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INNOPATHS

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1 Version log

Version	Date	Released by	Nature of Change
1.0	10/10/2019	LDA (UCAM)	Draft of third contribution
1.1	07/11/2019	JE (CMCC)	Draft of second contribution
1.2	20/11/2019	MG (CMCC)	Draft of first contribution
1.3	13/11/2019	EV (CMCC)	Revised and harmonized all contributions
2.0	15/11/2019	YJK (CMCC)	Reviewed draft

2 Definition and acronyms

Acronyms	Definitions
LIB	Lithium-Ion Batteries
IAM	Integrated Assessment Model
WITCH model	World Induced Technical Change Hybrid model
O*NET	Occupational Information Network (US)
EU-LFS	European Labour Force Survey
EPS	Environmental Policy Stringency
SSP	Shared Socio-Economic Pathway

3 Introduction

This Deliverable describes the research work carried out in Task 2.2. of the INNOPATHS project. Task 2.2. focused on labour dynamics and spillovers. These are two key aspects of the innovation process which are relevant for the energy transition, and which will need to be appropriately accounted for and managed for the success of this process. The task is composed of three contributions.

First contribution:

CMCC and SPO provided novel evidence on the interplay between energy and climate policies, the innovation process and labour force composition. Specifically, CMCC and SPO (1) developed a new methodology to measure the greenness of EU jobs, and their green skills content, at the sectoral level, starting from available literature on this topic focused on the USA (Vona et al. 2018 and Vona et al. 2019). CMCC and SPO also (2) provide descriptive statistics of this indicator across countries and sector. This report provides three contributions: First, the development of a taxonomy of green jobs for Europe, by matching information on green task content of jobs provided in the US Occupational Information Network (O*NET) with the occupational data in the EU Labour Force Survey (EU-LFS) to overcome the lack of data on greenness of jobs in Europe. Second, the description of the evolution of the greenness indicator and of the key green skills in different sectors of the EU member countries. Third, an initial descriptive evidence of whether and how the evolution of the greenness indicator and of green skills correlate with more stringent environmental policies, reduced emissions or higher level of green innovation for the EU.

A more detailed report for this contribution is provided in Annex A

Second contribution:

CMCC integrated endogenous labour supply and leisure preferences in the Integrated Assessment Model (IAM) WITCH, along with unemployment and the evolvement of active population rather than total population. This is a significant improvement to the literature: in most IAMs, the factor labour is considered as simply based on the population size of countries and regions all being active in the productive sectors. For this part of the task, CMCC projects employment and long term preferences over time allocation for different regions of the world and discusses their long-term macro implications. CMCC develops the standard utility function of a Ramsey-type optimal growth model to account for a 'market-time' vs. 'free-time' trade-off. To do so, a free-time preference coefficient is introduced in the formulation, which measures the utility gained by deviating from a maximum labour supply. This voluntary employment or free-time preference coefficient is then calibrated based on statistical and projected data from the United Nations, the International Labour Organisation and the OECD. Lastly, CMCC shows how energy and carbon intensities in the baseline or mitigation scenarios vary with employment and leisure or working hours.

A more detailed report of this contribution is presented in Annex B

Third contribution:

UCAM performed a systematic evaluation of to understand the role of technology spillovers from other sectors in specific areas of the energy sector and, most importantly, to understand how those spillovers took place. The motivation of this component was that, while technology spillovers have been widely recognized as motivators for policy and enablers of innovation in general, most of the work trying to understand spillovers relies on patent citations. While previous analysis of spillovers using patent citations in broad technological areas and, more recently, in specific

technologies (i.e. solar PV and lithium-ion batteries) allow researchers to understand at a high level what industries broadly have contributed to patents that are cited in patents that have been classified under particular technology categories, this approach does not allow researchers to understand how the spillover took place. In other words, there was a gap regarding the policy (or otherwise) mechanisms that can enable spillovers.

To understand at a more granular level where spillovers come from (beyond industries) and what enables them, T2.2 researchers, working with two colleagues at ETH Zurich (Prof. Volker Hoffmann and Dr. Annegret Stephan), investigated the key breakthroughs that enabled the commercialization of lithium ion batteries, identified which ones can be classified as knowledge spillovers, and determined how they came about. Lithium-ion batteries were selected both because they can play a major role in decarbonizing both the transport and power sectors, but also because of the major cost-reductions that we have seen over the past 30 years.

A draft article (Stephan, Anadon and Hoffmann 2019) describing the research carried out and the results will be drafted and submitted to a peer-reviewed journal in the coming months.

4 Activities carried out and results

First contribution:

To provide a descriptive evidence on the evolution of green jobs, CMCC and SPO built on the methodology first developed in Vona et al., (2018) and Vona et al., (2019) to compute a greenness indicator and to define the skills content of an occupation. Throughout the report, “task” and “skills” are defined according to the seminal work of Autor, Levy and Murmane (2003) and of Acemoglu and Autor (2010). An “occupation” or “job” consists of a set of different tasks, which are the units of work activity that produces some output. To perform a set of tasks, the worker will rely on a set of “skills” (i.e., competencies), which are the endowments of capability that allow him to get the task done. As a simple example, “monitor and evaluate the effectiveness of sustainability programs” is one of the tasks in the “Chief Executive” occupation; a skill necessary to perform this task is “economics and accounting”.

The methodology developed by CMCC and SPO was designed to overcome the fundamental lack of data on the green content of EU jobs. This methodology can be described by the four step below:

- a) The computation of greenness and skills by occupation in the US. This steps effectively reproduce the methodology adopted in Vona et al., (2018) and Vona et al., (2019) to compute a greenness indicator and to define the skills content of an occupation, with a more recent version of the O*NET database;
- b) The computation of greenness and green skills by occupation in the EU. This step requires matching jobs in the US, which are classified using the SOC¹ classification, to jobs in the EU, which are classified using the ISCO² classification;
- c) The computation of greenness and green skills by sector in the EU member countries. This step entails attributing EU jobs to specific sectors within the EU;
- d) The descriptive analysis of how EU green jobs correlate with more stringent environmental policies (proxied by energy price and EPS), with emissions

¹ Standard Occupation Classification is the employment taxonomy applied in the US

² International Standard Classification of Occupation is the employment taxonomy by the International Labour Organization and applied in the EU

reductions (i.e., CO₂ emissions embedded in trade) and with innovation (i.e., patents application and their stock) either at the sector or at the national level.

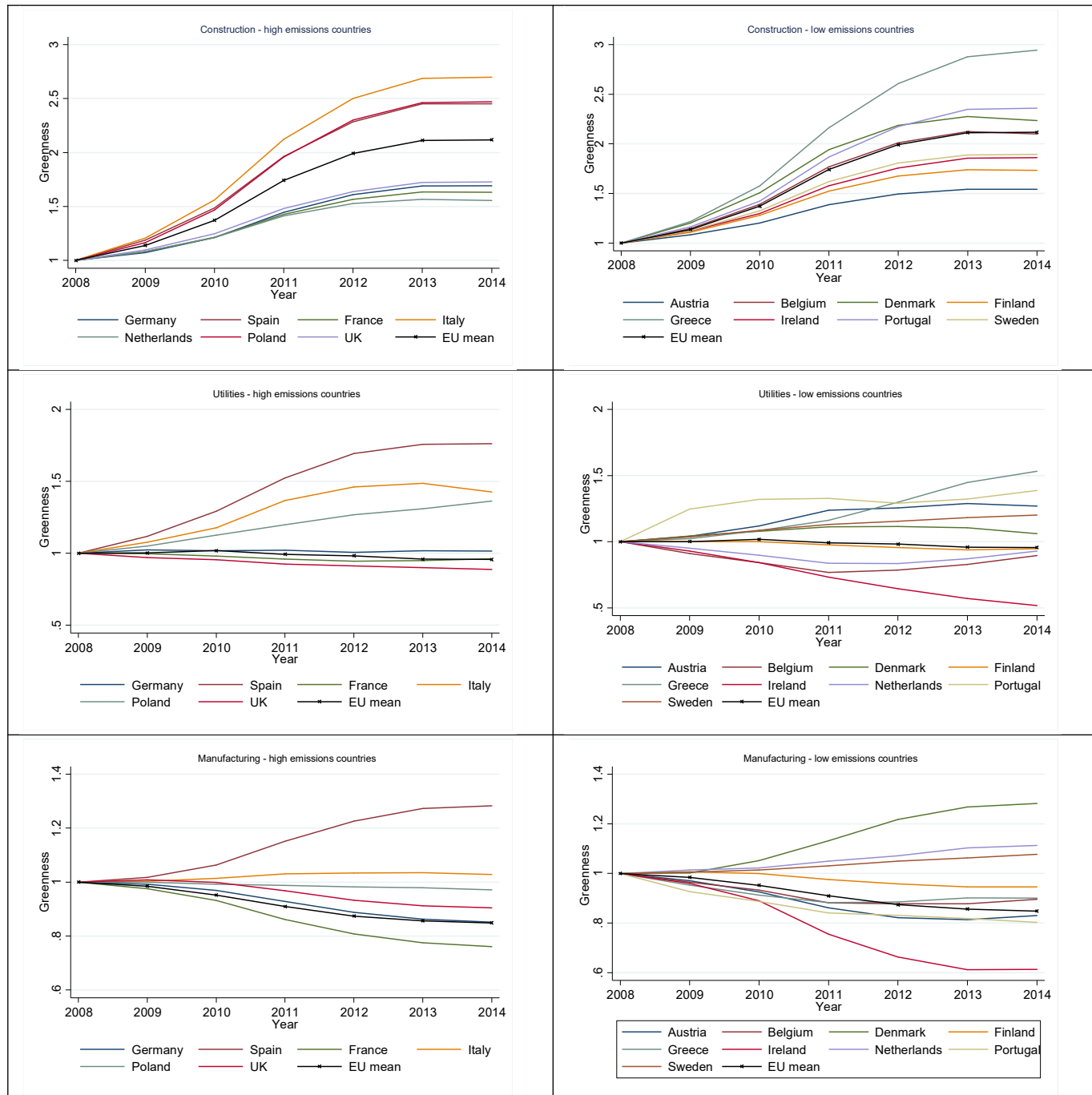
For what regards the sector-level greenness indicator, the results of this analysis show that greenness in European jobs is rather low on average across sectors and countries, as illustrated in Table 1. In detail, Construction has the highest average greenness in the EU (0.0909), while Utilities follows with an average greenness of 0.074. Manufacturing is the third greenest sector, scoring 0.0583. Figure 1 shows the sectoral greenness indicator trend in 2008-2014 for countries with emissions higher than (resp. lower) the EU emission average, in these three sectors. The figure shows a homogeneous trend of the greenness indicator for the Construction sector: the growth is stunning and on average, in 2014, greenness was 2% higher than in 2008. Conversely, the growth of greenness in the Utility sector is more heterogeneous across countries. Some high emissions countries substantially increased their greenness during the period, whereas others show a flatter trend. Better performances are shown by low emitters which mostly experienced an increase in greenness. The Manufacturing sector had an overall minor decrease during the period. Evidence at the country level is mixed: some countries experienced an increase in the indicator, some a decrease. This is true for both high emissions and the low emission countries. Nevertheless, with a few exceptions, the greenness of the Manufacturing sector is still higher than the average at the EU level.

