 demonstrate low skills-demand compatibility compared to green jobs. Furthermore, the green stimulus is estimated to act slowly in the long term and might be insufficient to respond to short-term recovery needs.

To conclude the analysis of low-carbon transition effects on the labour market, we look at the distributive implications of the green transition for wages in green jobs compared to those in non-green jobs. Some empirical studies (Antoni et al. 2015; Jackman and Moore 2021) identify the *green wage premium* paid to workers in green industries (+7%), particularly in construction, installation activities, and architectural and engineering services, as well as the existence of a renewable energy wage premium (10%).

On the other hand, this finding seems to be time-variant (reducing overtime) and appears to benefit only some job categories. There is no agreement as to which factors explain this pay gap between industries, i.e. whether it might be imputable to differences in skills, offered as compensation for the higher

level of uncertainty surrounding green jobs' perspectives or brought about as a consequence of public-awareness campaigning to promote the benefits of green and renewable energy.

Other studies (Chateau et al. 2018) have found that carbon pricing leads to a redistribution of income between production inputs in favour of labour, particularly in countries that are fossil fuel-intensive users. Wage changes appear to be variable among regions and sectors, and, in particular, the 'blue-collar and farm workers' category is displacing the higher ranges of outcomes, while the services and sales workers, professionals and managers, and officials are experiencing the largest benefits. With some exceptions, low-skilled workers see the smallest wage benefits from the transition. The impact on manual labour, in view of the higher exposure to trade and technological changes, is particularly concerning. This issue is expanded by Popp et al. (2020) who studied the effects of the green stimulus originating from the American Recovery Act. They found that the largest proportion of jobs created were manual labour jobs, thus registering an increase in demand that was not, however, followed by a concomitant increase in wages.

3.3 Green transition and financial markets

The green transition requires extensive investment, and public expenditure should play a leading role in boosting innovation, changes in infrastructure, human capital and the ecosystem. The actions and policies associated with this role require increased public funding, which might compete with the increasing public demand for health and pensions (Speck and Zoboli 2019). The growing pressure on public spending might be alleviated by strengthening private-sector involvement in the transition, which itself should be encouraged through the implementation of a well-designed incentive structure. In this connection, institutional investors, such as pension funds, can play an increasingly important role (Table 4).

Table 4 **Potential financial market challenges of the green transition**

Financing process	• public spending: financing for the transition might compete with welfare needs • private involvement in the transition reduces pressure on public spending • stranded assets represent a risk for institutional investors such as pensions funds

Source: Authors' own elaboration

The financial system plays a crucial role in determining the future costs and benefits of the low-carbon transition and influencing the overall mitigation costs, even if that role is still underrepresented in climate and economics models. Indeed, in the majority of cases, integrated assessment models (IAMs), which are used to predict the future economic consequences of climate policies, do not take into account the financial system, nor do they model investors' choices. It follows that the feedback responses between the

financial sector and the potential mitigation opportunities are blurred and compromised (Battiston et al. 2021). This is a relevant shortcoming because the interaction between these two factors is significant in both cases. In the first, financial actors underestimate the need for the transition and fail to appreciate its benefits; this causes delays in its implementation, which in turn leads to an increase in mitigation costs and financial risk. In the second, the financial system plays an enabling role, smoothing the reallocation of capital and stimulating mitigation opportunities.

In this context, the timing of mitigation measures is crucial. The low-carbon transition could occur in an orderly manner, i.e. by means of coordinated and timely action towards meeting the climate goals, or in a disorderly manner, involving rapid and unanticipated changes and shocks (Battiston and Monasterolo 2019).

Private and institutional investors are significantly exposed to this risk of stranded assets. It follows that, if they underestimate the value of the transition and fail to implement it in a timely manner, their physical and financial assets are at risk of 'suffer[ing] from unanticipated or premature write-downs, devaluations or conversion to liabilities' (Caldecott 2016). Investment funds, which have large shares in carbon-intensive activities, are particularly exposed; at the same time, they manage large shares of pension funds (Monasterolo et al. 2017), to which they inevitably transfer this vulnerability. The exposure of the financial sector is heightened by the mutual interactions between the different actors (such as investment funds and pension funds), and this strong connection increases the potential losses (Monasterolo 2020).

