The Social Dimensions of 'Greening the Economy'

Developing a taxonomy of labour market effects related to the shift toward environmentally sustainable economic activities

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1. INTRODUCTION

The transition from a 'brown', carbon-based economy, heavy in CO_2 emissions, to a 'green' economy, with very low CO_2 emissions, has preoccupied policy makers in the advanced capitalist and emerging economies alike over the past two decades. While there seems to be a wide consensus on the need for stronger policies for sustainability[1], one of the key pinching points in the group of wealthy OECD economies, particularly in the EU, pertains to the distributional effects of such a shift in economic activities. With (still) large numbers of workers in the EU gaining their livelihood in relatively brown sectors, any organized reduction in CO_2 emissions will have significant repercussions for these workers – and since they are among the more highly unionised workers, often with large investments in industry-specific skills, they are likely to resist such a de-carbonisation policy without accompanying measures. Such concerns feed into the debate about a 'just transition' to a more sustainable and productive economy.[2]

This particular debate largely takes place without good data. Somewhat surprisingly given the importance of the theme, there are very few reliable statistics on how many jobs, which jobs, and in which sectors we can see those effects emerge.[3] The aim of this Research Note on the social dimensions of 'greening the economy' is to develop a taxonomy of effects in the labour market that are related to this shift toward environmentally sustainable economic activities and to produce a set of numbers on how many occupations and workers are likely to be affected by the systematic decarbonisation of the economy. We base a large part of our analysis on a study for the US Department of Labor (Dierdorff et al. 2009), which identified occupations that were necessary to support the 'greening' of the US economy on the basis of expert review of relevant analysis of the tasks, skills and jobs needed in the main industries associated with the transformation. We use the same occupational classifications as the authors of that study used and simply transplant them to the EU, under the assumption that these categories travel without too many problems – but in the conclusion to this Research Note we make the case for a EU-wide study that verifies to what extent the assumption holds that these occupations are structured in the same way.

[1] See, for example, the output of the EU (https://ec.europa.eu/commission/files/reflection-paper-towards-sustainable-europe_en), the OECD, World Bank, UNEP, New Climate Economy, Global Green Growth Institute and Green Growth Knowledge Network as well as the European Commission.
[2] The literature in this area has been multiplying rapidly, not least in the wake of the pioneering work by the ILO, UNEP, IOE and ITUC reflected in UNEP (2008). See, for example, the New Economics Foundation's programme of work on the just transition, introduced at https://neweconomics.org/uploads/files/Just_transition_FINAL_ONLINE.pdf , and the discussion in Heffron and McCauley (2018).
[3] Some of the problems of defining 'green jobs' are discussed in Bowen and Kuralbayeva (2015).

As a result of the paucity of data and even of adequate analytical frameworks, it is useful to list some of the limitations of the study presented in this Research Note. First, and importantly, we concentrate on policies to reduce CO_2 emissions. In the next section we explain in detail why, but we limited the Research Note to this set of policies because the reduction of CO_2 emissions is by far the most important problem in the short and medium term, with the largest effects, and because it is an activity where both target sectors and occupations in those sectors are relatively easily identified.

Second, an important methodological caveat: the correspondence between occupations and sectors in the EU and the US is not perfect. This does not necessarily stop us from drawing conclusions on the nature of green jobs in the EU, but caution is warranted. We effectively assume that the design of jobs in the EU is very similar to the US – that they cover the same tasks in the two regions with the same rough distribution. The ISCO classifications at the basis of our analysis give us some confidence in this regard, but it might be worthwhile to verify this in future research for the EU. There may actually well be some variation between the EU and the US in this regard, in the same way that there are established differences between countries in Europe in the areas of company organization, technical and vocational education and training, and the distribution of authority and cooperation in the workplace. In Germany, Sweden and other 'coordinated market economies' (Hall & Soskice 2001), for example, employees often have significantly more say in practical and strategic decision-making than in the southern economies; vocational education and technical training is often extensive in those countries as well, whilst being relatively under-organised elsewhere; and in large part as a result, workers in northern Europe often have more autonomy in the workplace. Standardised occupational classifications, even those that build up from task descriptions, may ignore such dynamic elements of jobs, which may reverberate through into our analysis. If such significant differences exist within the EU, it is hardly far-fetched to think about comparability for the implicit US-EU comparison in this Research Note as well. We intend to come back to this in the final section of this Research Note below.

Finally, since this Research Note is primarily methodological, it does not contain a standard section reviewing the literature on the substantive debate. Instead, in section 2 (the 'background canvas') we review different components that should be taken into account when studying the social effects of the transition towards a green economy.

The Research Note is organized as follows: the next section reviews the broader overarching framework against which the method and preliminary data have to be read. Section 3 presents the methodology; section 4 presents the taxonomy for the EU and some preliminary data and discusses the results and some substantive implications from the analysis.

2. Thinking about the Green Economy and its Effects on Jobs

Much of the policy attention in this general area of jobs in a green economy has focused on jobs in the so-called environmental goods and services sectors or EGSS jobs. Typically, these include jobs in areas such as waste management, environmental protection, energy preservation, etc. – usually jobs in industries that are relatively easy to define, identify in existing data, and which are emblematic of the green revolution in both practical and symbolic terms. In particular, these are jobs associated with reducing adverse environmental impacts, not necessarily jobs in already clean, low-carbon activities.

Yet there are two types of problems with such a narrow take on 'green jobs.' One is related to the actual minimal employment impact of these jobs: according to one estimate, about 4 million such EGSS jobs exist in the EU-28 at the moment, and, while job growth in this area has certainly not been slow (up from slightly less than 3 million in 2000), the total employment effect is small against the background of an economically active population of over 230 million in the EU. Second, these data are also somewhat misleading about the potential labour market impact of a move towards environmental sustainability, precisely because they pertain to easily identifiable, existing industries and jobs while ignoring larger but often more diffuse developments in the economy in general and the labour market in particular that are associated with low-carbon and environmentally sustainable activities.

This critique of a narrow EGSS-based perspective does not imply that we are blind to the many faces that a green transition can take, both in terms of process and outcomes. The circular economy, for example, will produce new jobs – but often the skills in recycling activities will also be very similar to those in initial production: disassembling an old car, for example, is ultimately very similar to assembling the car the first time around (and car assembly has not fundamentally changed in logic over the last two or three decades: as assembly becomes more automated, so does disassembly). Similarly, the shift to a knowledge-based economy, where more and more workers are engaged in high-level handling of abstract data, and in which actual place of work and energy consumption will lead to a secular reduction in CO_2 emissions, even if we changed nothing else (see below).[4] And the combination of decentralised forms of crowd-funding and social entrepreneurship is, against that background of an emerging knowledge economy, almost certain to lead to new 'green(er)' socio-technical arrangements. But the effects are not likely to be very large. A recent study commissioned by DG Environment (DG Env 2018)[5] suggests that even under the most ambitious scenarios, net job growth by 2030 will be of the order of 700,000 as a result of the sustained introduction circular economy activities (DG Env 2018,

[4] The possibility of economic growth escaping the constraints of climate change and environmental limits is discussed in Hepburn and Bowen (2013).
[5] Available at https://circulareconomy.europa.eu/platform/sites/default/files/ec_2018_-_impacts_of_circular_economy_policies_on_the_labour_market.pdf. Accessed 3 March 2019.

section 5.3), in turn concentrated in a sharp rise in job numbers in the fast-growing sector of waste management and a relatively important drop in construction (new jobs will emerge in construction, according to that paper, but more traditional 'non-green jobs are likely to disappear).

While increased recycling will therefore have a relatively small positive impact in terms of number of jobs and type of skills, the effects of the other developments are unknown and probably unknowable, since they lie in the future and are subject to interactions with regulations and shifting cultural moods and political choices. Research on the future is notoriously difficult (to paraphrase Mark Twain), and we prefer on the whole not to engage in speculation for this Research Note. For these pragmatic reasons, we will concentrate our efforts here on de-carbonisation efforts (i.e. reductions in CO_2 emissions). These are quantitatively the most important short and medium-term 'greening' policies and have the most pervasive identifiable effects on jobs and skills.

Several decades of research on and thinking about environmental sustainability have produced a number of basic stylised facts that shed a different light on social sustainability and that form the backdrop for our analysis in this Research Note. The first in this regard is that the EU-28 has experienced a secular shift in employment to economic sectors that are relatively low in carbon emissions and material inputs. While highly polluting (usually traditional) sectors are concentrated in manufacturing and extractive industries that account for 20-25% of employment in the EU today, low-carbon industries in the service sectors employ more than 70% of the EU workforce (this is explored further in section 3). This evolution from intrinsically 'brown' to intrinsically 'green' sectors has been taking place since immediately after the Second World War, when service employment in the USA and Europe topped employment in manufacturing and agriculture for the first time. In much of Europe that switch towards an economy dominated by employment in services took place in the 1960s (Wren 2014). In the US, the shift to services was accomplished in the early 1960s (Urquhart 1984: 16).

In sum, the shift to a service economy produces, in and of itself, a trend towards lower carbon emissions and materials use (at least on the European continent; even high productivity growth would imply that some of the polluting industries move outside the EU to other parts of the world). Furthermore, in existing 'heavy metal' sectors such as steel, engineering, automotive etc. international competition will force the EU-28 to specialise even more in less cost-sensitive higher value-added market segments, where production and products are usually less polluting and where environmental costs can more easily be internalised. These developments are likely to be reinforced by the global shift in emphasis from materials-based activities towards more ideas-based activities that sustainability ultimately requires. Without wanting to suggest that Europe can be complacent, there is

little doubt that structural change in the economy is driving the continent toward a low-carbon future. Whilst policies could accelerate this process and may even be necessary to manage this transition, the trend is undeniably in the direction of low-carbon economic sectors. And even though some service sectors rely on heavy use of electricity (especially those associated with fintech, such as data servers or block chain), which is a problem as long as electricity is produced through carbon-rich methods, a shift towards sustainable energy production will eliminate that problem.