Table 1 – Greenness by NACE

Country	Agriculture, Fishing & Hunting	Manufacture	Utilities	Constructio n	Transport & Warehousing	Avg. by country	(std.dev)
Austria	0.0001	0.0645	0.0555	0.0700	0.0223	0.0555	0.0151
Belgium	0.0004	0.0493	0.0575	0.0883	0.0270	0.0517	0.0107
Germany	0.0157	0.0479	0.0515	0.0599	0.0236	0.0456	0.0130
Denmark	0.0000	0.0601	0.0851	0.0930	0.0188	0.0546	0.0122
Spain	0.0109	0.0586	0.0947	0.0877	0.0217	0.0573	0.0105
Finland	0.0154	0.0616	0.0910	0.0900	0.0192	0.0585	0.0121
France	0.0123	0.0558	0.0875	0.0764	0.0317	0.0545	0.0103
Greece	0.0001	0.0401	0.0690	0.0986	0.0117	0.0328	0.0059
Ireland	0.0027	0.0580	0.0581	0.0761	0.0288	0.0530	0.0180
Italy	0.0030	0.0393	0.0520	0.0905	0.0251	0.0426	0.0089
Netherlands	0.0177	0.0592	0.0690	0.0846	0.0251	0.0547	0.0114
Poland	0.0091	0.0574	0.0691	0.0997	0.0342	0.0608	0.0117
Portugal	0.0038	0.0359	0.0851	0.0947	0.0194	0.0431	0.0076
Sweden	0.0151	0.0627	0.0859	0.0879	0.0292	0.0604	0.0111
United Kingdom	0.0132	0.0735	0.0636	0.0951	0.0291	0.0678	0.0147
EU mean	0.0090	0.0583	0.0740	0.0909	0.0269		
(std.dev)	0.0005	0.0038	0.0041	0.0048	0.0013		

Note: EU mean by sector is computed as a weighted average where weights used are the relative size of a sector in a country over the total value added created in the same sector in the EU economy. Avg. country is computed as a weighted average within the same country where weight used the relative size of a sector over the total value added generated by the five sectors in each country.

Figure 1 – Greenness trend by selected by NACE Rev.2 Sections. 2008-2014, 2008=100. Data Source: Onet 23.1 and EU Labour Force Survey (2014)



Results also show a positive association between greenness and energy prices: on average, a 1% increase in energy prices is associated with 0.04% increase in greenness. However, when we condition on value added, the coefficient associated with energy prices is no longer significant. Greenness is also positively correlated to the EPS indicator. Yet, if we condition of each country's gross domestic product, the estimated association is negative. Finally, there is a positive correlation also between greenness and the technology variables, i.e. patent applications and their stock.

Second contribution:

We developed an analytical labour market model and added it in the WITCH IAM. Secondly, data was collected on different population cohorts, unemployment rates, educational attainment, and tax rates to be able to calibrate the model at the country level. Finally, all data has been aggregated to the WITCH17 regions to be able to be used in the integrated assessment model. Based on the labour-enhanced WITCH model, scenarios were performed under different assumptions about the labour market and leisure preferences.

Overall, working hours have declined from about 3000 hours per year at the beginning of the industrialization to about 2000 hours by 1960, and further to between 1500 and 1800 hours per year as of 2015. We project this trend to continue in the short term implying higher values of leisure. This effect is highest in countries for which we compute high values of leisure preference, notably Europe, but also Latin American countries among developing economies. Endogenous leisure decisions however produce also the effect in some regions of increased working time resulting overall in GDP gains of about 6% by the end of the century compared to a standard SSP2 scenario. This translates into a total primary energy increase by 4% and 3% higher baseline emissions. In the 1.5 degrees scenario, on the other hand, the impact is changing over time leading to a slight reduction in emissions in the long term by 2100.

The results of the model shed light on the interplay between climate policies, demand for labour and innovation (a key feature of the WITCH model), and on the effects of low-carbon technologies on inequality through changes in the wage and leisure dynamics. While the distinction of different skill levels is challenging in such models, the impact on the energy mix and emissions of labour in general can still be assessed through the general equilibrium framework. Further availability of global coverage of skill sectoral and greenness indicators will enable to implement different types of skills also in an IAM.

Third contribution:

Innovation in clean energy technologies is central to achieving a net-zero energy system. Given the urgency of climate change mitigation, policymakers and managers of public research organizations are interested in how to best support innovation in clean energy technologies. One key determinant of technological innovation in clean energy technologies that have been underexplored is the transfer or integration of external knowledge, i.e., of knowledge spillovers. Spillovers can substantially advance technological innovation (Mowery and Rosenberg, 1998; Scherer, 1984, 1982a, 1982b; Schmookler, 1966), which has empirically been also shown in the fields of clean energy (Huenteler et al., 2016a; Nemet, 2012), storage (Noailly and Shestalova, 2016) and battery (Battke et al., 2016) innovations

While the literature has described general patterns of knowledge spillovers in clean energy technology innovations—typically by analyzing large sets of patent data—these quantitative studies lack explanatory power how individual spillovers come about: of the mechanisms and enablers of these spillovers.

In this research, UCAM addresses this gap asking how knowledge from other technologies, sectors or scientific disciplines is integrated into the innovation process in an important technology for a net zero future: lithium-ion batteries (LIB). We conduct a qualitative case study to allow us to understand *how* (Yin, 2009) the integration of external knowledge happened. Empirically, we perform a qualitative case study of spillovers in LIB innovations based on a literature review on the evolution of LIBs and

on spillovers and an elite interview campaign with R&D/industry experts and key inventors in the LIB field.

The analysis draws on two data sources: literature research and semi-structured elite interviews with key actors in the LIB field, i.e., R&D and industry authorities/experts and well-known senior-level inventors of LIB innovations. The methodology applied followed Tansey (2007): researchers sampled the interviewees (elites) in a purposive, non-probability (i.e., non-random selection) way. In contrast to random sampling, this strategy allows for a real-time and first-hand participant observation of the key actors in the field. Researchers identified an initial subset of interviewees based on literature research, and then initiated a snowballing system whereby the initial interviewees were asked to recommend further experts in that area (Tansey, 2007). Researchers talked to eight interviewees, of which half were inventors and half were R&D and industry authorities/experts.

The UCAM research makes three main contributions to the literature on spillovers. First, seven key breakthrough LIB innovations are identified. Second, the research shows the extent to which breakthroughs and a few others have resulted from the integration of knowledge from a variety of sources (i.e., different areas of technologies, sectors and scientific fields); often a spillover only happened because of a combination of different sources. Third, different mechanisms and enablers underlying spillovers in LIB innovation were identified, including public research funding providing important researcher autonomy and the interdisciplinary structure of education and research teams. Fourth and last, this work allowed to identify a set of levers for decision makers in policy, academia, and industry who want to facilitate spillovers in LIBs and other clean energy technologies.

This analysis and data support four different mechanisms of how spillovers can happen. First, spillovers can occur because people (e.g., inventors) change the technological field, sector or have moved between different scientific disciplines. Second and related, spillovers can occur because people (inventors) receive interdisciplinary education or nurture interdisciplinary interests. Third, spillovers occur because of communication or contact between individuals. Fourth, the access to and the reading of publications such as academic papers, industry reports and press releases can also help to acquire external knowledge, as it happened in the field of LIB innovations. These mechanisms were facilitated by five enablers: the structure of public funding in some cases, which provided freedom of search, the existence of interdisciplinary education and exchange programs, the management and organization in space of R&D groups (including hiring), firms working across multiple sectors, and public interest in an issue.

We emphasize two caveats that might limit the external and internal validity of these findings. First, we analyze the specific case of LIBs. For example, LIBs exhibit specific technology characteristics such as high complexity, or mass-production, which might also affect innovation patterns (Huenteler et al., 2016b; Stephan et al., 2017). Second, our findings are constrained by the data sources available. While the elite interviews allow for a first-hand participant-observation of the innovations, our results are limited to the understanding and framing of the individual interviewees.

5 Conclusions

First contribution:

CMCC and SPO developed a new methodology to measure the greenness of EU jobs, and their green skills content and provided a description of these indicators across 16 countries and five sectors of the green economy. The novelty of this report is the development of a taxonomy for green jobs in the EU, which was previously lacking. CMCC and SPO did this by expanding the methodology in Vona et al., (2018) and Vona et al., (2019), which relied on US data.

The report shows that the greenness of EU jobs is rather low. This notwithstanding, Construction, Utilities and Manufacturing are the three sectors which have been better able to integrate and exploit green jobs over time and that the importance of the green skills follows the same distribution. Moreover, it also shows that there is a positive correlation between policy stringency (captured by energy prices) and a rise in greenness at the sector level. Similarly, greenness and innovation also appear to be positively correlated.

Second contribution:

In the last 70 years, in developed countries, preferences for time allocation between market and free time have been evolving with the increase in prosperity. But evolutions have been different and cannot be explained by the growth in GDP alone. A large part of the world, the so-called fast growing countries, are not entering a phase where preferences for time allocation will potentially change in a dramatic way. This will have a large impact on what is the expected growth of these countries. Although important as a task per se, producing the long term growth projections for these fast growing countries is all the most crucial as the demand for natural resources will largely come from these countries. We show that projections of time use preferences could affect dramatically the world we will be living in. Henceforth, long term analysis of sustainable development cannot abstract from this key issue. The different preference parameters and scenarios, through their compared impacts on GDP, time allocation, energy consumption and carbon emissions, also give a notion of the vastly contrasted development perspectives that the introduction of a labour supply vs. free time trade-off opens.