With this in mind, Battiston et al. (2017) set out to analyse the climate policy impacts on the financial system, comparing a brown scenario with a green one, in order to evaluate whether the goal of keeping the global mean temperature increase below 2°C and the related low-carbon transition could trigger systemic risk. The scope of this process is estimated to cover 82% of global coal reserves, 49% of gas reserves and 33% of oil reserves, and it appears that EU pension funds are exposed to climate policy relevant sectors (CPRS) both directly (8%) and indirectly (8%) – through shares of investment funds and banks similarly vulnerable to these sectors – for about 16% of their assets (ibidem).

A disorderly transition increases the number of assets at risk of being stranded and dramatically increases the aggregated mitigation costs, putting a strain on the welfare system.

4. Major policy implications of the green transition for pensions

To assess how the challenges posed by the green transition might have an impact on pension systems, it is useful to clarify, on the one hand, the main characteristics that shape these systems and, on the other, the main objectives that they should pursue.

Accordingly, drawing on the findings of the environmental economics literature reviewed in Section 3, in this section we discuss the challenges facing the financial sustainability of pension spending and the adequacy of the benefits provided in the light of the current architecture of pension systems in the EU. In particular, we study the three main dimensions of these systems – i.e. the financing method, the benefit computation formula and the mix between public and private providers – that could potentially be adjusted as an adequate response to the challenges presented by the green transition.

The primary objective of pension systems in the EU thus relates to the financial sustainability of public schemes, i.e. a balanced intertemporal budget between revenues (social contributions or general taxes) and pension spending. As clarified by studies that have investigated the effect of an ageing population on pension system sustainability (Raitano 2014), the core variables that guarantee sustainability – depending on the way the architecture of the pension scheme is structured (e.g. with regard to the retirement age and the benefit computation formula) – are the GDP growth rate, which influences the capacity of the potential tax base to finance pension and social protection spending, and, in the case of pensions that are mostly financed through social contributions, the wage share (the ratio between total wages and GDP) which the amount of social contributions depends on.

According to this perspective, the challenges posed by the green transition regarding pension sustainability should not be insurmountable (Table 5 below). On the one hand, the expected fall in GDP is modest and could be further mitigated by the co-benefits of the green transition (e.g. higher productivity) and the alleviation of the costs of climate change. On the other hand, in contrast to the most plausible future scenarios on technological change (Natali and Raitano 2022), no dramatic reduction in the wage mass or decline in the wage share should occur: indeed, at least in the long term, neither net employment nor the mean wage rate – the two factors used to determine the wage mass – should fall as a result of the green transition. Furthermore, provided the drivers of functional income distribution

between wages and profits remain the same, the wage share should also not be adversely affected by the green transition.[4]

Table 5 **Potential challenges of the green transition for pensions and related reform strategies**

	Challenges	Reform strategies
Financial sustainability	Minor challenges due to the expected small decline in GDP.	Parametric reforms (e.g. possible increase in tax revenues).
Social adequacy	Prominent challenges due to the transition from brown to green jobs (consequent inequalities).	Parametric/structural reforms: – for temporary losers, reforms consistent with the improvement of notional contributions (in the case of unemployment); – for persistent losers, reforms consistent with early retirement; improvement of minimum protection.
Public/private mix	No major push for privatisation: – ambivalent effects on private pension funds; – risks of future loss related to the decline of the polluting sectors; – risk of limited protection for the losers of the green transition; – opportunities to lead the green transition with investments in green sectors.	Possible need for reforms to protect the workers at risk of wage loss and/or unemployment (through more extended contribution credits).

Source: Authors' own elaboration

Therefore, structural changes in pension systems characteristics – such as a reduction in mean benefits, an increase in the retirement age, opting out towards private schemes or a transition from PAYG to fully funded schemes – cannot be justified per se by challenges for financial sustainability associated with the green transition. The only major change should be, at most, an increase in general taxation if social contributions fail to grow in line with GDP as a result of a rise in functional inequality.