But the story here is slightly more complex than this optimistic picture suggests. There are plenty of sources of CO_2 emissions associated with economic activity that are relatively hard to record and quantify and therefore also hard to target. For example, even if the manufacturing sectors themselves would reduce their activities, a large part of their CO_2 emissions are linked to prevailing organizational models. One is related to the need for all employees to be in the same place at the same time, especially in dominant conventional sequential forms of assembly. This requires significant commuting by the workforce and large traffic jams (with significant CO_2 effects). In addition, the internationalisation of supply chains in the Single European Market also implies that the embedded CO_2 footprint is now very large for parts that are used in assembly. While the exact volume of CO_2 emissions is hard to estimate, a simple example will illustrate the magnitude of the problem.

While such effects are hard to quantify, an estimate is possible. Assuming (not unreasonably) that CO_2 emissions and Value Added (VA) are relatively tightly correlated, shifts in input-output across different industries and regions can be used as a proxy to examine the environmental effects of the significant fragmentation in manufacturing (Baldwin 2016) over the past few decades. The World Input-Output Database (Timmer et al. 2014) allows us to decompose value chains, locate these individual elements, and account for the VA associated with each of them (Timmer et al. 2014: 103). German cars, the example used by Timmer et al. (2014), have seen the proportion of foreign components increase from 21% in 1995 to 34% in 2008. CO_2 emissions associated with the fragmentation of the value chain are therefore likely to have grown at a similar rate during that period and, extrapolating, may be as much as 30% higher today than they were in 1995.

Box 1: The voyage of the crankshaft

In 2017, *The Guardian* newspaper reported (in the context of trade after Brexit) on a crankshaft in the Mini Cooper produced near Oxford, which crossed the Channel several times before it ended up in the final product (The Guardian 3 Mar 2017).[6] From France, where the cast was made, it travelled to Warwickshire in the UK where it was adjusted, then on to Munich, where it was inserted into the engine, and finally to Oxford, where the engine and the crankshaft were linked to the rest of the vehicle (the part would cross the Channel once more if the Mini were to be sold on the continent). Across these trips, the crankshaft chalked up about 4000 km, some of which were attributed to the automotive industry (e.g. when the truck was owned and operated by BMW or its suppliers) and others to the transport industry (in the case of a dedicated delivery service).

This simple conclusion heralds a different set of second-round economic adjustment problems with important labour market effects. Suppliers produce the vast majority of parts in this industry and supply chains have become ever more fragmented as a result of corporate strategies to concentrate on core activities and exploit comparative advantages that exist across the Single European Market. The supply chains often cover the entire continent, as the example above shows, with significant (often unaccounted) CO_2 emissions; any reduction of CO_2 emissions in supply chains will, almost inevitably, have to include a relocation of suppliers closer to the assembly plants, with positive effects for local employment, training and skills there (or vice versa: relocate assembly plants near suppliers). But the flip side of the process is, inevitably, that there are significant negative effects in the regions where suppliers (or final assemblers) were located before. Taking into account that some of the suppliers' locations were chosen as a result of important cost advantages (not least through low wages), this will have relatively important effects on local labour markets – and in the case of Central European member states, where many suppliers located in the late 1990s and 2000s, important effects on national economic performance as well (unless, of course assemblers relocate, in which case a parallel scenario might unfold in the western part of the continent, probably not without significant social problems due to labour protests).[7]

A similar problem emerges in the sectors covered under the broad heading of services, which often follow organizational patterns (including time-related arrangements) of the early industrial period (9 to 5 jobs; high concentration of employees in one office under

[6] https://www.theguardian.com/business/2017/mar/03/brexit-uk-car-industry-mini-britain-eu. Accessed 28/1/18
[7] Supply chain related emission issues also can emerge in wholesale and retail if more but smaller delivery vans are used following the Amazon model. Similarly, the automation of warehouses will likely produce a net increase in energy use.

close supervision; payment by hour and/or job classification). It might be useful here to distinguish analytically between three types of services: those that require both producer and consumer to be present (such as cleaning, restaurants or haircuts); large bureaucracies in the public and private sector (for example insurance and banks); and relatively small-scale knowledge-based service sectors that allow more easily for tele-working. While the first of these service sub-sectors requires a commute because of the co-location condition for delivery, a vast number of activities in the other two in principle do not. Many tech start-ups already have hot-desking arrangements today and many of the large bureaucracies could, in principle at least, be rethought in terms of decentralised project teams. Such organizational redesigns would have quite a significant effect on the need for commuting and thus on indirect CO_2 emissions through traffic (even public transportation).

In sum, while the EU28 will experience a secular shift from brown to green, there is also a need to rethink the now dominant organizational models so that transport costs in general and massive commuting in particular, probably the largest indirect source of CO_2 emissions in low-carbon sectors today, is significantly reduced.

A second important overarching consideration is that many of the detailed activities that are usually associated with environmental sustainability – the EGSS jobs mentioned earlier – can on the whole relatively easily be integrated into existing tasks and jobs or can be built up from existing skill sets. This puts a whole new complexion on the spectre of large transition costs, including high levels of structural unemployment in industrial sectors. In fact, the few instances where employment-related transition costs may be high could in principle relatively easily be mitigated through sector-specific accompanying measures, such as social plans to address shifts in employment, including retraining for younger workers and more active regional/spatial policies.

Far more important in this regard than the net effect on jobs might be the second-round aggregate wage effects on the rest of the working population when many workers in traditional high-carbon-intensity industries enter the labour market *en masse* (particularly if job losses are geographically concentrated and different local labour markets are not well integrated). All other things equal, a sudden pervasive reduction of 'brown' jobs without social measures will have adverse effects on wages in other sectors, if only through the quantitative effect of an increase in unemployment. This effect will be mitigated, of course, as a result of the level of skill specificity of both disappearing jobs and receiving labour markets – miners are not likely to become social carers – but any analysis will have to start from a non-trivial effect on employment in the local areas and possibly beyond.

Such potentially dramatic shocks have important political and policy implications, which suggest that relying on market-based policy instruments to mitigate labour-market impacts may not be the socially most optimal adjustment mechanism. In fact, a whole array of local welfare and (loosely called) social investment policies, such as social plans and active labour market policies, will be necessary to absorb the shocks. In addition, some measure of job redesign and reclassification will have to be negotiated with social partners to minimise unnecessary unemployment and maximise redeployment of people with new job profiles that build in large measure on existing ones. And local employment agencies will have to get involved in assessments and provision of flexible 'prospective' human capital needs for a greener economy.

A quite different but to some extent parallel set of problems is associated with price effects. Policies to promote sustainability are, *ceteris paribus*, likely to push up consumer prices, as increased relative prices for carbon-intensive inputs such as energy from traditional sources, are passed down supply chains. Pervasive upward pressure on consumer prices from this source may increase pressure to raise wages in the rest of the economy. It is also possible that increased demand for some specific skills may lead to increases in pay in some sectors, with knock-on effects via wage bargaining in others. None of these effects are cast in stone, and it is almost certain that existing domestic institutions in the labour market will guide the way they play out; but it serves as a useful reminder that macro effects are often more than the sum of micro effects.

These reflections on the second-order effects of de-carbonisation on wages and prices suggest the gains from thinking about the potentially negative aggregate, macroeconomic effects of the beneficial micro-level policies associated with the turn towards greener activities – the distributive effects of such a turn, the bottlenecks that standard organizational structures impose; and how training systems, taxes and collective bargaining systems can be used to smoothen rather than hinder this transition.

Much of the discussion above will feed into the methodology at the basis of our taxonomy of 'green' jobs. Especially the idea that green activities or tasks can find their way into existing jobs (and that the distributive costs of the transition can therefore be handled through job redesign, retraining and different wage determination systems) will guide the construction of the typology.

3. Method

Employment can be classified in several different ways. If the focus of concern is the impact on jobs of changes in the demand for particular goods and services – a switch from groceries to restaurant meals, for example – then industrial classification of data is useful. For this purpose, Eurostat uses the 'NACE Rev. 2' Statistical classification of economic activities. If the focus is on which jobs within an industry are affected, then occupational data about the nature of jobs, rather than the product or service sold, is helpful. Eurostat uses the 2008 International Standard Classification of Occupations ('ISCO-08').[8] However, neither classification system is by itself ideal for studying challenges cutting across industrial and occupational boundaries, such as automation or – in this case – the transition to a sustainable, green economy.

One way forward is to look at the 'greenness' of existing industry and occupational classifications. With the former, two routes are often taken. First, a subset of industries producing environmental goods and services can be defined – the EGSS sector discussed earlier.[9] But that does not cover the jobs in other industries that will nevertheless be affected by the green transition. Second, greenhouse gas emissions intensity is available by industry. This is useful because it is well understood that the Paris Agreement on climate change action implies net zero carbon emissions by around the middle of this century. On the one hand, that poses a particularly big challenge to industries that are currently emissions-intensive. On the other hand, ranking by emissions intensity can reveal those industries that are currently low-carbon, the expansion of which relative to the high polluting industries will facilitate the green transition.

Box 2: Alternative methods of measuring green jobs (drawing on Bowen, 2012)

There is no single agreed definition of a 'green' job. That makes it hard to compare studies of 'green' job creation and has led some researchers not to use the term at all. In a loose sense, though, 'green' jobs can be regarded as those associated with environmental objectives and policies.

Some definitions of 'green' jobs or related concepts focus on occupations and skills with an identifiable environmental focus, but most focus on employment in industries or specific projects the products of which are deemed to be of environmental benefit. Such benefits can be defined more or less broadly – for example, some concentrate on

[8] A third important way of classifying employment is by the worker attributes needed in particular jobs – an individual's skills and credentials. Educational attainment is measured by Eurostat using the International Standard Classification of Education ('ISCED 2011').
[9] The EU Sustainable Finance Action plan offers a' Sustainability Taxonomy' that provides a framework for classifying all potential assets or activities against a comprehensive set of sustainability goals – from climate change to broader environmental and social goals, including the Sustainable Development Goals. In principle, this approach, using the SDGs not just the decarbonisation objective to assess jobs, could be used to assess job creation too. However, in practice, such an approach would be problematic, particularly as 'decent jobs' are regarded as an end in themselves in the SDG schema (SDG4).

renewable energy, including or excluding biofuels, while others also include environmental services and/or employment related to improving energy efficiency or developing less-carbon-intensive products (e.g. building railways).