More generally, our model enhancement is the first large-scale IAM to explicitly consider labour different from simply calibrated to a region's population, by taking into account unemployment, the active population, and endogenous labour leisure decisions. The results indeed indicate strong impacts on GDP and energy demand and hence emissions. Given the demographic SSP based calibration of the active population, endogenous leisure decision and (for now static) unemployment, this provides the first important step in integrating labour productivity and employment in in IAM. This model thus has the potential to substitute a micro-funded, comprehensive approach. Future research building on this model would be linking unemployment with energy system transformation (with at stake about 11 million direct jobs in the energy system only in Renewables in 2018 (IRENA 2019)), labour productivity changes, and the skill dimension. Moreover, a changing retirement age resulting in different active population scenarios can be analysed.

The resulting climate is also remarkably affected by leisure related emissions resulting in a temperature about 0.3 degrees higher in the BAU scenario than with fixed population as labour. This results shows that considering the changes in regional labour and leisure preferences and behaviour will possibly have a stark impact on the degree of climate change.

In terms of overall Energy and Carbon intensity, we find that from today's values of about 10 MJ/\$ and 70 gCO₂/MJ, the improvements in terms of energy efficiency are faster (pink vs. blue squares) in the base line at only moderate carbon intensity

improvements. In the 1.5 degrees scenario on the other hand, labour preference needs to a lower energy intensity (green vs. brown) while the ranking in terms of ultimate carbon intensity is ambiguous and switches sign between 2050 and 2100

Third contribution:

This contribution analysed how external knowledge is integrated in the innovation process. Empirically, researchers performed a qualitative case study of lithium-ion batteries (LIBs) based on literature and elite interviews. First, they identified the key breakthrough LIB innovations. They also found striking agreement across experts regarding what are the key breakthrough innovations. Second, they showed the extent to which breakthroughs and a few others have resulted from the integration of knowledge from a variety of sources (i.e., different areas of technologies, sectors and scientific fields); often a spillover only happened because of a combination of different sources. Third, they identified different mechanisms and enablers underlying spillovers in LIB innovation, including public research funding providing important researcher autonomy and the interdisciplinary structure of education and research teams. Fourth and last, they pointed to a set of levers for decision makers in policy, academia, and industry who want to facilitate spillovers in LIBs and other clean energy technologies.

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ANNEX A of D2.5: Employment and labour leisure preferences in the WITCH IAM

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Abstract

In most IAMs, the factor labour is considered as simply based on the population size of countries and regions all being active in the productive sectors. We integrate endogenous labour supply and leisure preferences in the IAM WITCH, along with unemployment and the evolvement of active population rather than total population. In particular, we project employment and long term preferences over time allocation for different regions of the world and discuss their long-term macro implications. We develop the standard utility function of a Ramsey-type optimal growth model to account for a ‘market-time’ vs. ‘free-time’ trade-off. To do so, we introduce a free-time preference coefficient that measures the utility gained by deviating from a maximum labour supply. We calibrate this voluntary employment or free-time preference coefficient based on statistical and projected data from the United Nations, the International Labour Organisation and the OECD. We then show how energy and carbon intensities in the baseline or mitigation scenarios vary with employment and leisure or working hours. While the distinction of different skill levels is challenging in such models, the impact on the energy mix and emissions of labour in general can still be assessed through the general equilibrium framework.

The results of the model shed light on the interplay between climate policies, demand for labour and innovation (a key feature of the WITCH model), and on the effects of low-carbon technologies on inequality through changes in the wage and leisure dynamics. Further availability of global coverage of skill sectoral and greenness indicators will enable to implement different types of skills also in an IAM.

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1. Introduction

In most IAMs, the factor labour is considered as simply based on the population size of countries and regions all being active in the productive sectors. We integrate endogenous labour supply and leisure preferences in the IAM WITCH, along with unemployment and the evolvement of active population rather than total population. In particular, we project employment and long term preferences over time allocation for different regions of the world and discuss their long-term macro implications.

Although time allocation preferences as well as (voluntary) unemployment are a crucial factor in order to understand long term economic growth, as well as convergence across countries, they are largely ignored in the literature concerned with long term projections including the SSPs (Riahi et al. 2017). More generally, economists tend to neglect time, but for its market component that has important implication on production (Hamermesh and Pfann 2005). In addition, there exists a growing dissatisfaction with GDP and consumption as the prominent indicators of development and hence the main objective of policymakers. These factors have led us to study the implications of an augmented definition of welfare that endogenises the free time *vs.* labour market time choice in an optimal growth model.

The literature on the trade-off between the free and market use of time is for some of it more than 50 years old (for a recent elegant survey *cf.* Weiss, 2009). It is fundamentally concerned with understanding the divergence in working hours in European countries and the United States. In recent years, Prescott (2004) concentrated on the effect of differentials in labour taxes, while Alesina *et al.* (2006) pointed to the effect of unionisation of European labour forces. Both papers do not deal with the consequences on either productivity and innovation or welfare of these two different paradigms, although Alesina *et al.* (2006) hint to studies showing larger reported happiness in countries where the number of vacation days is greater. More recently Gimenez-Nadal and Sevilla) 2012 have looked into trends in leisure time distribution and use in seven industrialized countries. But except for few exceptions (*cite?*), the issue of how preferences towards leisure have changed, how they might evolve in the future and what consequences this might have on our prosperity and on the sustainability of economics growth, have been largely ignored.

A different strand of literature looks at the impact of time allocation on productivity and on economic cycles. This vast literature spans from microeconomic studies on health, flexible working hours and economic productivity, to business cycle analyses and the analysis of the household *versus* market work conundrum. Blanchard (2004) offers a synthetic view of its conclusions based on a discussion of the differential in market working hours on either side of the Atlantic and the increase in labour productivity in European countries, in the context of a broader assessment of the evolution of European economies. He concludes that, although Europe has caught up on the United States in productivity terms over the last thirty years, contrary to the United States it has used some of this progress to increase leisure rather than income.

Finally, an overarching literature is that looking into new measures of growth, going beyond pure GDP measures and accounting for other crucial indicators of life satisfaction and happiness. Initiated by Sen in the late 60's (*cf.* the milestone Sen, 1976), this literature has had important contributions on the specific theme of leisure, as by Nordhaus and Tobin (1973); the 'beyond GDP' report commissioned by the French government has recently offered an extensive survey and revitalisation of this debate (Stiglitz *et al.*, 2009). From its angle the key issue is how to properly account for the

leisure/household/work trade-off and what metrics to use: diary data and surveys on the use of time distinguish between time spent on the market, on providing and managing the household, in leisure activities and for basic needs. For the largest part, though, data on paid working hours alone are available. In addition, even when data on non-paid activities are available, cultural differences complicate the aggregation of detailed time uses into operative categories—*e.g.* caring for children can alternatively be considered as management of the household or sheer leisure time.

We build on this literature, while purposely limiting our interpretation of it: our ambition is to provide broad assessments of paradigm shifts to alternate societal futures characterised by rebalanced time allocation choices between the two aggregates of labour market time and ‘free time’; we insist on the intrinsic value of ‘free time’ without disambiguating between its social (welfare value of sheer leisure, of a gift economy, *etc.*) vs. microeconomic interpretations (household production function, educational investment justified by dynastic solidarity, *etc.*).

We start with a section exploring the analytics of our augmented Ramsey model based on the IAM WITCH (Emmerling et al. 2016), followed by a section discussing the data used for the calibration of our numerical model. A third section presents the particulars of our numerical model, and the simulation runs for contrasted convergence assumptions regarding the central free time valuation coefficient introduced in the model, calibrating active population and unemployment in the IAM towards a full capture of the labour dimension in the model. Finally we present the results and conclude.

2. An analytical model

The microeconomic rationale of our market labour supply model is based on Prescott (2004), which itself traces back to Kydland and Prescott (1982). The ‘real business cycle’ motivation of the latter paper is much toned down in the former one though—which suits our purpose well: we do not aim at explaining short term fluctuations around a fundamental trend. As already developed, we also abstract from addressing the complex heterogeneity of time spent off the labour market, despite the caveats expressed as early as Gronau (1977), nor do we try to build on Becker’s household production model (Becker, 1965) and the subsequent literature.¹ We also differ from Prescott (2004) and Alesina *et al.* (2006) inasmuch as we do not aim at identifying why free time preferences vary across societies—without settling between Alesina *et al.*’s case for unionisation or that of Prescott for fiscal pressure, we simply consider that both putative causes can more fundamentally be interpreted as the expressions of collective preferences. What we rather do is adopt their functional form, firmly rooted in microeconomic reasoning, and use macroeconomic data to project its impact on future development trajectories. Thus, adapting Prescott (2004) we assume that the objective function of the aggregate agent of some economy over T time periods is

$$U = \sum_{t=1}^T \left(u_t(C_t) + \lambda_t v_t(\phi_t) \right) \beta^t, \quad (2)$$

with a utility discount factor β^t , C_t total consumption, λ_t a leisure preference coefficient and u_t and v_t the utility functions through which the utility impacts of C_t and ϕ_t are measured with $u_t' > 0$ and $v_t' < 0$. The variable ϕ_t measures the share of total time spent working, so that it is a value between

¹ For a review of labour supply models *cf.* Blundell and Macurdy (1999).

zero and one indicating the percentage of time dedicated working, and the utility function v_t is decreasing in its argument. The standard utility source consumption C_t is thus augmented by a negative function of the share of time devoted to the labour market, ϕ_t . The trade-off is made explicit by formulating the budget constraint of the aggregate agent, stating that production Y_t is equal to (or greater than, but it is obviously optimal to systematically saturate the constraint) the sum of investment I_t and consumption C_t :

$$Y_t = I_t + C_t \quad (3)$$

then by considering that the succession of Y_t derives itself from a production function combining capital stock K_t and labour force L_t :

$$Y_t = A_t F(K_t, \phi_t L_t) \quad (4)$$

with A_t a calibrated total factor productivity coefficient. Compared to the standard neoclassical production function ϕ_t is now multiplying labour endowment L_t , to embody the new trade-off possibility. Note that we maintain the exogeneity of total factor productivity A_t , and leave to further research an explicit modelling of the complex connections between A_t and ϕ_t .² As a consequence Y_t , and thus, through equation (3), C_t are now functions of ϕ_t . K_t is itself connected to I_t through its dynamics:

$$K_{t+1} = (1 - \delta) K_t + I_t \quad (5)$$

The intertemporal maximisation programme can thus be collapsed in:

$$\text{Max}_{C_t, \phi_t} \sum_{t=1}^T R_t (u_t(C_t) + \lambda_t v_t(\phi_t)) \quad (6)$$

subject to:

$$K_{t+1} = (1 - \delta) K_t + A_t F(K_t, \phi_t L_t) - C_t \quad (7)$$

The corresponding Bellman value function (a recursive re-writing of the optimisation problem viewed from any time t) is

$$V_t(K_t) = \text{Max}_{C_t, \phi_t} u_t(C_t) + \lambda_t v_t(\phi_t) + \frac{R_{t+1}}{R_t} V_{t+1}(K_{t+1}) \quad (8)$$