Significant challenges are more likely to emerge with regard to the capacity of pension systems to provide adequate benefits to all workers; these challenges relate to how the benefits of the transition from brown to green jobs – i.e. increased employment opportunities leading to higher and increasing mean wages – will be distributed across the population. In other terms, the challenges depend on the impact the green transition will have on inequalities in employability and wage patterns (also connected with the spread of atypical contracts) among workers.

4. Functional inequality refers to how the total product is distributed among the various productive sources, mostly wages and profits.

Indeed, even if the prospects of more highly skilled individuals are expected to improve both in terms of employability and wage dynamics, the green transition – bringing about a major structural change in the economic and productive system – could be characterised by the copresence of winners (i.e. the most highly skilled workers) and losers. The latter should belong to the most disadvantaged groups of workers in terms of skills, contractual arrangements, wages, and types of jobs and tasks performed. Even if net employment were to rise and workers were, on the whole, able to gain from the green transition, there may still be individuals who lose their job and are unable, at least in the short to medium term, to find a new one that is both stable and rewarding. Moreover, two cases should be distinguished here: 'temporary losers', i.e. those who are able to be reskilled and subsequently employed in green sectors, and 'persistent losers', i.e. those whose prospects are permanently damaged, in terms of employment opportunities and wage dynamics, by the disappearance of their brown jobs.

The effect of the green transition on inequality among workers and its persistence is currently undetermined and will depend on the efficacy of a set of complementary policies (industrial policy, training activities, active labour market policies) aimed at contrasting negative labour market events during the transition of the productive system from brown to green tasks. Nevertheless, the temporariness of the persistence of the 'loser status' might call for different compensatory policies in the pension field as well.

Indeed, if downgrade risks for workers are likely to be only temporary, no significant changes in the structure of the pension system should be introduced; rather the link between unemployment benefits and expected pension benefits should be made stronger, for the most part by extending the guarantee of adequate notional defined contributions (NDCs) during periods of unemployment. Accordingly, no changes to the pension computation formula (e.g. earnings-related or notional defined contributions) should be made if adequate notional contributions were paid to protect temporary losers of the green transition.

The case is different for those who are likely to be persistent losers in the transition, becoming long-term unemployed or remaining stuck on a labour market pathway characterised by low-paid and fragmented employment spells. Indeed, in such cases, some changes in pension computation formulas and the retirement age could be introduced to compensate these persistent losers. In the first instance, early retirement options should be made available to elderly losers; in the second, pension computation formulas should become 'less individualised'. In other terms, benefit formulas such as NDCs, which take into account contributions paid during the whole career as the only factor in the computation of pensions, should be tempered by introducing, for example, a pension floor, a base pension or a minimum pension that may allow individuals who have had long but unsuccessful careers to receive an adequate pension benefit at retirement independently of a possible limited amount of total contributions. Likewise, earnings-related schemes or 'point systems' (especially in first pillar social insurance systems) that take into

account the whole working career in defining the benefit amount should be partly relaxed to improve the future pensions of persistent losers. It is worth noting that these guarantees – even if they were to be more generous, calculated on an actuarial base in terms of returns on paid contributions, than those made to the 'nonlosers' – would not have a serious impact on public spending sustainability (as a consequence of the limited decline in GDP and the possible increase in mean wages). Instead, they would have the advantage of increasing the fairness of the pension scheme for individuals who would lose out from structural changes in the economic system because of negative circumstances that are beyond their control.

Finally, it is also worth noting that the role of private supplementary pension schemes is not expected to increase in importance owing to the challenges of public pension sustainability and adequacy associated with the green transition. Indeed, on the one hand, as mentioned above, sustainability challenges do not seem so insurmountable that they require a reduced role of the public sector in the pension field. On the other hand, the winners of the green transition would benefit from improved career patterns that may allow them to receive an adequate public pension without needing to opt out in favour of supplementary schemes. Conversely, it is very likely that the losers might not benefit from second and third pillar schemes which, because of liquidity constraints and administrative limits, are not usually an effective choice for low-paid and precarious workers. As observed previously, solutions to the implications for future pensions arising from their increasing labour market risks should be found within the public social protection system.