UNEP has adopted a definition that attempts to incorporate aspects of job content as well as the characteristics of industry gods and services (UNEP, 2008). It defines 'green' jobs as "work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution." This definition takes a broad industry perspective, extending beyond employment in narrowly defined environmental services. In principle, it embraces employment in producing any goods and services that have smaller adverse environmental impacts than existing close substitutes. UNEP also argues that there is a spectrum of 'greenness': "There are different degrees to which technologies, products, businesses, and business practices can be said to be green, ranging from reactive and remedial measures on the one hand to proactive measures on the other." In other words, cleaning up pollution after the event is less green than stopping the pollution in the first place. That appears to beg the question as to the most efficient way of dealing with an environmental problem and would lead to the classification of many environmental services as less green than, say, employment in the packaging industry.

However, UNEP adds the rider that "green jobs need to be decent work, i.e. good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights. People's livelihoods and sense of dignity are bound up tightly with their jobs. A job that is exploitative, harmful, fails to pay a living wage, and thus condemns workers to a life of poverty can hardly be hailed as green." UNEP suggest that, at a conservative estimate, there were more than 2.3 million jobs in the renewable energy sector around the world in 2006, and more in construction, providing improved energy efficiency in buildings, in low-carbon transport and in other environmental activities. But that compares with an employed labour force globally of around 1.8 billion.

Thus the UNEP definition also extends to characteristics of the jobs themselves. However, their definition conflates different social objectives in one term. The rider is particularly problematic in developing countries where more employment may be desirable for the relief of poverty and an increase in overall productivity – even if the jobs created pay

little more than a subsistence wage or the employment is in less green industries and skill classes.

Some definitions focus on a subset of industries producing environmentally desirable outputs. Thus some studies, notably by the European Commission's Environment Directorate, have used the OECD/Eurostat definition of the environmental goods and services industry (OECD, 1999), comprising "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources." That covers pollution management (e.g. air pollution control) and resource management (renewable energy plants and water supply). Jobs in the nuclear power sector are not included, and these are not generally regarded as 'green', although they are in a low- carbon industry. Jobs in the car industry are excluded, even though some may be devoted to developing low- carbon vehicles.

Some studies have developed their own terminology, using data from detailed employment statistics or detailed company databases. The Pew Center, for example, defines the 'clean energy economy' as follows: "The 'clean energy economy' generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources" (Pew, 2009). It comprises five categories: Clean Energy; Energy Efficiency; Environmentally Friendly Production; Conservation and Pollution Mitigation; and Training and Support. Using data about individual companies, Pew estimates the USA's 'clean energy economy' to account for about half a percent of all US jobs.

Some definitions start from a different analytical perspective and try to answer the question: "What are the employment consequences of introducing 'green' policies (e.g. 'cap and trade') relative to a baseline case?" This approach requires implicit or explicit economic modelling of the policies. Some studies in this vein count only jobs directly created by the policies ('direct' employment effects) while others include jobs created in the supply chain for the products and services supported by 'green' policies ('indirect' employment effects).

Kammen at al. (2004) reviewed several studies that estimate direct employment effects of promoting renewable and other low-carbon energy supply and energy efficiency, focusing on the specific labour requirements of particular technologies ('bottom up' estimates, using simple spreadsheet-based analytical models in conjunction with engineering estimates). They also consider studies that use input-output (I-O) tables to

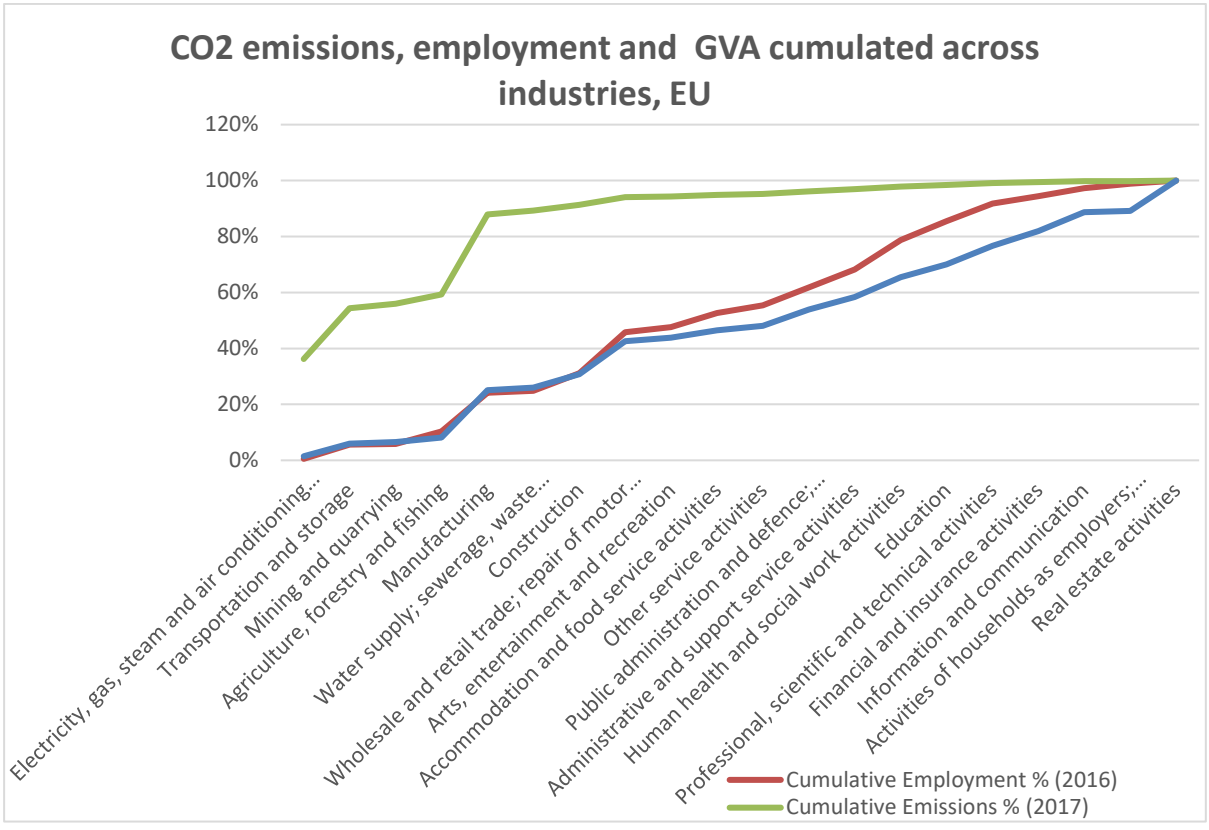
estimate both direct and indirect employment effects, taking account, for example, of the jobs created in business services provided to the renewable energy sector. These extend the scope of the estimates while sacrificing the greater granularity derived from engineering studies of specific energy projects. I-O based studies also fall prey to the usual criticisms of input-output models: that they do not allow for changes in input-output coefficients induced for example by relative price changes and technological progress; that they are often out-of-date; that they depend on industrial classifications that do not distinguish some of the key sectors of interest; and that they are highly aggregated. The meta-studies by Kammen and his associates attempt to derive standardized measures to compare estimates of jobs created per average megawatt over the life of an energy facility. As they take into account jobs destroyed when fossil- fuel-based energy is displaced by low-carbon sources, their projections are for a net concept of employment change, but they do not take into account general equilibrium effects through relative wage changes.

Others go further still and include jobs created by the aggregate demand generated by the extra direct and indirect employment ('induced' employment effects). This approach allows jobs to be counted as 'green' if they are created by 'green' policies, even if they are in sectors with no obvious direct relationship to environmental objectives (e.g. tobacco processing) or only a secondary relationship (e.g. construction). A question arises as to whether one should net off jobs destroyed in sectors disadvantaged by 'green' policies (e.g. coal mining). This issue is less relevant if one is simply trying to enumerate jobs associated directly with environmentally attractive goods and services. But it is crucial if one is trying to evaluate the overall labour market impacts of environmental policies. Some studies finesse this issue by focusing on the job creation implications of different fiscal stimulus packages with greater or lesser reliance on 'green' spending, none of which are expected to destroy jobs e.g. Pollin et al. (2008).

Finally, some studies attempt to take more thorough account of economy-wide ramifications of 'green' policies such as carbon pricing by using some form of general equilibrium modelling. This is implicit in estimates of induced employment, because some macroeconomic theory is needed to determine what happens to aggregate demand. The multiplier-based approach exemplified by Pollin et al. can be thought of as being based on a simple fixed-price Keynesian view of the macro-economy with Keynesian unemployment and some 'leakage' of injections of aggregate demand to exports from other countries. Computable general equilibrium models in the neoclassical tradition (e.g. Goettle and Fawcett (2009) paint a very different picture.

Figure 3.1 ranks broad industry categories by CO_2 emissions intensity, from the most CO_2 intensive on the right-hand-side to the least emissions-intensive on the left-hand-side. The green line shows the cumulative proportion of total emissions accounted for by the industries to the left of any point, the red line shows cumulative proportion of employment and the blue line the cumulative proportion of gross value added. Thus, the graph shows that the most polluting industry – electricity, gas, steam and air conditioning supply – accounts for well over 30% of emissions but a very small share of employment and value added (the figures are 36%, 1% and 1.5% respectively). The biggest carbon polluters actually account for a relatively small proportion of total EU employment. For example, the industries that account for 91% of total emissions ('manufacturing and all sectors to the left of it in the graph) account for only 31% of employment and gross value added. That suggests that there is a proportionally larger challenge to firms to re-allocate investment than there is for labour-market institutions to re-allocate workers.