The first order conditions on C_t and ϕ_t , after injection of the partial derivatives of K_{t+1} obtained from equation (7), read:

$$\frac{\partial u_t}{\partial C_t} - \frac{R_{t+1}}{R_t} \frac{\partial V_{t+1}}{\partial K_{t+1}} = 0 \quad (9)$$

and

$$\lambda_t \frac{\partial v_t}{\partial \phi_t} + \frac{R_{t+1}}{R_t} \frac{\partial V_{t+1}}{\partial K_{t+1}} A_t \frac{\partial F}{\partial \phi_t} = 0 \quad (10)$$

while the envelope condition (K_t derivative of V_t from equation (8)) of the programme is:

² Following the lines opened by Blanchard (2004), as evoked in our introduction.

$$\frac{\partial V_t}{\partial K_t} = \frac{R_{t+1}}{R_t} \frac{\partial V_{t+1}}{\partial K_{t+1}} \left(1 - \delta + A_t \frac{\partial F}{\partial K_t} \right) \quad (11)$$

Equations (9) and (10) provide expressions for the derivatives of V at time $t+1$, which also hold at time t ; injecting them in the envelope condition yields the two Euler conditions:

$$\frac{\partial u_{t-1}}{\partial C_{t-1}} = \frac{R_t}{R_{t-1}} \left(1 - \delta + A_t \frac{\partial F}{\partial K_t} \right) \frac{\partial u_t}{\partial C_t} \quad (12)$$

and

$$\frac{\partial v_{t-1}}{\partial \phi_{t-1}} = \frac{R_t}{R_{t-1}} \frac{\lambda_t}{\lambda_{t-1}} \frac{A_{t-1} \frac{\partial F}{\partial \phi_{t-1}}}{A_t \frac{\partial F}{\partial \phi_t}} \left(1 - \delta + A_t \frac{\partial F}{\partial K_t} \right) \frac{\partial v_t}{\partial \phi_t} \quad (13)$$

The question is then: can the recursions hope to be solved? Under the standard constraint of a positive I_T and disregarding any transversal condition on K_{T+1} , C_T is obviously equal to $A_T F(K_T, \phi_T L_T)$: it is optimal to consume all of the last period's production. Provided the u_t , v_t and F functions are 'tractable' enough, substituting $A_T F(K_T, \phi_T L_T)$ for C_T in the first order conditions of V_T , allows computing ϕ_T as a function of K_T , L_T , A_T , λ_T and R_T . By recursion of equation (7) and the Euler equations (12) and (13) the optimal trajectories of C and ϕ can be inferred, at least numerically—even for the simplest functional forms (*e.g.* F a Cobb-Douglas, u and v logarithmic functions) the recursions, consisting in complex polynomial expressions, are not analytically solvable. They can however be used, for calibration purposes, to derive an analytical expression of the central λ_T coefficient. Indeed, substituting $A_T F(K_T, \phi_T L_T)$ for C_T in V_T allows deriving, through the first order condition on ϕ_T , an expression for α_T :

$$\lambda_T = A_T \frac{\frac{\partial F}{\partial \phi_T}}{\frac{\partial u_T}{\partial C_T} - \frac{\partial v_T}{\partial \phi_T}} \quad (14)$$

As injecting (12) into (13) yields

$$\lambda_{t-1} = \frac{A_{t-1}}{A_t} \frac{\frac{\partial F}{\partial \phi_{t-1}}}{\frac{\partial F}{\partial \phi_t}} \frac{\frac{\partial u_{t-1}}{\partial C_{t-1}}}{\frac{\partial u_t}{\partial C_t}} \frac{\frac{\partial v_t}{\partial \phi_t}}{\frac{\partial v_{t-1}}{\partial \phi_{t-1}}} \lambda_t, \quad (15)$$

the recursion on α is easily solved as:

$$\forall t \in [1, T] \quad \lambda_t = A_t \frac{\frac{\partial F}{\partial \phi_t}}{\frac{\partial u_t}{\partial C_t} - \frac{\partial v_t}{\partial \phi_t}} \quad (16)$$

Rearranging the expression by shifting the ϕ -derivative of v on the left-hand side makes interpretation clearer: λ_t must be calibrated in such a way that the marginal utility of extended 'free time'

$-\lambda_t \frac{\partial v_t}{\partial \varphi_t}$ equates the instantaneous marginal utility of extended working hours (which derives

from consuming the product of such hours) $-A_t \frac{\partial F}{\partial \varphi_t} \frac{\partial u_t}{\partial C_t}$. It might come as a surprise that the dynamic impact of production on capital accumulation does not seem to play any role; but at the optimum, where λ_t is calibrated, the marginal utility of consumption is by definition equal to that of investment. Equation (16) could indeed be inferred from the static programme of maximising $u_t + \lambda_t v_t$ only: the calibration process assumes that the intertemporal trade-off between current and future consumption is already settled, and holds.

In the numerical application, we will moreover consider the case where λ_t is constant over time, or perform a scenario analysis to study different changes in preferences from this historically calibrated values.

3. The data

Following a literature tracing back to Lucas and Rapping (1969), we acknowledge that market labour supply results from the combination of three distinct determinants: the sheer dynamics of population growth, which determines the population of working age; the participation rate, which measures the share of the population of working age that is indeed participating to the labour market; the average amount of time spent at work, measured *e.g.* in annual working hours—a statistics that indeed widely differs from one country to another. Like most of the available economic literature, we do not try to endogenise the first of these dimensions, *i.e.* population growth *per se*, and rather focus on the two other determinants. To our knowledge this still constitutes quite a development for the state-of-the-art of large numerical optimisation models.

Prescott's assumption about the maximum work time focuses on hours worked *per week*, and sets an upper bound of 100 hours common to all economies. Our approach differs as we start from the population data going towards considering only the adult labour force (excluding people aged below 15 and over 70 years of age), based on age-education cohort data from (KC and Lutz 2017). Then, we adjust labour supply for observed unemployment data from the WDI to obtain the active labour force. Finally, based on observed working hours per year, we estimate the leisure consumed comparing actually working hours from ILO with the maximum of 60 hours over 50 weeks per year,³ for a total of 3,000 hours worked annually. This allows us to adapt to the time allocation choices induced by our specification (an argument developed by *e.g.* Zilibotti, 2007).

Overall, the data used are of three main sorts: Detailed population projections by age cohort and educational attainment are obtained from the WDI and IIASA SSP database of the Wittgenstein Centre. Working hours per country and year are obtained from the ILO. Thirdly, unemployment data are taken from the World Bank Development Indicators (WDI). All data are then aggregated across the 17 WITCH regions using population weights to account for the actual population distribution across the world.

It must be underlined that the demographics of intertemporal optimisation models (*e.g.* the RICE model of Nordhaus and Yang, 1996) is generally limited to total population, used as a proxy of the

³ Note that the 2 weeks left out include national holidays.

available labour force. After proper calibration of the production functions this only amounts to assume that labour endowment grows at the same pace as total population. But the collected data contradicts this assumption: it reveals growth rate differentials of up to 5 percentage points, in some instances indeed growth rates of opposed signs—because of inertia the decrease of active population lags behind that of total population. The issue is not to be exaggerated, as most models resort to exogenous regional total factor productivity improvements that are calibrated to shape trajectories on exogenous growth scenarios, typically those of international institutions—such as those of the IPCC Special Report on Emission Scenarios or SRES (IPCC, 2000). A higher degree of demographic detail is however necessary to our labour supply modelling endeavour.

The second ingredient necessary to project labour supply potentials is working time statistics.⁴ Although some national surveys on the use of time and diaries exist, a comprehensive and consistent ‘pseudo-data’ source comparable to EAPEP with global coverage does not. OECD provides estimates of annual working hours for its 34 members and the Russian Federation,⁵ which we directly used. Then ILO has a database of 4 distinct types of weekly hours⁶ for a large number of countries from 1969 to 2008, but with quite large gaps in both geographical and time coverage.⁷ Considering the scarcity of this data we focus on our twelve macro regions and the 2005 base year. We then combine the two sources to produce an estimate of annual working hours for each region—an average of member country estimates weighted by the active population counts of each country.

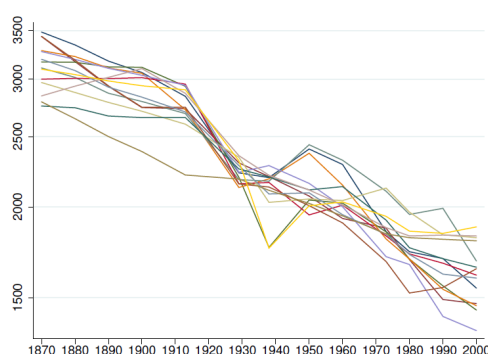


Figure 1: Hours worked per worker

Notes: The figure shows data for the following countries: Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, the U.K., Australia, Canada, and the U.S. The scale is logarithmic which suggests that hours fall at roughly 0.57 percent per year. Source: Huberman and Minns (2007). Maddison (2001) shows a similar systematic decline in hours per capita.

Figure 1: Historical hours worked (Source: Krusell and Boppart, 2019)

The OECD estimates are retained for regions that are mainly composed of OECD countries—5 out of 12. Then ILO data is used to derive estimates for the non OECD regions, with the difficulty that the weekly hours have to be converted to annual ones. To guide this conversion we systematically explored the ratio between OECD estimates and ILO ones, theoretically corresponding to the average number of weeks annually worked, but to little benefit: results suggest some discrepancies between the 2 sets of data: from 2004 to 2008 (the 5 most recent years available), the ILO and OECD data for

⁴ Throughout this section, for reference purposes to the underlying statistical data, we fall back on the ambiguous practice of qualifying as ‘working’ the time spent on activities paid for by market transactions, thereby misleadingly implying that any time other than monetised labour is non-working time. The statistical object is however precisely that which we need measurement of, *i.e.* market labour supply.

⁵ Cf. the OECD statistics portal at <http://stats.oecd.org>.