However, as discussed in the following section, private schemes, and especially occupational pension funds, could become a relevant actor if they were to ease the reconversion towards a green economy by appropriately managing the large amount of resources they have at their disposal in line with the green transition.

5. Major political implications of the green transition for pensions

Trade unions face a typical dilemma in addressing the green transition. On the one hand, if the unions advocate the mitigation of climate change, workers in 'brown jobs' may turn away because of potential job losses. Meanwhile, companies will blame the unions for lower profits. On the other hand, if the unions safeguard employment in carbon-intensive sectors — to the detriment of the environment — this may spark criticism from society at large and from environmental movements (Thomas and Dörflinger 2020). In other words, there is tension between economic concerns such as the cost of living, wages and employment on the one hand, and the need for costly policy action to counter climate change on the other (Azmanova 2020; Pochet 2017).

The political consequences of the green transition for pension policy seem fairly consistent with the broader dilemma referred to above. Firstly, there is the potential problem of inequalities in the distribution of job opportunities across sectors and occupational categories. As stated above, carbon-intensive sectors might suffer from a further decrease in employment due to the loss of market share and the negative effect of stricter environmental regulation. At the same time, manual workers may suffer from absolute and relative wage losses. Workers in carbon-intensive sectors and/or low-skilled, manual jobs may thus suffer from low wages, interrupted careers and insufficient pension contributions. By contrast, workers in green sectors may have more job opportunities (thus lower unemployment risks) and higher wages.

However, the more disadvantaged are well unionised and have a disproportionate representation in the trade union movement. As noted by Räthzel and Uzzell (2011), unions in production and transport are often posited to be particularly likely to oppose environmental efforts, since their jobs are at risk in the green transition – although there are differing positions to be found within such a broad category (Thomas and Dörflinger 2020). The opposite applies to service-sector unions, because environmental policy is assumed to increase employment in this sector (Obach 2004: 347).

In the pension field, the consequences of the green transition may be addressed through different (complementary) strategies for reform.[5] The first

5. The strategies mentioned in this section are consistent with the two different logics of unions' organisation: in the first, unions are economic actors pursuing immediate workplace and/or sectional interests; in the second, unions mobilise as social movements, building broader alliances on the basis of workers' interests (see Ringqvist 2021).

is a *defensive strategy* where unions may defend carbon-intensive sectors and demand compensation (financial resources to buffer the main economic consequences of the transition). Trade unions defend brown jobs so as to protect the future pensions of their workers. Temporary compensation and/or re-training to allow those same workers to move to the green jobs may be envisaged. Labour organisations may also call for 'special' old-age rules for the losers of the green transition: e.g. more options for early retirement. In this connection, the risk is to internalise the dilemma, with the federation of carbon-intensive sectors defending their own interests and potential tensions arising with the trade unions that are more involved in the green sectors. In addition, trade unions run the risk of coming into conflict with ecological movements.

The second is a more *encompassing strategy* forged on the basis of a cross-occupation alliance. Trade union confederations may call for broader reforms to increase redistribution and improve protection in the first pillar (both in social insurance and multi-pillar models) for those categories at risk of insufficient old-age protection: e.g. improving minimum pensions, and introducing and/or strengthening top-ups to contributory pensions. This encompassing strategy may be justified in that brown jobs suffer permanent losses, and even the green sectors still suffer from insecurity and the spread of atypical jobs.

The third is a *pro-active strategy* and tends to pre-empt any major loss for the labour movement in the context of the green transition. Here, the focus is more on the role of pension funds in helping reshape the global financial market. Pension funds can use their strength and position to intensify the response of the investment industry to climate change and ensure it is prepared for the future transition. Two possible strategies for trade unions involve exerting their role in the design and management of pension funds; or embracing 'shareholder activism': to influence pension funds and their investment—by gaining expertise in monitoring the management of the schemes (Natali 2018). In this connection, trade unions may promote green sectors through the pension funds, while directing public investments towards protecting workers in other sectors. In this scenario, an alliance between social and ecological movements is conceivable.