Figure 3.1: CO_2 emissions, employment and gross value added industries, EU (2016-7)



(Source: Eurostat and authors' calculations)

While this sectoral analysis has been well documented, relatively less effort has been expended on assessing the 'greenness' of different occupations in Europe. However, the

U.S. Department of Labor Employment and Training Administration has undertaken the effort to classify occupations and their constituent tasks in a way that facilitates better analysis of their 'greenness.' This has happened under the aegis of its 'O*NET Program,' described on its website as 'the nation's primary source of occupational information.'[10] The classification is carried out by means of an expert review of occupations mentioned in connection with greening the economy in some way in papers in industry, technical and engineering papers, and academic research papers.[11] It focuses on industry sectors associated with the greening of the economy, a broader range of industries than the EGSS sector but still excluding some sectors that may grow as a result of greening (e.g. educational services).[12] O*NET counts any occupation that will be affected by greening as a green job, and defines three subcategories of green jobs according to the effect that greening will have on the tasks, skills, and knowledge required for the job:

1) Green Increased Demand (Green ID) jobs are existing jobs that are expected to be in high demand due to greening, but do not require significant changes in tasks, skills, or knowledge. These jobs are considered as indirectly green because they support green economic activity, but do not involve any specifically green tasks. (Example: bus drivers, counted in the occupational category 'bus drivers, transit and intercity.')

2) Green Enhanced Skills (Green ES) jobs are existing jobs that require significant changes in tasks, skills, and knowledge as a result of greening. (Example: electric vehicle electricians: counted in the occupational category 'automotive speciality technicians.')

3) Green New and Emerging (Green NE) jobs are unique jobs (as defined by worker requirements) created to meet the new needs of the green economy. (Example: fuel cell engineers.)

This classification can be used to identify jobs in EU countries as well as the USA because the US occupational classification maps directly onto the international classification ISCO used by Eurostat. We have matched the job titles provided by O*NET to the job titles used in ISCO-88 and ISCO-08[13], thus providing the ISCO codes to identify green jobs in the EU Labour Force Surveys.

A few caveats need to be flagged about transferring the O*NET occupational classifications into the EU. First, the label of 'green' is likely to have been assigned to specific occupations

[10] See https://www.onetcenter.org/overview.html
[11] See section III.1 in Rivkin, et al. (2009).
[12] As we pointed out earlier in this Research Note, there is a tendency in the literature to associate the 'green economy' with sectors that deliver environmental goods and services or will have to adopt radically different technologies to lessen their environmental impact. This underplays the potential importance of the expansion of sectors that already have a low environmental footprint, including many service sectors.
[13] See ILO: https://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm and
ESCO: https://ec.europa.eu/esco/portal/occupation?resetLanguage=true&newLanguage=en accessed

by O*NET on the basis of evidence drawn primarily from US studies. European occupations may be more or less advanced in their degree of greenness, depending in part on differences in technologies adopted in the US and Europe.

Second, the green occupations were originally defined at a more granular level than the data available for countries in the EU Labour Force Survey (in ISCO terms, at the four-digit level instead of the three-digit level). Since all four-digit occupations are a sub-set of three-digit occupations, they overlap considerably; however, we had to make a choice when converting 4-digit into 3-digit occupations, and have labelled 'green' any three-digit occupation that contains at least one four-digit level 'green' occupation[14].

Third, O*NET focused on certain industry sectors that are deemed to be more heavily involved in the green transformation. We have reasoned that any occupation that is identified as green in these industries is likely to be green in other industries, too; ignoring the latter would underestimate the scope for green jobs outside the conventional green (and brown) sectors.

Since the O*NET database identifies the tasks required by workers in any given occupation and classifies the tasks that occupations use as green or non-green, the greenness of occupations can be measured in a more granular way than they are here, according to the proportion of tasks making up an occupation that are green.[15] Non-green jobs can be split into 'green rival' jobs and 'other' jobs, where 'green rival' jobs are considered 'similar' to one of the three 'green' job categories, either because the tasks they involve are very similar or (in the case of new employees) because they require similar skills and other worker attributes.[16] The next section reports the data for occupations after this transfer of the US categorisation to the EU, relying on data from the EU Labour Force Survey.

4. Green Jobs in the EU: a Taxonomy, Basic Data and Discussion

This section reports the results of our data reorganization and presents a first cut at EU-wide shifts in skills and jobs in terms of the GID, GES and GNE classification and its implications for total green jobs defined in this way. Table 4.1 summarises the levels of employment in the different industry sectors (using the NACE system), to give an idea of their relative size.[17] Tables 4.2 and 4.3 show how the numbers of workers in the three different types of 'green' job identified changed from 2006 (right before the crisis and therefore when the economy was at full capacity or beyond) to 2016. They also show what

[14] We have had to go further with four countries that do not report data to the EU LFS survey at a three-digit level: Bulgaria, Malta, Poland and Slovenia. In these cases, we have used the most detailed occupational classification available. This will tend to exaggerate somewhat the number of green jobs of each type for these countries, relative to the treatment of the other countries.
[15] See, for example, Vona et al. (2017).
[16] Bowen et al. (2018).
[17] The labels used correspond to NACE rev2, in use at the time of the 2016 EU Labour Force Survey. Some industries have been aggregated to permit comparison with 2006, when NACE rev1.1 was in place. Thus, for example, 'Transportation and storage' and 'Information and communication' have been combined, as together they broadly correspond to NACD rev1.1's 'transport, storage and communication.' See p.47, Eurostat (2008).

happened to the total number of green jobs after allowing for possible double-counting when adding together the three specific types of green job. Tables 4.4-4.7 give the proportion of each of these types of 'green' jobs per industrial sector, and the corresponding figures for total green jobs after eliminating double-counting, for the same two years – with the change listed in the final column.

Table 4.1 Employment (aged 15-64) by industry (000s), EU

NACE Activities	2016	2006	% change 2006-2016
Total	218972	212254	3.2%
Agriculture, forestry and fishing	8737	11530	-24.2%
Mining and quarrying	757	959	-21.1%
Manufacturing	34157	39022	-12.5%
Electricity, gas, steam and air conditioning supply; Water supply; Sewerage, waste management and remediation activities	3236	2023	60.0%
Construction	14716	16947	-13.2%
Wholesale and retail trade; Repair of motor vehicles and motorcycles	30712	30400	1.0%
Accommodation and food service activities	10567	8894	18.8%
Transportation and storage; Information and communication	18180	13062	39.2%
Financial and insurance activities	6476	6384	1.4%
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	22994	19680	16.8%
Public administration and defence; Compulsory social security	15176	15262	-0.6%
Education	16639	14903	11.6%
Human health and social work activities	23820	20341	17.1%
Arts, entertainment and recreation; Other service activities	9043	9897	-8.6%
Activities of households as employers; Goods- and services-producing activities of households for own use	2243	2287	-1.9%
Activities of extraterritorial organisations and bodies	190	145	31.0%

Source: Eurostat

Table 4.1 reports that aggregate employment in the EU rose by just over 3% between 2006 and 2016. However, the headline figure conceals the flux in employment at the industry level. Some sectors, notably agriculture, forestry and fishing, showed major contractions. The biggest industry by employment level was manufacturing in both years, but the sector's employment fell by over 12%. Clearly, the production of new capital stock for the emerging green sectors has not been sufficient to preserve manufacturing employment. However, the biggest increase in employment has been in 'Electricity, gas, steam and air conditioning supply; Water supply; Sewerage, waste management and remediation activities,' which is closely associated with environmental goods and services (a category that does not appear in the standard NACE classification). The data also show signs of two major trends in industry structure: the expansion of information and communication activities with the information revolution and the growth of human health and social work activities, reflecting in part the ageing of European society.

Table 4.2 Green jobs and total employment (aged 15-64), EU, 2016

	Employment (000s)	Proportion of total employment (%)
Total	218972	100.0
Green Increased Demand	49276	22.5
Green Enhanced Skills	43879	20.0
Green New and Emerging	38197	17.4
Green Total after adjustment	87611	40.0

Source: Eurostat and authors' calculations

Table 4.3 Green jobs and total employment (aged 15-64), EU, 2006

	Employment (000s)	Proportion of total employment (%)
Total	212254	100.0
Green Increased Demand	47859	22.5
Green Enhanced Skills	34782	16.3
Green New and Emerging	22928	10.8
Green Total after adjustment	75407	35.5

Source: Eurostat and authors' calculations

Tables 4.2 and 4.3 summarise the scale of green jobs in the EU economy.[18] 'Green Enhanced Skills' jobs and, even more so, 'Green New and Emerging Skills' jobs have risen as shares of total employment. However, perhaps surprisingly, 'Green Increased Demand Skills' jobs have remained the same share. This is the category where O*NET researchers expected an increase in traditional jobs associated with 'green' activities simply due to the increase in demand for environmental goods and services and decarbonisation. Instead, employment has increased more in occupations requiring new skills and/or retraining, suggesting that new green-oriented activities and technologies, with new demands on the labour market, have been becoming more important.

[18] The proportions of green ID, green ES and green NE jobs should not be added up because some occupations at the three-digit ISCO level contain green jobs of more than one type. Summing proportions across the three types would therefore give rise to some double-counting. But an adjusted total number of green jobs can be derived by only counting once any jobs in an occupation that falls in more than one of the three green jobs categories.