⁶ “Hours actually worked”, “hours paid for”, “hours usually worked”, “normal hours of work”. For the distinction between the 4 statistics cf. <http://laborsta.ilo.org/applv8/data/c4e.html>.

⁷ Cf. the ILO statistics portal at <http://laborsta.ilo.org>.

Canada, Estonia, Greece, Italy, New Zealand and the United States are irreconcilable (annually worked weeks resulting from the combination of the two datasets are over 50), without any possibility to discriminate between the reliability of each source. For non-OECD regions, we for now consider the yearly average of MEXICO with an average of 2000 hours per year.

To conclude this subsection, let us underline that our repeated use of the ‘working time’ and ‘working hours’ expressions is simply mirroring statistical practice, whereas the time aggregated in such series is consistently that spent on activities paid for by market transactions, excluding any type of unpaid work. We hesitated on introducing new notations to clarify this ambiguity, but eventually settled against it for the sake of clarity, considering the widespread use of the statistical series under the conventional though somewhat misleading appellations.

Figure 2 shows the main population data aggregates for the calibration year 2015 that are used for calibration for the model calibration, notably total population, active labour force, unemployment rate, and working hours.

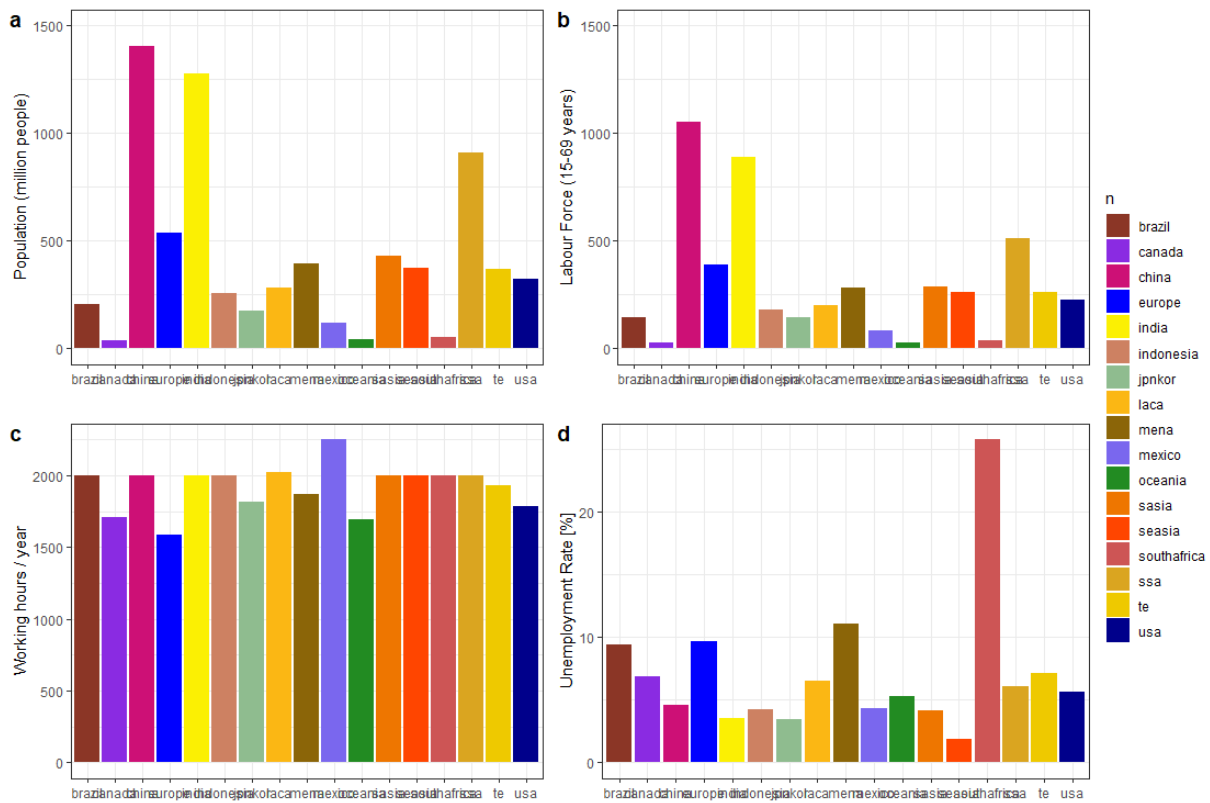


Figure 2: Calibration data of the base year (2015) in WITCH

4. Numerical implementation

We now turn to a numerical implementation of the model described in section 1, with a view to illustrate the impact on GDP and labour market time of prospective shifts in ‘free time’ valuation. To do so we mobilise WITCH (Emmerling et al. 2016), a climate-energy-economy model designed to assist in the study of the long-term environmental and socio-economic processes. WITCH was developed to provide information on the optimal responses of world economies to climate damages and to identify the impacts of climate policy on global and regional economic systems. It has also been used to study the mid and long-term dynamics of innovation in energy technologies.

Our analytical framework was laid out with a view to be compatible with WITCH's specifications. Specifying the hitherto nondescript F , u and v functions in the case of a modified WITCH model will allow calibrating α coefficients on pre-existing baseline trajectories of the model, a necessary first step to our numerical implementation.

First, the production function of each of the model regions combines a Cobb-Douglas aggregate of capital stock K_t and labour force L_t , and energy services ES_t , in a constant elasticity of substitution (CES) aggregate:

$$Y_m = A_m \left(\alpha \left(K_m^\beta L_m^{1-\beta} \right)^\rho + (1-\alpha) ES_m^\rho \right)^{\frac{1}{\rho}} \quad (17)$$

with unchanged A_m , K_m , and L_m notations, α a calibrated CES coefficient, β the cost share of capital in the KL aggregate, and ρ the CES coefficient related to the substitution elasticity of the KL and ES aggregates.

Note also that this specification departs from our analytical exploration, inasmuch as output is not a function of K , L and TFP only, but also of ES . Although accounting for the endogeneity of ES is difficult to derive in analytical terms, this does not invalidate our calibration of the regional λ coefficients: similar to the consumption/savings trade-off, the arbitrage in favour of energy expenses is already accounted for in the pre-existing optimal trajectories on which we will calibrate λ .

In most IAMs, labour L_t is simply assumed to be given by the total population in a given region:

$$L_m = Pop_m$$

We hence go in three steps to consider labour supply more specifically in the production function in line with the data described above. First, we take for the maximum labour only the economically active population. Secondly, we consider the given unemployment rate u_m . Thirdly, we consider the leisure decision given a maximum of 3000 hours worked per year to each active member of the labour supply. That is, we take a value of $h_m \in (0, 3000)$ of hours worked for each worker. Altogether, we change in the production function L_m to $Labour_m$ given by:

$$Labour_m = \left(Pop_m - Pop_m^{i.15 \vee >70} \right) * (1 - u_m) \quad (18)$$

And taken into account the working hours per year, converted to full working year equivalents, we get for our new value of L_m that

$$L_m = \underbrace{Labour_m * \frac{h_m}{3000}}_{\phi_m} \quad (19)$$

Second, in WITCH the utility derived from consumption is of the form: $U_m = \left(\frac{c_m^{1-\eta}}{1-\eta} \right)$ Third, for this first numerical implementation we will follow Prescott (2004) again in assuming that

$$U_t = \frac{c_t^{1-\eta}}{1-\eta} - \lambda_t \underbrace{\frac{Labour_t}{Pop_t} \left(\frac{h_t}{3000} \right)^{1-\eta_l}}_{\phi_t} / (1-\eta_l) \quad (20)$$

where 3000 is the upper bound to market labour supply in yearly hours (50 weeks of 60 hours on average). The standard utility source, *i.e.* the product of total population L_t and the CRRA function of *per capita* consumption, is thus augmented by the product of active population $Labour_t$ and of the logarithm of the leisure share that this population could devote to the labour market, but is not,

$\phi_t = \left(\frac{h_t}{3000} \right)$, which equals our parameter ϕ_t of the analytical model. Compared to the analytical

model we have hence specified the utility functions as $u_t = \frac{c_t^{1-\eta}}{1-\eta}$ and

$v_t = -\lambda_t \frac{Labour_t}{Pop_t} \left(\frac{h_t}{3000} \right)^{1-\eta_l} / (1-\eta_l)$.⁸ Compared to Prescott (2004) and above we thus add the fact

that not all population is working and the utility function from leisure can be from the CRRA class with η_l rather than be restricted to be logarithmic.

The parameter λ_t captures the leisure preference in the augmented utility function of the household and is an important parameter to calibrate. We start by calibrating it statically based on the latest available data ($\lambda_t = \lambda$). (Krusell and Boppart 2019) indeed find an time-invariant value of leisure preference for the U.S., resulting in a decrease of hours worked by about 0.5% per year, explained mostly by the income effect.

Under these specifications, and retaining the simplifying assumption that energy services ES_t are exogenous and independent of labour decisions, we can derive the first-order conditions of the representative firm and household.

First, based on the utility function, equating the marginal rate of substitution between leisure and consumption, this has to be equal to the wage (after taxes). This can be seen from the budget constraint of the representative household at time t :

$$c_t + i_t \leq (1-\tau_t) w_t \frac{Labour_t}{Pop_t} \frac{h_t}{3000} + T_t + (r_t - \delta) k_t$$

That is our first condition to use for calibration is the first-order condition

$$\frac{\frac{\partial U_t}{\partial \left(\frac{h_t}{3000} \right)}}{\frac{\partial U_t}{\partial c_t}} = - (1-\tau_t) w_t \frac{Labour_t}{Pop_t} \quad (21)$$

⁸ The adjustment of the leisure factor by the share of the active population of total population is due to the fact that leisure is assumed to be actively consumed and enjoyed only by the active working population deciding on their working hours. Extending this to other age classes and unemployment would be an interesting extension.