The challenges highlighted in this section could push trade unions to look for new strategies. The trade unions could be forced to focus on improving their social power resources (e.g. their capacity to communicate with the public and strike alliances with new green social movements) and defending their administrative and institutional role in both the first and second pillars. Some recent pension reform processes provide evidence of the new issues on the agenda (e.g. calls for improved protection for atypical workers; introduction of top-up benefits to improve the functioning of earnings-related schemes). The latter signal the trade unions' attempt to address the demands of non-unionised workers and provide an encompassing strategy to old-age protection in the green age. In social insurance countries, the most likely trade union strategy will consist of incremental reforms to strengthen the

first pillar capacity to effectively cover those workers who are victims of the green transition, while avoiding the shift to basic protection and the parallel spread of supplementary pension funds. In multi-pillar systems, trade unions will probably prioritise the adequacy of basic protection and the financial viability of the public pillar, while extending the coverage of second pillars to new forms of employment and green jobs.

6. Conclusions

This paper has aimed at shedding light on the possible effects of the green transition on the future of pension policy. It has focused on three main types of challenges related to the ecological transition (economic, employment and financial challenges) and their possible effects on the future of pension policy, in terms of both their financial viability and social adequacy and the interplay of public and private schemes.

Irrespective of the typical limits of forward-looking analysis (e.g. complex pre-conditions on which projections are based; many possible intervening variables affecting the expected results of socio-economic trends), the study suggests some preliminary reflections.

Firstly, the green transition is not expected to pose a significant threat in terms of economic, employment and, to some extent, financial challenges. In cost-effective scenarios aimed at keeping the global mean temperature increase below 2°C, a slight decline in GDP is expected by 2050, while employment is expected to increase both in the short and longer term (with some possible decline in the medium term), although the overall net change appears to be limited. Wage trends are also expected to improve, especially in those sectors where there is projected growth in the number of green jobs. At the same time, while investment and pension funds may suffer from the green transition – with increased risks of loss – the same funds may support the transition and contribute to the growth of green sectors.

Nevertheless, problems are expected to be more pronounced in relation to inequalities across economic sectors, jobs and skills. Inequalities are expected to widen in the green transition. Some sectors – especially those with brown jobs – are likely to suffer more from unemployment, a wage decline and low productivity; while green sectors may see increased job opportunities as well as more rapid wage increases.

Such a scenario is consistent with a number of potential challenges for pension policy. While the limited impact of the green transition on economic and employment growth should not lead to any major concerns about the financial sustainability of public pension schemes (with parametric reforms expected to be enough to address the future financial needs of pension schemes), social adequacy and the capacity to address inequalities are more at risk. Temporary unemployment, related to the need to update skills and promote the transition from brown to green jobs, may indicate a need for

reforms to increase contribution credits and the protection of old-age risks for workers with interrupted careers. Reform strategies to address long-term unemployment and job instability may include new measures for early retirement and an increase in the number of minimum pension schemes in order to provide effective protection for workers with insufficient seniority and contributions.

The green transition thus presents only moderate challenges to pension policy. Nevertheless, after years of cost-containment and individualisation of risks, pension systems are in need of reform. Pension systems need to be more redistributive in order to address new inequalities: measures such as basic schemes, top-up of low benefits and a more widespread use of notional contributions all appear useful in addressing possible increased inequality as a result of the green transition. At the same time, the implications of the green transition for pension funds are more ambivalent: pension funds may be subject to investment risks, but they can also serve as a platform to boost opportunities for green investments and jobs.

The green transition is characterised by a number of challenges that appear to be not insurmountable for future policymakers. Nevertheless, it does raise a number of political issues for the trade union movement. While the position of trade unions and their demands/proposals for the green transition need more research, here we have shed light on potential trade union strategies in addressing these issues. The unions may decide to defend the interests of their own rank and file, while attempting to put the brakes on the green transition. Alternatively, unions may develop a more encompassing strategy that defends the interests of polluting sectors while promoting environmentally friendly investments. Ultimately, the trade unions may use their important role in supervising pension funds to promote the green transition.

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