Table 4.4 Proportion of *'Green Increased Demand'* jobs in industry sectors, EU (%)

NACE Activities	2016	2006	% point change 2006-2016	% change 2006-2016	Memo: number of green ID jobs (000s) 2016
Agriculture, forestry and fishing	18.64	18.51	0.13	-23.7%	1629
Mining and quarrying	27.62	22.51	5.11	-8.9%	206
Manufacturing	34.18	35.71	-1.53	-16.2%	11675
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	29.75	28.15	1.60	69.1%	963
Construction	45.12	38.62	6.50	3.7%	6640
Wholesale and retail trade; repair of motor vehicles and motorcycles	17.62	21.54	-3.92	-17.4%	5411
Accommodation and food service activities	17.47	22.52	-5.05	-7.8%	1846
Transportation and storage; Information and communication	36.63	34.53	2.10	47.6%	6659
Financial and insurance activities	12.96	11.4	1.56	15.3%	839
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	25.38	21.01	4.37	41.1%	5836
Public administration and defence; compulsory social security	28.9	26.81	2.09	7.2%	4386

Education	5.53	4.19	1.34	47.4%	920
Human health and social work activities	9.68	6.59	3.09	72.0%	2306
Arts, entertainment and recreation; Other service activities	8.54	4.25	4.29	83.6%	772
Activities of households as employers; Goods- and services-producing activities of households for own use	7.85	2.49	5.36	209.2%	176
Activities of extraterritorial organisations and bodies	2.61	0.89	1.72	284.3%	5

Source: Eurostat and authors' calculations

Table 4.4 takes a more detailed look at what has happened to 'green increased demand skills' jobs. The highest proportions of this type of green job are in construction; transportation and storage; information and communication; manufacturing; and mining and quarrying. This is consistent with the need for these industries to increase outputs associated with the low-carbon transition, such as building insulation, domestic energy efficiency, low-carbon vehicles, public transport, solar panels and wind turbines, and remedial work in mining and quarrying. But professional, scientific and technical services are important, too. Most industries have shown an increase in the share of 'green increased demand skills' jobs, but three, including importantly manufacturing, have shown a decrease. This may be because of other, adverse, shocks to these industries that have reduced the demand for these relatively traditional jobs. This is much less likely to have been the case with the other two types of green job, which are defined by skills that are more intrinsically linked to the growth of the green economy. However, manufacturing remains the source of largest absolute number of these green jobs, followed by construction.

Table 4.5 Proportion of *'Green Enhanced Skills'* jobs in industry sectors, EU (%)

NACE Activities	2016	2006	% point change 2006-2016	% change 2006-2016	Memo: number of green ES jobs (000s) 2016
Agriculture, forestry and fishing	8.50	3.61	4.89	78.4%	743
Mining and quarrying	31.66	18.77	12.89	33.1%	240
Manufacturing	22.50	22.79	-0.29	-13.6%	7685
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	33.87	31.54	2.33	71.8%	1096
Construction	36.74	39.62	-2.88	-19.5%	5407
Wholesale and retail trade; repair of motor vehicles and motorcycles	20.11	14.1	6.01	44.1%	6176
Accommodation and food service activities	5.05	3.25	1.80	84.6%	534
Transportation and storage; Information and communication	30.09	21.6	8.49	93.9%	5470
Financial and insurance activities	23.69	13.13	10.56	83.0%	1534
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	29.12	27.44	1.68	24.0%	6696
Public administration and defence; compulsory social security	18.07	14.21	3.86	26.4%	2742
Education	4.28	2.19	2.09	118.2%	712
Human health and social work activities	15.62	6.24	9.38	193.1%	3721
Arts, entertainment and recreation; Other service activities	11.69	5.01	6.68	113.2%	1057
Activities of households as employers; Goods- and services-producing activities of households for own use	3.55	1.72	1.83	102.4%	80
Activities of extraterritorial organisations and bodies	7.67	3.43	4.24	193.0%	15

Source: Eurostat and authors' calculations

Table 4.5 repeats the exercise for 'green enhanced skills' jobs. While a similar set of industries shows high proportions of this sort of green job as well as 'green enhanced

demand skills' jobs (notably construction), the pattern is not exactly the same. For example, these jobs are scarcer in agriculture, forestry and fishing and more common in financial and insurance activities. The biggest increases between 2006 and 2016 were in mining and quarrying and in financial and insurance activities. This is perhaps suggestive of enhanced skills being in greater demand in more innovative industries and those where major technological changes are demanded in response to climate change. Some of the high-emissions industries are included but so are some service sectors that have an important part to play in bringing about the low-carbon transition.

Table 4.6 Proportion of *'Green New and Emerging'* jobs in industry sectors, EU (%)

NACE Activities	2016	2006	% point change 2006-2016	% change 2006-2016	Memo: number of green NE jobs (000s) 2016
Agriculture, forestry and fishing	8.35	4.03	4.32	57.0%	730
Mining and quarrying	29.56	11.24	18.32	107.6%	224
Manufacturing	15.55	14.15	1.40	-3.8%	5311
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	29.8	26.53	3.27	79.7%	964
Construction	19.46	10.32	9.14	63.7%	2864
Wholesale and retail trade; repair of motor vehicles and motorcycles	14.93	16.68	-1.75	-9.6%	4585
Accommodation and food service activities	5.18	8.89	-3.71	-30.8%	547
Transportation and storage; Information and communication	21.01	9.91	11.10	195.1%	3820
Financial and insurance activities	42.21	9.4	32.81	355.5%	2734
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	35.48	22.04	13.44	88.1%	8158

Public administration and defence; compulsory social security	22.72	5.73	16.99	294.3%	3448
Education	6.93	1.81	5.12	327.5%	1153
Human health and social work activities	11.34	3.33	8.01	298.8%	2701
Arts, entertainment and recreation; Other service activities	10.9	6.14	4.76	62.2%	986
Activities of households as employers; Goods- and services-producing activities of households for own use	1.05	0.58	0.47	77.6%	24
Activities of extraterritorial organisations and bodies	6.7	8.33	-1.63	5.4%	13

Source: Eurostat and authors' calculations

Table 4.6 can be used to examine 'green new and emerging skills' jobs. The mining and quarrying industry has a relatively high proportion of such jobs but what is striking about the table is the significant proportion in several service sectors, especially financial and insurance activities and professional, scientific and technical activities. Novel green occupations are not limited to the production of narrowly defined environmental goods and services. The changes since 2006 reinforce this point. These sectors have seen much bigger percentage point increases than has manufacturing.

Table 4.7 Proportion of *'Green'* jobs, adjusted to eliminate double-counting, in industry sectors, EU (%)

NACE Activities	2016	2006	% point change 2006-2016	% change 2006-2016	Memo: number of green jobs (000s) 2016
Agriculture, forestry and fishing	25.90	21.68	4.22	-9.5%	2,263
Mining and quarrying	54.36	37.16	17.20	15.5%	412
Manufacturing	52.23	53.59	-1.36	-14.7%	17,840
Electricity, gas, steam and air conditioning supply; Water supply; sewerage,	58.01	54.23	3.78	71.1%	1,877

waste management and remediation activities					
Construction	73.32	66.99	6.33	-5.0%	10,790
Wholesale and retail trade; repair of motor vehicles and motorcycles	33.87	34.13	(0.26)	0.3%	10,402
Accommodation and food service activities	21.83	26.33	(4.50)	-1.5%	2,307
Transportation and storage; Information and communication	60.70	50.87	9.83	66.1%	11,035
Financial and insurance activities	36.79	21.94	14.85	70.1%	2,383
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	51.55	43.49	8.06	38.5%	11,853
Public administration and defence; compulsory social security	45.28	37.36	7.92	20.5%	6,872
Education	15.31	5.99	9.32	185.4%	2,547
Human health and social work activities	21.41	11.38	10.03	120.3%	5,100
Arts, entertainment and recreation; Other service activities	18.41	8.75	9.66	92.2%	1,665
Activities of households as employers; Goods- and services-producing activities of households for own use	10.49	3.75	6.74	174.4%	235
Activities of extraterritorial organisations and bodies	16.05	4.76	11.29	341.8%	30

Source: Eurostat and authors' calculations

Looking across Tables 4.1-4.7, it is striking that, first, there are a lot of people working in occupations that could be considered green. An unweighted average of the proportions in the sectors listed is about 20% for each of the three types of green job.

Second, although some industry sectors that can be expected to have a high proportion of green jobs, such as construction, some service sectors, such as financial and insurance

activities, do as well. However, some sectors that one might have thought are intrinsically green, such as agriculture, forestry & fishing, turn out not to have such a high proportion, perhaps because of less directed activity to reduce emissions and a relatively less educated workforce. Among the service sectors that are large employers, education is notable for the paucity of green jobs.

Third, the proportion of green jobs rose between 2006 and 2016, from about 35.5% to 40%. The unweighted average of the proportion in green ID jobs rose only a little, but the proportion of green ES jobs rose substantially and the proportion of green NE jobs even more so. This suggests that more worker retraining is needed than would be evident treating green jobs as a homogeneous group. The main increases in green ID and green ES jobs were in the same three industries: Professional, scientific & technical activities; Mining & quarrying; and Transportation & storage. The first of these also showed the biggest increase in the share of green NE jobs, drawing attention to the role of advisory services in the green transformation. The data may also reflect some outsourcing of these services from firms in other sectors.

So far, we have said little about non-green jobs. However, it is useful to define a subcategory of these jobs, 'green rival' jobs. These are jobs that are similar in a sense to green jobs, while not themselves being identified with explicitly green activities (unlike the three categories of green jobs defined by O*NET). More precisely, they are defined from the O*NET files as jobs (at a very disaggregated occupational level) that are 'similar' to a green occupation, according to job-specific aspects such as skills, experience, or work context ('Career Changers' in O*NET) or worker-specific aspects, such as abilities and occupational interests ('Career Starters'). At a more aggregated level, any occupation containing one of these 'green rival' jobs is treated as a 'green rival' occupation. Further detail is given in Bowen et al. (2018). It is reasonable to suppose that it is easier for workers to transition from such jobs to green jobs (and vice versa) than from other non-green jobs to green jobs.[19] Table 4.8 below suggests that transition back and fore between green and non-green jobs may be easier in 'Agriculture, forestry and fishing,' 'Mining and quarrying,' 'Wholesale and retail trade and repair of motor vehicles and motorcycles,' 'finance and insurance activities,' and public administration than in other sectors. One striking feature of the data is that, on the whole, the proportion of 'green rival' jobs declined

[19] One disadvantage of this definition in the current context is that it is dependent on O*NET analysis of job tasks and individual characteristics that are specific to the US data. Without further research that looks more deeply into these aspects of jobs, it is difficult to establish if jobs that are 'green rivals' in the US are also 'green rivals' in the EU. The overlap between the US and the EU is likely to be very large, by virtue of their concordance with international standards (ISCO), but almost certainly not 100%.

from 2006 to 2016, suggesting that the divide between green and other jobs is becoming more pronounced.