From the utility function we have that $\frac{\partial U_{tn}}{\partial \left(\frac{h_{tn}}{3000}\right)} = -\lambda_{tn} \frac{Labour_{tn}}{Pop_{tn}} \left(\frac{h_{tn}}{3000}\right)^{-\eta_i}$ and moreover that

$\frac{\partial U_{tn}}{\partial c_{tn}} = c_{tn}^{-\eta}$. Second, the optimal factor allocation between labour and capital from the Cobb-Douglas part of the equation of output Y_{tn} implies

$$\frac{(1-\beta)Y_{tn}}{L_{tn}} = w_{tn} \quad (22)$$

with $L_{tn} = \frac{Labour_{tn} * h_{tn}}{3000}$. For the more general CES specification including energy services, this results is only approximately true as $ES \rightarrow 0$. In fact, in this general case we have that

$$\frac{\partial Y_{tn}}{\partial L_{tn}} = A_{tn} \underbrace{\left(\alpha \left(K_{tn}^\beta L_{tn}^{1-\beta} \right)^\rho + (1-\alpha) ES_{tn}^\rho \right)^{\frac{1}{\rho}-1} \alpha \left(K_{tn}^\beta L_{tn}^{1-\beta} \right)^\rho}_{\dot{=} Y_{tn} \text{ if } ES_{tn} \rightarrow 0} \frac{1-\beta}{L_{tn}^{1-\beta}}$$

In the numerical implementation we use this exact form while for the analytical model we refer to the Cobb-Douglas approximate case. From the optimal factor allocation we hence get the optimal wage

$w_{tn} = \frac{\partial Y_{tn}}{\partial L_{tn}}$ based on the production function, while output is given by its direct equation.

Combining both first-order conditions and substituting the wage definition, we get that

$$\frac{-\lambda_{tn} \left(\frac{h_{tn}}{3000}\right)^{-\eta_i}}{c_{tn}^{-\eta}} = -(1-\tau_{tn}) w_{tn} = -(1-\tau_{tn}) \frac{(1-\beta)Y_{tn}}{L_{tn}} \quad (23)$$

For our base-year ($t=1$ ($year=2015$)) $\dot{=}$ in the case of WITCH) we have all the data necessary to satisfy this equation apart from the leisure preference parameter λ_{1n} for all model regions or countries. By solving this condition for λ_{1n} we find its value as

$$\lambda_{tn} = (1-\tau_{tn}) \frac{(1-\beta)Y_{tn}}{L_{tn}} c_{tn}^{-\eta} \left(\frac{h_{tn}}{3000}\right)^{\eta_i}, \text{ for } t=1 \quad (24)$$

Which finally by substituting $L_{tn} = \frac{Labour_{tn} * h_{tn}}{3000}$ yields

$$\lambda_{tn} = (1-\tau_{tn}) \frac{(1-\beta)Y_{tn}}{Labour_{tn}} c_{tn}^{-\eta} \left(\frac{h_{tn}}{3000}\right)^{\eta_i-1}, \text{ for } t=1 \quad (25)$$

These values for leisure preferences are hence computed for the base year (here 2015) using historical economic data together with the data on labour, unemployment, and hours worked as explained in the

previous section. The obtained values across the 17 WITCH regions are shown in Figure 3 based on the last equation.

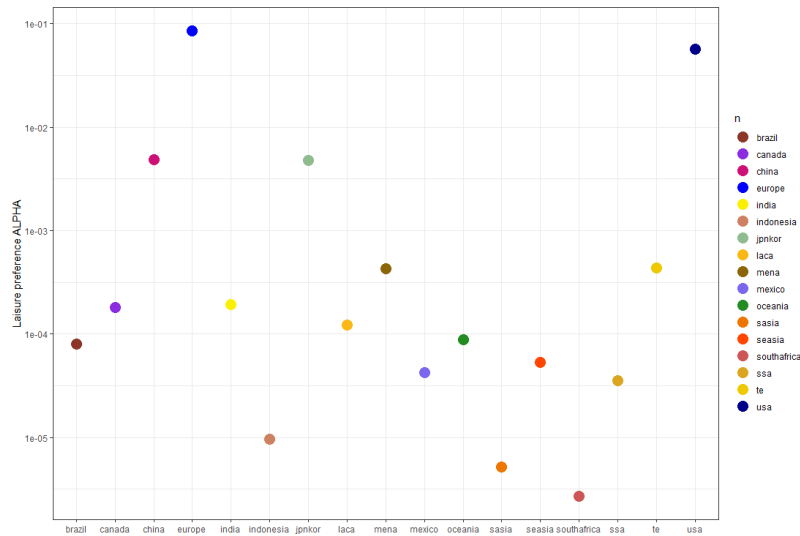


Figure 3: Calibrated leisure preference parameters across the WITCH regions

Europe shows the highest value of leisure preferences followed by the U.S. while South Asia and Sub-Saharan Africa exhibit the lowest value.

Note that for now we don't consider emissions impact of leisure, even though emissions from leisure activities have been estimated and found to be significant, which could be added to the model. A further avenue of research would be to compare the calibrated values of leisure preferences with survey data such as the World Value Surveys (WVS).

5. Numerical results and scenarios

This last section implements exogenous modifications of the regional α trajectories in WITCH to produce pathways in complement to its original BAU. In particular we consider six scenarios:

1. bau_default (the business-as-usual scenario in the standard WITCH model)
2. bau_labour (the extended model including active labour and unemployment)
3. bau_leisure (on top having labour preferences endogenously solved in the optimization)
4. 15deg_default (1.5° scenario in the standard WITCH model)
5. 15deg_labour (1.5° scenario including active labour and unemployment)
6. 15deg_leisure (1.5° scenario with labour preferences endogenously solved in the optimization)

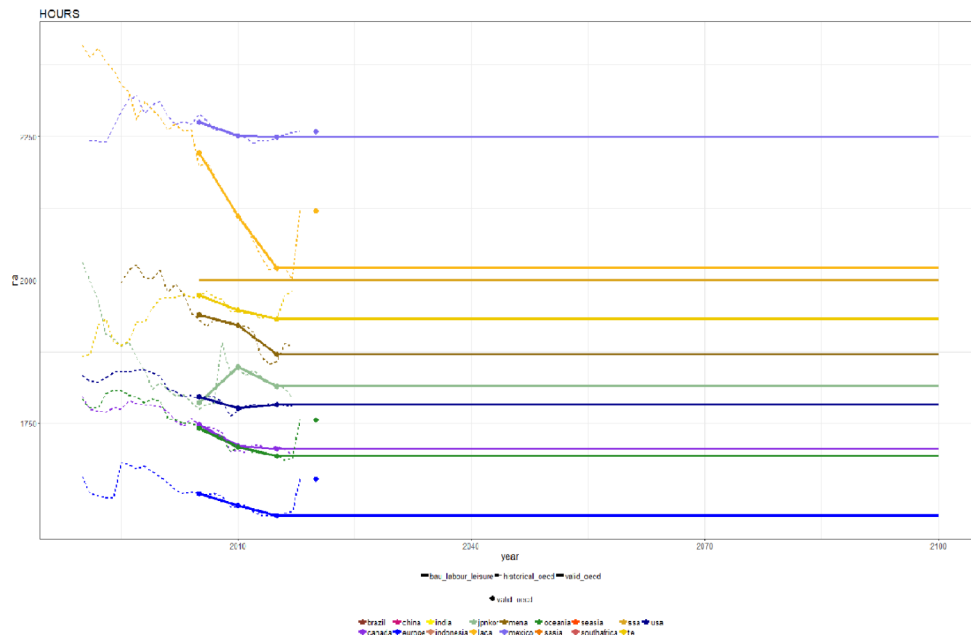
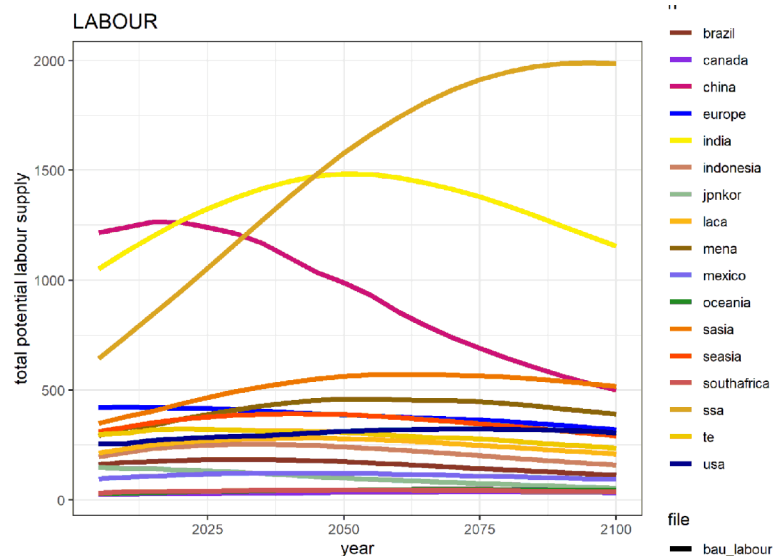


Figure 4: Scenario results of constant hours worked across WITCH regions

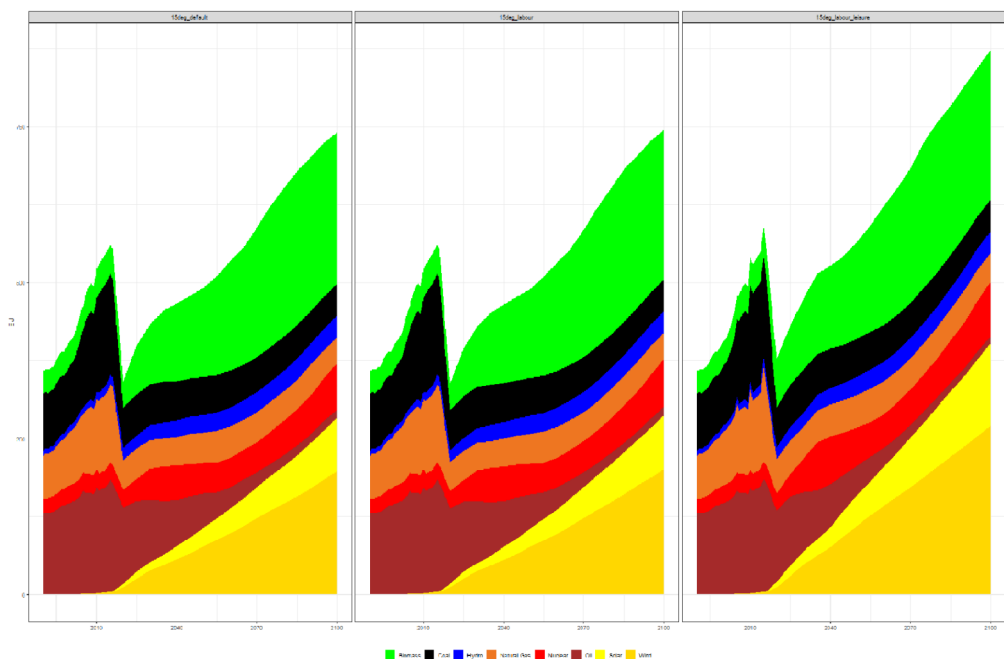
Let us first report on the GDP and labour supply variations induced by the contrasted generalisation of the US vs. Western European free time preferences, compared to BAU. Labour supply is measured in man hours, which are computed by directly applying to BAU man hours (products of the BAU labour forces and average working hours) the optimal variations of labour supply ϕ_i induced by the changes in free time preference.