Table 4.8 Proportion of *'Green Rival'* jobs in industry sectors, EU (%)

NACE Activities	2016	2006	% point change 2006-2016	% change 2006-2016	Memo: number of green rival jobs (000s) 2016
Agriculture, forestry and fishing	50.63	58.55	-7.92	-34.5%	4,424
Mining and quarrying	39.28	40.78	-1.50	-24.0%	297
Manufacturing	27.53	33.56	-6.03	-28.2%	9,403
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	22.48	26.48	-4.00	28.8%	727
Construction	21.65	30.09	-8.44	-37.3%	3,186
Wholesale and retail trade; repair of motor vehicles and motorcycles	43.02	50.27	-7.25	-13.5%	13,212
Accommodation and food service activities	18.59	17.52	1.07	22.6%	1,964
Transportation and storage; Information and communication	36.58	39.39	-3.32	29.3%	6,650
Financial and insurance activities	53.15	50.84	2.31	6.0%	3,442
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	33.97	39.14	-5.17	-1.2%	7,811
Public administration and defence; compulsory social security	38.45	44.13	-5.68	-13.4%	5,835
Education	38.01	38.77	-0.76	9.5%	6,324
Human health and social work activities	20.93	26.12	-5.19	-6.2%	4,986

Arts, entertainment and recreation; Other service activities	30.22	25.24	4.98	9.3%	2,733
Activities of households as employers; Goods- and services-producing activities of households for own use	11.74	13.55	-1.81	-15.3%	263
Activities of extraterritorial organisations and bodies	7.41	5.01	2.40	93.7%	14

Source: Eurostat and authors' calculations

As this analysis of 'green' jobs uses EU Labour Force Survey data, it is possible to analyse the categories of 'green' jobs in 2006 and 2016 according to other characteristics of the job-holder (and, indeed, of the job). As an illustration of what can be achieved, we have undertaken a preliminary analysis of the educational attainment of job-holders, reported below. This gives some indication of the skill levels of workers recruited in the different categories and how these skill demands have changed over time. This exercise could be repeated for other characteristics, such as sex and marital status; full-time work versus part-time; temporary and other atypical work statuses; and economic status of the worker a year before the relevant LFS survey. One could investigate whether green jobs of different sorts tended to be in large or small work-place units or in particular regions. However, although this is potentially a very fruitful way to examine green jobs further, with any exercise of this sort, one has to be careful about confusing correlations with causation.

Table 4.9 Proportion of green job occupants (15-64) by educational attainment, EU (% of jobs category

	H	2016	L	H	2006	L
Total	33.9	48.3	17.6	25.7	49.4	24.7
Green Increased Demand	29.1	43.5	27.3	21.5	40.9	37.6
Green Enhanced Skills	30.8	49.4	19.9	23.2	38.4	38.4
Green New and Emerging	40.1	49.8	10.1	28.8	44.1	27.1

Source: Eurostat and authors' calculations.
N.B. H denotes 'Tertiary education' (ISCED11 levels 5-8), M denotes 'Upper secondary and post-secondary non-tertiary education' (ISCED11 levels 3 and 4) and L denotes 'Less than primary, primary and lower secondary education' (ISCED11 levels 0-2).

Table 4.9 shows that educational attainment levels in each of the three categories of green job rose between 2006 and 2016, as they did for people in employment as a whole. GES and especially GID jobs appear to have less onerous educational attainment requirements than average while GNE jobs tend to have the opposite. It is striking how much the education attainment of people with GNE jobs rose between 2006 and 2016: the percentage reaching a high level of attainment rose by over 12 percentage points (compared with 8.2 percentage points for total employment and just 7.6 percentage points for GID and GES jobs). The proportion of workers with the lowest levels of educational attainment fell more in all three categories of green jobs than in employment as a whole but in GID and GES jobs remained below the average.

Tables 4.10-4.12 below show the educational attainment levels of the green workforce in individual industries and how they have changed, while Table 4.13 does the same for ‘green rival’ jobs. The ranking of industries by the crude measure of the proportion of high-level attainment minus the proportion of low-level attainment is similar across all three green job types. ‘Agriculture, forestry and fishing’ and ‘Mining and quarrying’ have on average low attainment and electricity & water supply, finance, education and health & social services have on average high levels.

Over time, the average attainment of each category of green job across the economy as a whole has risen more than that in any individual industry, presumably because of a net shift of green employment towards high-attainment sectors in addition to a rise in attainment in individual sectors. For GID and GES jobs, the crude attainment measure rose more in some of the lower-attainment sectors such as ‘Agriculture, forestry and fishing’ and ‘Mining and quarrying,’ and there is a sense of some ‘catching up’ taking place. That is not so evident among the GNE jobs, where large increases in attainment are closer to being across the board.

‘Green rival’ jobs appear to be somewhat more like GES jobs in terms of educational attainment than the other two categories, especially GNE jobs. Workers with ‘green rival’ jobs therefore seem less likely to find it easy to transition to a GNE job, the type of green job that appears to be multiplying most rapidly.

Table 4.10 Proportion of *'Green Increased Demand'* jobs in industry sectors with high, medium or low educational attainment, EU (%)

NACE Activities	H	2016	L	H	2006	L
Agriculture, forestry and fishing	19.04	39.64	41.32	15.69	37.12	47.19
Mining and quarrying	13.23	49.06	37.71	11.98	37.59	50.43
Manufacturing	29.15	42.11	28.74	26.27	46.21	27.52
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	31.72	48.12	20.16	33.25	36.96	29.79
Construction	34.67	36.05	29.28	31.15	34.58	34.27
Wholesale and retail trade; repair of motor vehicles and motorcycles	17.28	51.95	30.77	14.3	48.47	37.23
Accommodation and food service activities	21.57	49.52	28.91	19.11	45.17	35.72
Transportation and storage; Information and communication	29.69	45.33	24.98	25.21	42.28	32.51
Financial and insurance activities	34.12	51.4	14.48	30.78	52.86	16.36
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	31.51	40.88	27.61	30.55	39.72	29.73
Public administration and defence; compulsory social security	28.91	49.88	21.21	26.92	51.82	21.26
Education	42.71	45.19	12.10	41.09	46.32	12.59
Human health and social work activities	32.86	40.95	26.19	29.75	45.29	24.96
Arts, entertainment and recreation; Other service activities	38.45	39.52	22.03	35.05	45.96	18.99
Activities of households as employers; Goods- and services-producing activities of households for own use	27.58	44.98	27.44	25.37	49.02	25.61
Activities of extraterritorial organisations and bodies	32.61	52.12	15.27	29.71	49.27	21.02

Source: Eurostat and authors' calculations

Table 4.11 Proportion of *'Green Enhanced Skills'* jobs in industry sectors with high, medium or low educational attainment, EU (%)

NACE Activities	H	2016	L	H	2006	L
Agriculture, forestry and fishing	24.48	36.45	39.07	16.37	29.65	53.98
Mining and quarrying	19.63	41.04	39.33	15.85	33.71	50.44
Manufacturing	31.02	48.41	20.57	28.63	49.12	22.25
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	35.60	52.17	12.23	32.87	45.03	22.1
Construction	32.41	47.51	20.08	31.65	43.3	25.05
Wholesale and retail trade; repair of motor vehicles and motorcycles	19.05	58.91	22.04	12.67	57.14	30.19
Accommodation and food service activities	23.54	51.99	24.47	21.97	45.51	32.52
Transportation and storage; Information and communication	31.77	44.53	23.70	27.08	42.88	30.04
Financial and insurance activities	38.18	55.81	6.01	35.52	57.41	7.07
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	29.58	48.12	22.30	25.14	52.03	22.83
Public administration and defence; compulsory social security	31.18	52.46	16.36	28.86	51.54	19.6
Education	51.83	40.19	7.98	49.64	41.15	9.21
Human health and social work activities	38.69	47.12	14.19	38.01	41.91	20.08
Arts, entertainment and recreation; Other service activities	42.08	46.43	11.49	35.48	52.81	11.71
Activities of households as employers; Goods- and services-producing activities of households for own use	39.25	43.98	16.77	36.69	47.12	16.19
Activities of extraterritorial organisations and bodies	35.82	51.91	12.27	29.15	42.71	28.14

Source: Eurostat and authors' calculations

Table 4.12 Proportion of *'Green New and Emerging'* jobs in industry sectors with high, medium or low educational attainment, EU (%)

NACE Activities	2016			2006		
	H		L	H		L
Agriculture, forestry and fishing	31.61	38.91	29.48	23.38	40.91	35.71
Mining and quarrying	24.13	51.76	24.11	21.93	49.11	28.96
Manufacturing	38.81	52.17	9.02	36.04	43.98	19.98
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	41.93	49.25	8.82	39.21	42.08	18.71
Construction	40.82	49.51	9.67	33.1	48.66	18.24
Wholesale and retail trade; repair of motor vehicles and motorcycles	23.06	65.54	11.40	18.85	59.87	21.28
Accommodation and food service activities	28.12	47.98	23.90	23.67	43.71	32.62
Transportation and storage; Information and communication	41.77	48.49	9.74	38.43	35.17	26.4
Financial and insurance activities	49.54	46.25	4.21	42.89	51.98	5.13
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	42.76	42.81	14.43	27.56	58.13	14.31
Public administration and defence; compulsory social security	41.77	50.45	7.78	32.61	49.04	18.35
Education	55.43	40.98	3.59	47.41	48.93	3.66
Human health and social work activities	44.87	51.78	3.35	39.28	45.08	15.64
Arts, entertainment and recreation; Other service activities	47.91	49.02	3.07	41.75	48.09	10.16
Activities of households as employers; Goods- and services-producing activities of households for own use	48.13	45.62	6.25	35.21	49.77	15.02
Activities of extraterritorial organisations and bodies	44.69	52.76	2.55	41.57	50.03	8.4

Source: Eurostat and authors' calculations

Table 4.13 Proportion of *'Green rival'* jobs in industry sectors with high, medium or low educational attainment, EU (%)