The labour supply now in terms of active population without employment and actual hours worked is shown in the following figures showing the SSP2 trajectories.

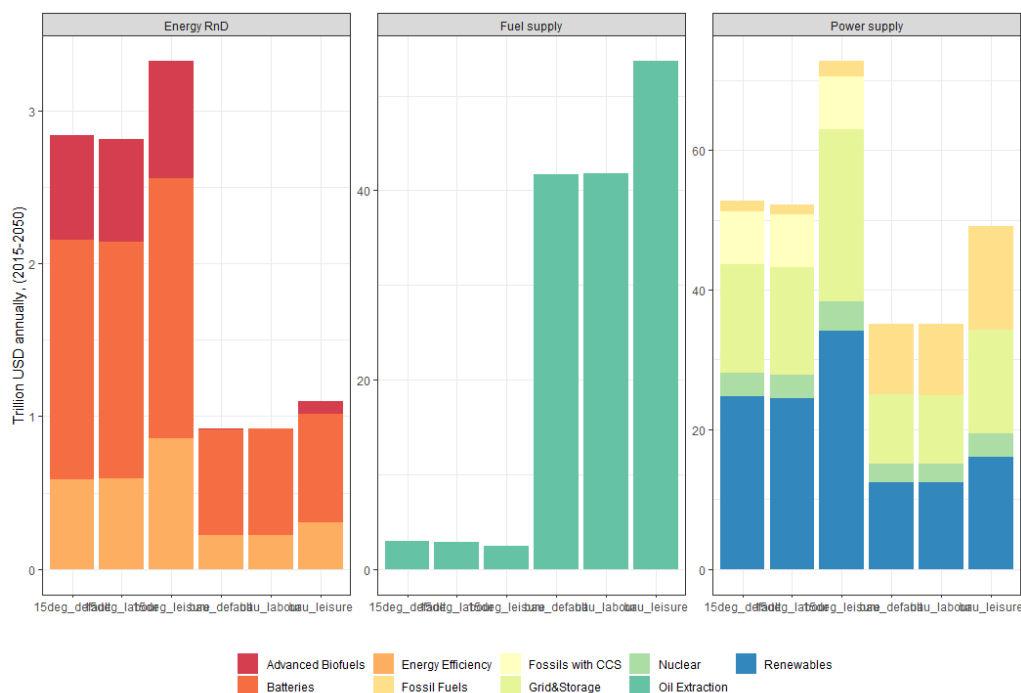


A closer scrutiny however reveals that GDP impacts tend to be more extended than labour supply ones, both when negative and positive. This is a consequence of the cumulative nature of GDP growth: part of the output of a higher labour supply impacts the GDP of further periods through investment; the fact that the returns on labour are decreasing then explains that GDP losses are closer from labour supply cuts than GDP gains from labour supply increases.

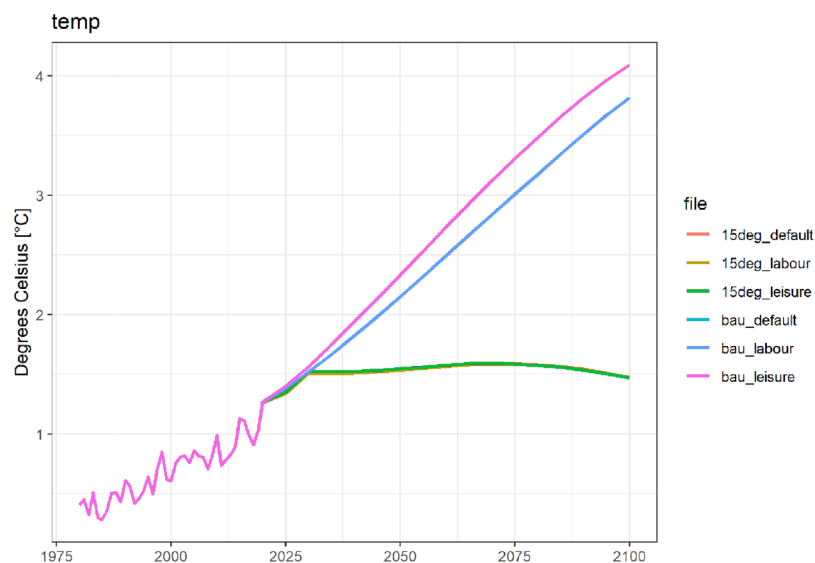
At last, it is worth mentioning that because of the varying shares of each region in the total global GDP and man hours, the global aggregation of the 2 scenarios delivers results that are not easily derived from the disaggregated ones. Beyond GDP and labour market time, the use of WITCH allows tracking and translating differences in GDP into differences in total primary energy demand and the resulting greenhouse gas emissions. The mechanisms at play are most visible in the case of the two central regions of the US and Western Europe for those scenarios that generalise their free time preferences: despite unchanged GDP both their energy consumptions and emissions evolve in quite illustrative ways.



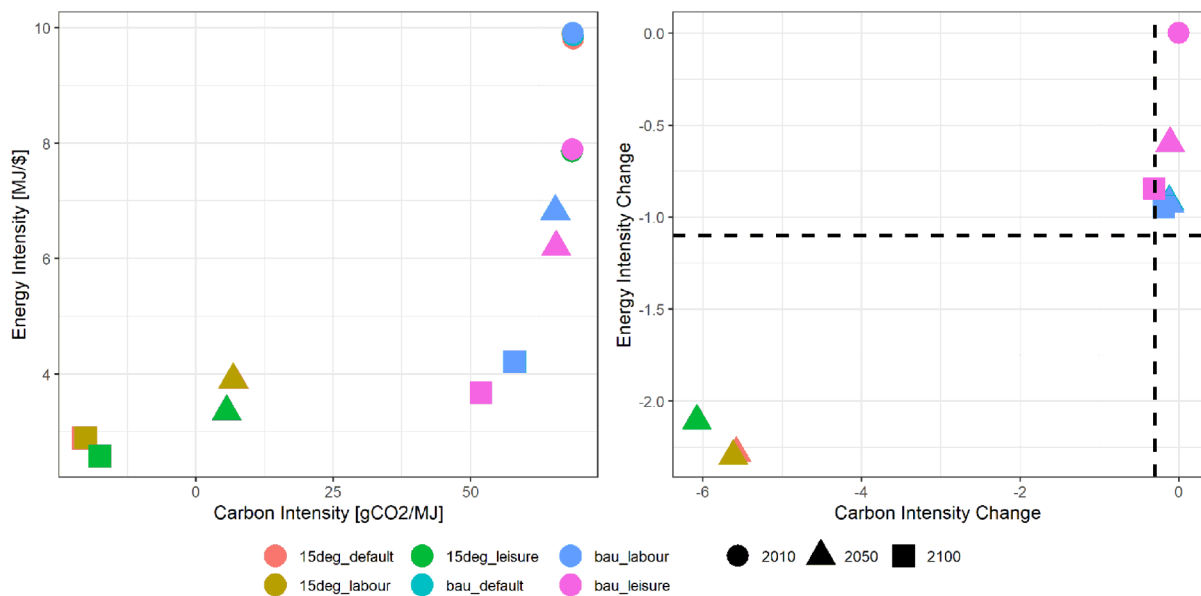
In terms of primary energy mix, note that adding leisure preferences adds significant renewables and biomass in the energy mix (rightmost figure). Comparing the BAU and 1.5 degree scenarios, we find a large shift towards investments and innovation / RnD investments in the stringent scenarios, that are even increases when labour is endogenous and leisure preferences are included, by about 20 per cent.



The resulting climate is also remarkably affected by leisure related emissions resulting in a temperature about 0.3 degrees higher in the BAU scenario than with fixed population as labour. This results shows that considering the changes in regional labour and leisure preferences and behaviour will possibly have a stark impact on the degree of climate change.



In terms of overall Energy and Carbon intensity, we find that from today's values of about 10 MJ/\$ and 70 gCO₂/MJ, the improvements in terms of energy efficiency are faster (pink vs. blue squares) in the base line at only moderate carbon intensity improvements. In the 1.5 degree scenario on the other hand, labour preference needs to a lower energy intensity (green vs. brown) while the ranking in terms of ultimate carbon intensity is ambiguous and switches sign between 2050 and 2100.



7. Conclusion

In the last 70 years, in developed countries, preferences for time allocation between market and free time have been evolving with the increase in prosperity. But evolutions have been different and cannot be explained by the growth in GDP alone. A large part of the world, the so called fast growing countries, are not entering a phase where preferences for time allocation will potentially change in a dramatic way. This will potentially have a large impact on what is the expected growth of these countries. Although important as a task per se, getting the long term growth projections for these fast growing countries is all the most crucial as the demand for natural resources will largely depend on their demand. We show that projections of time use preferences could affect dramatically the world we will be living in. Henceforth, long term analysis of sustainable development cannot abstract from this key issue. The different preference parameters and scenarios, through their compared impacts on GDP, time allocation, energy consumption and carbon emissions, also give a notion of the vastly contrasted development perspectives that the introduction of a labour supply vs. free time trade-off opens.

More generally, our model enhancement is the first large-scale IAM to explicitly consider labour different from simply calibrated to a region's population, by taking into account unemployment, the active population, and endogenous labour leisure decisions. The results indeed indicate strong impacts on GDP and energy demand and hence emissions. Given the demographic SSP based calibration of the active population, endogenous leisure decision and (for now static) unemployment, this provides a first important step in integrating labour productivity and employment in in IAM. This model thus has the potential to substitute a micro-funded, comprehensive approach. Future research building on this model would be linking unemployment with energy system transformation (with at stake about 11 million direct jobs in the energy system only in Renewables in 2018 (IRENA 2019)), labour productivity changes, and the skill dimension. Moreover, a changing retirement age resulting in different active population scenarios can be analysed.

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Annex I: Human capital and distribution in WITCH

While here we only consider labour supply of one type or skill and income / wage level, considering different skill levels and income/wage values is possible within the model. TO that end, we added inequality data and educational attainment data and aggregated it across macro regions to obtain a global picture of these important dimensions for labour supply. Ultimately, we aim to disaggregate the time preference effect combined with income distribution and human capital / educational attainment. Notably, we constructed income quintiles and Lorenz-Curves and human capital decomposition including projections until 2100 for these relevant variables. Figure 5 shows these values in the model as we implemented them.