NACE Activities	H	2016	L	H	2006	L
Agriculture, forestry and fishing	23.73	32.97	43.30	20.09	32.8	47.11
Mining and quarrying	15.41	38.25	46.34	19.32	39.11	41.57
Manufacturing	32.46	46.92	20.62	26.04	46.17	27.79
Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	30.28	49.87	19.85	31.87	42.93	25.2
Construction	25.19	48.51	26.30	29.64	48.22	22.14
Wholesale and retail trade; repair of motor vehicles and motorcycles	18.54	52.46	29.00	14.47	55.42	30.11
Accommodation and food service activities	21.32	48.11	30.57	18.29	49.13	32.58
Transportation and storage; Information and communication	25.14	50.28	24.58	26.13	41.89	31.98
Financial and insurance activities	38.62	52.56	8.82	32.16	56.98	10.86
Real estate activities; Professional, scientific and technical activities; Administrative and support service activities	33.75	45.87	20.38	29.56	54.66	15.78
Public administration and defence; compulsory social security	27.43	49.24	23.33	28.41	48.12	23.47
Education	42.37	45.98	11.65	46.52	38.02	15.46
Human health and social work activities	35.53	42.84	21.63	36.85	44.27	18.88
Arts, entertainment and recreation; Other service activities	40.36	49.62	10.02	33.17	44.99	21.84
Activities of households as employers; Goods- and services-producing activities of households for own use	35.01	45.62	19.37	38.48	48.73	12.79
Activities of extraterritorial organisations and bodies	31.97	52.06	15.97	36.24	52.06	11.7

Source: Eurostat and authors' calculations

5. Discussion and Policy Implications

These data yield a series of interesting insights, which we will explore here in light of the broader context sketched in section 2 of this research note. At the end of this section, we intend to present a few important policy implications that we see as following from these data. The first insight from the data is that there are simply a large number of jobs with a significant green component, and that this number has grown, both in absolute terms and as a proportion of total employment. Across all industries, in 2006 already perhaps more than half of all jobs were green by our definition, as Table 4.2 shows.[20] In 2016, according to the accounting in Table 4.3, the total proportion of green jobs was significantly higher, against a background of 6.5 million new jobs (or 3.2% overall job growth). European labour markets are becoming greener at a rapid pace, in other words.

The second insight pertains to the overall picture regarding the increased demand for existing skills useful in producing green goods and services (GID; Table 4. 4). The most striking fact here is undoubtedly how much the profiles of jobs of this type in 2016 resemble the profiles of such jobs in 2006. Especially in the sectors that are traditionally associated with (pre-) industrial societies – agriculture, mining, manufacturing, water, energy and construction – existing skills have barely increased in demand, with the exception of construction. The latter has almost certainly much to do with relatively basic elements in houses, such as insulation and more efficient heating, electricity or plumbing, and is therefore mainly the result of shifts in relative prices for energy and other natural resources. Overall, the biggest positive and negative shifts are of the order of 4-5%. This is in sharp contrast with data for GED and GNE skills, and also significantly different from the analysis of the USA on which we based ours. In the Department of Labor research that served as our template, the authors expected growth in this type of green jobs as a result of increased demand (the title they gave the category of jobs), but that seems not to be the case in the EU.

Our interpretation relates this relative stability in skill profiles (and concurrent employment), specifically in traditional industrial sectors in the EU, to the political economy of the labour market in Europe. In many European labour markets many employees, especially in these traditional sectors, have been through relatively sophisticated training programmes, in which they have acquired a set of 'deep' industry-specific skills[21]. Those workers would find it very hard to change jobs within and between industries without a significant loss in wages. Employers in these sectors have, in a parallel way, invested heavily in specific capital assets that are extremely hard to convert for use in other settings.

20 One must recall that the numbers of the three kinds of green jobs should not, strictly speaking, be summed, as a given broad occupation may be counted as more than one type of green job. The statement in the text is about the upper bound on green jobs.
21 While there is no direct correspondence, these highly specific skills are mainly 'medium' level (but not vice versa: not all 'medium' skills are necessarily 'specific'). As the data there suggest, about half of the workforce in the traditional sectors is in the 'medium' skill category. There are also likely to be some specific skill clusters among highly skilled workers in those sectors, such as engineers.

Both are reluctant to change jobs in such a way that these investments are lost – and in the case of employees, this interest is usually backed up by very strong trade unions, who will defend the skills, and therefore also the workers in the jobs with these skills. A dominant 'producer coalition' thus emerges in favour of the status quo, in which jobs and organizations remain roughly what they have been, even in the face of ecological pressures. The fact that manufacturing sectors in particular have barely turned existing jobs into green jobs at all confirms this interpretation: in Europe these are the sectors that have been pushed up-market to escape low-cost competition (or disappeared when such adjustment was impossible). That has forced them to adopt deeper and more sophisticated technical and vocational training and more sophisticated and dedicated capital assets, thus exacerbating the status quo bias.

The picture of job changes in tables 4.5 (GES) and 4.6 (GNE) is perfectly consistent with this interpretation and suggests that in these traditional sectors green skills are either more developed (GES) or that completely new bundles of tasks in new jobs (GNE) emerged, rather than increased green tasks in existing jobs. The changes in GES jobs reported in Table 4.5 are an order of magnitude larger than GID (if positive it approximates or surpasses 10%) and negative scores are practically absent. Most interestingly, and in contrast to the relatively dismal picture of existing jobs and tasks (GID), the traditional sectors all report an increase in both GES jobs and GNE jobs. If traditional sectors become greener, in other words, they do so by adding new, different jobs (GNE) and broaden the green skill basis (presumably through retraining) (GES), rather than through an increased demand for traditional skills and jobs (with the exception of construction).

The third significant insight from these data concerns the flip side to the traditional sectors: most services are intrinsically green in a broader sense, as we pointed out in Section 2 above. According to our data in Table 4.4, the GID change is positive in all of the services sectors, and they often lead to relatively high proportions of jobs with green characteristics. But even more interestingly, the service sectors are also densely populated with more, newer, green jobs, as the data in Tables 4.5 and 4.6 suggest. In particular, some of the gains in new and emerging green jobs are significant (for example 32% in finance; 17% in public administration; and 14% in the broad private services sectors), leading to large proportions of jobs in those sectors being new and having a significant 'green' task component. These could be energy auditors, sustainability officers, compliance managers, carbon credit traders and analysts, investment underwriters, climate change analysts or others.

The only service sector that systematically stands out as having a low percentage of green jobs, and with very low levels of change over the past decade, is the education sector. The sector recorded net changes in GID jobs between 2006 and 2016 of 1.3%, in GES jobs of

2.1% and of GNE jobs of 5.12%. Taking into account that the education sector is (with health and social work) among the largest civil sectors in public administration, this means that a lot of potential for greener public services exists there. The comparison with health and social work is particularly instructive: the overall size of both sectors is quite similar the EU, but the health sector is considerably greener in labour market terms and has become much greener than the educational sector. This may reflect three factors. First, the health and social work sector tends to have many large-scale hospitals and clinics run on a relatively centralised model, which warrants the employment of a higher proportion of specialised staff. Second, hospital requirements for energy, waste management and transportation services 'in house' are likely to be larger. But, third, education may paradoxically be seen as less green because there is less that needs to be done to 'green' the sector in the first place. As mentioned in Section 2 of this note, there is some confusion with respect to the term 'green' as to whether it refers to activities to reduce the environmental impact of high-impact sectors (which then turn up in the statistics as having a lot of green jobs) or to increase the role of already-green sectors.

The aggregate figures for green jobs are encouraging in that regard – but with a few caveats. First of all, the totals in tables 4.2 and 4.3 suggest that the job growth over the past decade has been quite green. While six million new jobs were added to the workforce in the EU, the proportion of green jobs (across all categories) increased from 49% to 61% of all jobs. Somewhat surprisingly, however, GID jobs remain the largest sub-category of green jobs, essentially carried by the construction sector, and professional, technical and other service activities. But the fastest growth has been in GES and GNE jobs, as Tables 4.2 and 4.3 show, and that growth is concentrated in administration and a handful of (large) service sectors such as transport and communication, the financial sector, such as carbon credit trading, and health and social work. The same is true and even more pronounced with regard to GNE jobs, where four sectors (transport and communication; financial services; and other private and public services account for the lion's share of the gains in those jobs (almost 75% of new GNE jobs since 2006). These aggregate data thus confirm, again, that the secular transition from an industrial to a post-industrial economy and society has, in itself, secular positive 'green' effects. Furthermore, it does not appear as if the low-hanging fruit has been picked – i.e. that we will soon exhaust green job growth in the service sectors. The low green job growth figures for several large service sectors, such as education and even health and social work, suggest that much more can be done. Assuming a similar growth profile to other services sectors (not an entirely unreasonable assumption, despite the fact that these are both much more other person-oriented than other service sectors), the increase can be quite significant. If education and health matched only half of the green job growth that we have found in the financial sector (where green jobs grew by about 40%), around 20% of the new jobs in these two sectors – 5

million, or almost the entire job growth in the decade between 2006 and 2016 – could be green.

These reflections also intersect with our points earlier in this research note on the wider context of these jobs. Some of the organizational patterns in the service sector, which do not strongly rely on co-location (i.e. most public and private administrative services), could be reconfigured to limit commutes, and this have an even stronger positive secondary impact. This is structurally much easier in large administrative organizations than in traditional sectors, where simultaneous presence of all workers is often a necessary condition for production. It is therefore likely that these already relatively 'green' sectors will induce an additional green boost as a result of organizational rearrangements, although that may turn up in the data for transportation rather than the relevant service sectors themselves.

In contrast, up until now human-centred service sectors require a simultaneous presence of 'producer' and 'consumer': teacher and pupil, doctor or nurse and patient (even in an age of increasing tele medicine), etc. That condition alone may significantly muffle positive green effects linked to the job, since large parts of CO_2 emissions associated with these workers have to do with daily transport to and from workplaces. As long as this transport relies on fossil fuels, in other words, even green job growth in these sectors is not very likely to offset the emissions associated with transport. Considering the (hardly compressible) size of both sectors and the likely growth of at least the health and social care sectors in the EU due to population ageing, this suggests that a wider green energy plan is necessary to support the increased 'greenness' of jobs.

This remark about the need for green energy brings us to the policy implications associated with our analysis and interpretation of these data. First, some sectors with relatively high levels of emissions do not have a lot of green jobs at the moment, suggesting that they need particular encouragement through regulation or financial incentives to develop new products, technologies and ways of working and the jobs that go with them. 'Agriculture, forestry and fishing' stands out in this regard. Some of the high-emissions sectors, such as 'manufacturing' in particular, have not shown a significant increase in green jobs over time either. This fits with what we said earlier about the 'conservative bias' in industries with heavy sunk investments in existing capital equipment and skills. Such industries may find it difficult to bring in green innovations at scale and may therefore require more support in these areas, especially with regard to innovation and new skills. In addition, the relative stagnation in the share of green increased demand skills (GID) jobs suggests that some countervailing influence has held back the growth in these relatively traditional jobs, despite the increase in demand likely from 'going greener'. This reinforces the evidence from other studies that workers with such traditional skills face bleaker prospects than

average and therefore need more attention in active labour market policies. Therefore, implementation of both *active* support policies (public investment in the technology and training associated with the green transition) and *passive* support (such as restructuring funds and social plans) seems warranted.

The second policy area of interest is education and training. Greener growth has raised the educational requirements of green jobs faster than the required qualifications in the economy as a whole. Education planning everywhere should therefore start taking these upward shifts into account today – perhaps especially in the member states that lag behind in the green transition – lest a skills bottleneck slows down the green transition. Put simply, accelerating the green transition requires more schooling amongst prospective job market entrants but particularly for jobs with new and emerging skills.

Finally, the results earlier in this paper show that the labour market consequences of the transition to a low-carbon economy have a significant impact on all sectors, and policy-makers should keep this in mind alongside the specific measures on skills, technology, etc. Judging by the data and the categorisation of jobs in this paper, the industry with perhaps the most significant greening of its labour force to date is the financial sector. However, if a broader conception of green jobs is adopted than the one underpinning the tables in this report, for example one that counts jobs in sectors that already have very low carbon emissions as green, the potential positive effect of an expansion of the service sectors (such as growth in the education sector) on lower aggregate carbon emissions becomes more evident. Policy-makers seeking to promote the low-carbon transition need to take a more holistic view of its implications for the structure of the economy and the corresponding changes in the job skills needed in the future.

6. Conclusions

In this research note, we developed a way of thinking about the effects of a greening economy on the labour market, based on a similar study in the US. Whilst the EU labour market is not the same as the US labour market, leaning on the analysis for the Department of Labor in 2009 (Rivkin et al. 2009) allows us a first cut at the effects on jobs. We divided the effects into four main ones: increased demand for existing green skills in jobs; jobs with skills that would need to be enhanced during the green transition; and new jobs with new skills to support and further the green economy. Importantly, we took a much wider view of green jobs than just those that are usually associated with explicitly green, recycling, and other environmentally sustainable jobs in 'environmental goods and services sectors' (EGSS).

There are many green jobs in Europe, and the gradual shift from traditional industries to service sectors is going to make the labour market even greener and probably at a faster pace. But there are some transition costs: existing skills and capital assets in these traditional sectors are likely to remain ‘brown’, and that may produce resistance from these workers which needs to be handled carefully up-front. Some service sectors will become greener much faster than others, and organizational change that indirectly lowers carbon emissions may boost the green service sectors. The secondary effects associated with transporting workers to and from workplaces will have to be taken into account and call for a wider de-carbonisation of all energy and transport sources. Finally, the educational system will require some rethinking to produce the green skills for new jobs that the green transition demands. Europe has, on the whole, very good education systems, but they have their roots in the industrial era, and the green economy requires many parallel and similar skills (those produced for what we called ‘Green rival’ jobs), but also a wide variety of new skills. Educational systems, social partners in vocational and technical training, and employers in skill-intensive industries thus need to sit down, design and negotiate the education and training systems for that new, green, economy.

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8. Appendix 1

Table A.1: Cumulative shares of employment, CO_2 emissions and gross value added (GVA) by industry, arranged from highest emissions intensity of GVA to lowest (as used in S3)

Industry count (NACE-08)	Cumulative employment (2016)	Cumulative emissions (2017)	Cumulative gross value added (2017)
Electricity, gas, steam and air conditioning supply	1%	36%	1.5%
Transportation and storage	6%	54%	6.0%
Mining and quarrying	6%	56%	6.5%
Agriculture, forestry and fishing	10%	59%	8.1%
Manufacturing	24%	88%	25.1%
Water supply; sewerage, waste management and remediation activities	25%	89%	25.9%
Construction	31%	91%	30.8%
Wholesale and retail trade; repair of motor vehicles and motorcycles	46%	94%	42.6%
Arts, entertainment and recreation	48%	94%	43.8%
Accommodation and food service activities	53%	95%	46.5%
Other service activities	55%	95%	48.1%

Public administration and defence; compulsory social security	62%	96%	53.9%
Administrative and support service activities	68%	97%	58.4%
Human health and social work activities	79%	98%	65.4%
Education	86%	98%	70.0%
Professional, scientific and technical activities	92%	99%	76.7%
Financial and insurance activities	94%	99%	82.0%
Information and communication	97%	100%	88.8%
Activities of households as employers; goods- and services-producing activities of households for own use	99%	100%	89.1%
Real estate activities	100%	100%	100.0%

Source: Eurostat and authors' calculations

9. Appendix 2

The table below provides an example of employees in a transport company. It provides further intuition about how the job categories are defined. The job that most closely fits the BLS and Eurostat definition of 'green' is the transportation planner (Green NE). As the economy switches to environmentally-friendly transportation methods, there will be a specific need for workers who can develop and implement new models of sustainable transportation systems, and transportation planners may need to acquire a new knowledge or skill set in order to do their job. Greening will also require a significant change in the tasks conducted by truck drivers (Green ES) but consist more of changes in the way that their skills and knowledge are applied. For example, driving a hybrid truck and using GPS systems to plan a low-carbon route might require some on-the-job training, but drivers already know how to handle a truck and work the GPS system.

Workers such as customer service representatives are likely to be in high demand due to greening (Green ID), because they can use their existing skills to support the green economy, even though their jobs do not involve any green tasks. For example, customers may have questions about the environmentally-friendly delivery process that the transport company is adopting, which the representative can answer. However, they are considered 'indirectly' green because they do not directly contribute to making the economy low-carbon. Workers in similar occupations, such as retail salespersons, currently are not supporting the green economy but already possess skills that could enable them to transition to a green job (Green ID in this case).

Table A2: Defining green jobs: an example taken from Bowen et al. (2018), p.274

Differences between job categories: A transport company example.

Job type	Job title	Job description	Example of tasks involved
Green Rival	Retail salespersons	Sell merchandise, such as furniture, motor vehicles, appliances, or apparel to consumers.	Recommend, select, and help locate or obtain merchandise based on customer needs and desires. Demonstrate use or operation of merchandise. Consult with company officials, sales departments, and advertising agencies to develop promotional plans.
Green ID	Customer service representative	Interact with customers to provide information in response to inquiries about products and services and to handle and resolve complaints.	Confer with customers by telephone or in person to provide information about products or services, take or enter orders, cancel accounts, or obtain details of complaints. Solicit sales of new or additional services or products. Recommend improvements in products, packaging, shipping, service, or billing methods and procedures to prevent future problems.
Green ES	Heavy and tractor-trailer truck driver	Drive a tractor-trailer combination or a truck with a capacity of at least 26,000 pounds Gross Vehicle Weight (GVW). May be required to unload truck. Requires commercial driver's license.	Plan or adjust routes based on changing conditions, using computer equipment, global positioning systems (GPS) equipment, or other navigation devices to minimize fuel consumption and carbon emissions. Operate idle reduction systems or auxiliary power systems to generate power from alternative sources, such as fuel cells, to reduce idling time, to heat or cool truck cabins, or to provide power for other equipment. Drive electric or hybrid-electric powered trucks or alternative fuel-powered trucks to transport and deliver products, livestock, or other materials.
Green NE	Transportation planners	Prepare studies for proposed transportation projects. Gather, compile, and analyse data. Study the use and operation of transportation systems. Develop transportation models or simulations.	Produce environmental documents, such as environmental assessments or environmental impact statements. Analyse information related to transportation, such as land use policies, environmental impact of projects, or long-range planning needs. Collaborate with other professionals to develop sustainable transportation strategies at the local, regional, or national levels.

10. Appendix 3

Glossary of terms used in this paper (taken from Bowen et al. (2018), pp. 274-275)

Green economy: economic activity related to reducing fossil fuel usage, decreasing pollution and greenhouse gas emissions, recycling materials, increasing energy efficiency, and developing/adopting renewable energy sources.

Greening: the effect of the green economy on occupations, which includes increased demand, changes in worker requirements, and the creation of new occupations/worker requirements.

Green Increased Demand (ID): Existing jobs that are expected to be in high demand due to 'greening', without requiring significant changes in tasks, skills, or knowledge (hence considered 'indirectly green').

Green Enhanced Skills (ES): Existing jobs that require significant changes in tasks, skills, and knowledge due to 'greening'.

Green New & Emerging (NE): New jobs with unique worker requirements that meet the specific needs of the green economy.

Green job/occupation: Any job classified by O*NET to be affected by 'greening', which could involve increased demand, changes in worker requirements, and the use of new worker requirements. All other jobs are considered Non-green.

Career changer: Jobs with similar skills and experience as the initial job, requiring minimal additional preparation to transfer from the initial job.

Career starter: Jobs that appeal to individuals with similar general abilities and preferences over job characteristics/work environment, which may require more extensive preparation to transfer from the initial job.

Green Rival job/occupation: Non-green jobs with at least one Green career changer or career starter.

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