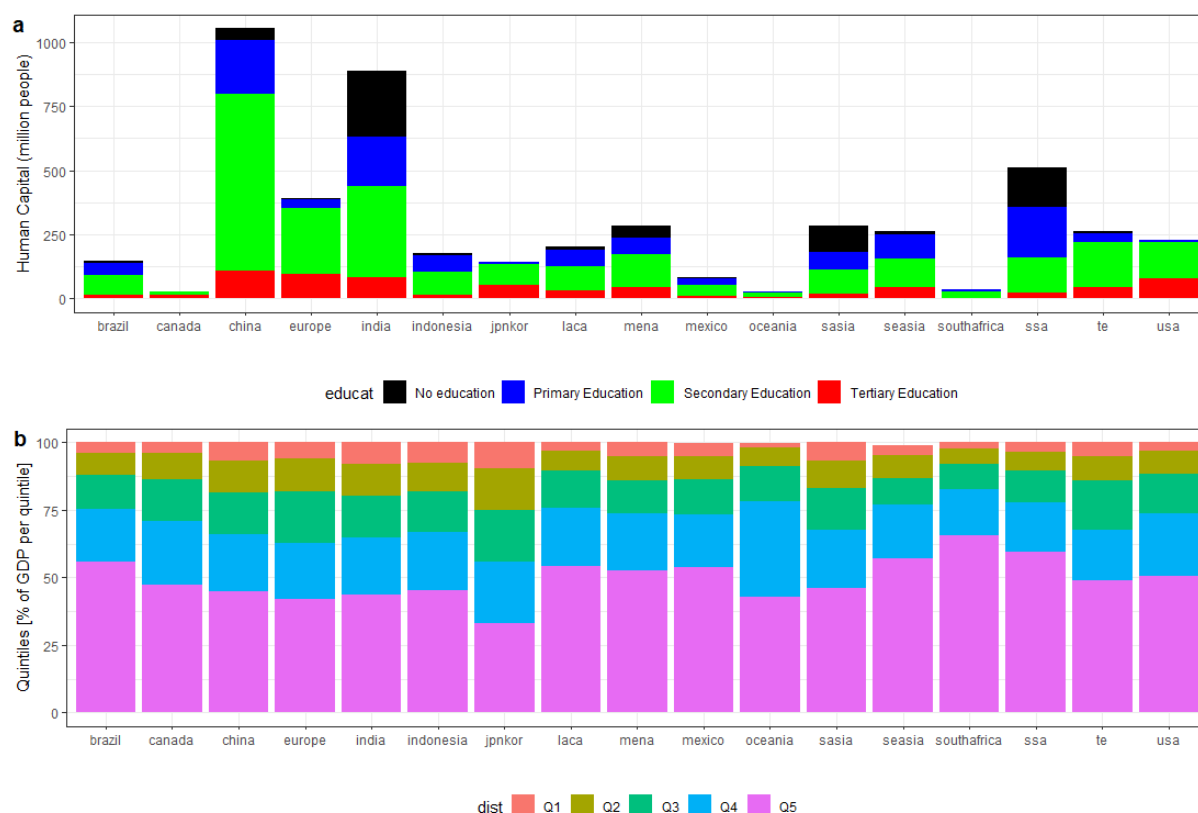


Figure 5: Human capital and distributional data in the WITCH model, base year (2015)

ANNEX B of D2.5: Green jobs in the EU

Marianna Gilli¹, Elena Verdolini² & Francesco Vona³

Abstract

In this report, we describe the evolution of green jobs across sectors of the economy in the member countries of the European Union. Extending the methodology presented in Vona et al. (2018) and Vona et al. (2019), we identify the green content of occupations in a sample of five sectors in fifteen European member countries and describe the set of skills that qualify an occupation as green (i.e., green skills). Our analysis is the first attempt to provide answers to the following questions: i) To what extent can EU jobs be classified as green? ii) Which economic sectors are characterized by the higher level of greenness, and rely more on green skills? iii) How did the greenness of EU jobs change over time?

1. Introduction

The purpose of this report is to improve our understanding of the evolution of green jobs with a focus on five economic sectors in a sample of fifteen European countries. According to the International Labour Organization⁴, a green job is a decent job that contributes to preserving and restoring the environment. As such, green jobs can arise both in the traditional sectors (agriculture, manufacture and services) or can emerge as a new sector such as the renewable energy generation or energy efficiency. How the labour market will give rise to, and accommodate, this kind of occupations will determine whether a given economy is well-positioned to successfully pursue stringent climate targets while with less impact on the labour force. Indeed, the European Commission is dedicated to foster economic growth and job creation in a smart, sustainable and inclusive way, to improve European competitiveness worldwide (European Commission 2019).

Yet, understanding the extent to which jobs in a given sector undergo a process of greening is impaired by the lack of statistics measuring green jobs and green skills. Specifically, there is no information regarding the greenness of European jobs. Indeed, this information is only available for the US market. This report provides answers to the following questions: i) To what extent can EU jobs be classified as green? ii) What are the sectors that rely on green jobs the most? In which sectors are abilities and competencies related to green jobs better exploited? iii) How did the greenness of EU jobs change over time? To answer such questions, we extend the methodology outlined in Vona, Marin, Consoli and Popp, (2018) and Vona, Marin and Consoli (2019) to identify

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⁴ https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm

the green content of occupations at the sectoral level for Europe and to describe the set of skills (e.g., engineering and technical abilities) that qualify an occupation as green.

We contribute to the literature in three ways. First, we develop a taxonomy of green jobs for Europe. To do so, we match the information on green task content of jobs provided in the US Occupational Information Network (O*NET) with the occupational data in the EU Labour Force Survey (EU-LFS) to overcome the lack of data on greenness of jobs in Europe. Second, we describe the evolution of the greenness indicator and of the key green skills in different sectors of the EU member countries. Third, we provide initial descriptive evidence of whether and how the evolution of the greenness indicator and of green skills correlate with more stringent environmental policies, reduced emissions or higher level of green innovation for the EU. This will provide preliminary evidence on whether environmental and climate policies implemented so far in the EU have promoted the greening of the EU workforce.

The rest of the report is organized as follows: in section 2, we start by briefly discussing the methods to measure the greenness of tasks and skills for a given occupation, including their limitations. Section 3 presents the methodology we adopt in our analysis. Section 4 presents results on the greenness of EU occupations in detail, as well as at the sector level. Section 5 presents unconditional and conditional correlations of the greenness indicator with indicators of environmental policy stringency and innovation. Section 6 concludes.

2. Measuring greenness and green jobs

Defining what is green is conceptually difficult and green employment is no exception. First and foremost, a good or a service can be green or not depending on how we produce, use and dispose of it. For instance, an electric vehicle represents either a unique opportunity to store renewable energy or simply a way to relocate pollution from city centers to the peripheral areas where (coal or gas) power plants may be located. This issue is directly related to that of measuring what product and service are green by computing its pollution content along the value chain.

Yet, definitions of what is green used in the debate on green tariffs at the WTO and to measure green jobs consider the green potential of an activity, so its capacity to reduce pollution, rather than at its actual pollution impact, which depends on usage. According to this definition, an electric vehicle, and all the associated technologies (e.g. battery), is considered as green because it has the potential to become fully green if and when electricity is produced with clean energy.

Secondly, commonly used classifications of green products include technologies with different intensities of greenness. Both technologies to prevent pollution at the source (the so-called integrated technologies) and activities that limit the harmful effects of polluting activities (the so-called end-of-pipe technologies) are classified as green in all lists of green products used in the debate at the WTO. Clearly, integrated technologies have a substantially larger potential to reduce emissions than end-of-pipe ones.

The blurred boundaries of what is green and what is not are also relevant in the definition of green employment. On the one hand, approaches inferring green employment from the share of green production implicitly assume proportionality between the share of green jobs and the share of green products, defined without differentiating for green intensity in a given sector (e.g., Green Good and Service Survey of the Bureau of Labor Statistics, BLS, 2013). On the other hand, a large measurement error emerges also using methodologies that classify a job as green in a dichotomous

way such as the O*NET one (see Peters, 2011; Consoli et al., 2016). Again, the problem is that a dichotomous measure cannot capture the different levels of greenness.

In the case of jobs, only certain activities performed by a worker can be classified as green. An electrical engineering technician performs a green activity when he “participates in the development or testing of electrical aspects of new green technologies, such as lighting, optical data storage devices, or energy-efficient televisions”, but not necessarily when “assemble electrical systems or prototypes, using hand tools or measuring instruments.” (see O*NET). As discussed extensively in Vona et al. (2018, 2019), there are different intensity of average occupational greenness, which is defined as the share of green tasks over total tasks. That is: on average, 14% of tasks performed by a US electrical engineering technician are green, 100% of the task performed by a wind energy project manager is green and 0% of tasks performed by a clerk are green. Using O*NET information on green and non-green tasks rather than on green and non-green jobs allows for significant improvement in accurately measuring the share of green jobs in an economy because it allows to detect differences in green intensity across occupations.

The implicit assumption made in Vona et al. (2018, 2019), which we also make in this report, is that the share of tasks in a certain occupation is proportional to the time spent in doing this activity. This assumption is consistent with the task approach to labour markets presented, for instance, in Acemoglu and Autor (2011). Under this assumption, the greenness of an occupation is the fraction of time spent on green activities by the workers in said occupation. According to this view, aggregated green employment can be built as the sum of the share of employment of all occupations reweighted by their greenness. Vona et al. (2019) show that using this measure of green employment rather than the measure directly provided by O*NET allows to match the level of green employment in the years of the Green Good and Service Survey in the US, while the crude O*NET measure simply counting as job as green or not overestimate green employment by an order of magnitude.

3. Methodology

To provide a descriptive evidence on the evolution of green jobs, we build on the methodology first developed in Vona et al., (2018) and Vona et al., (2019) to compute a greenness indicator and to define the skills content of an occupation. Before we delve into the specifics of the methodology, we necessarily have to provide a few key definitions.

Throughout the rest of this research occupation, “task” and “skills” are defined according to the seminal work of Autor, Levy, and Murmane (2003) and of Acemoglu and Autor (2010). An “occupation” or “job” consists of a set of different tasks, which are the units of work activity that produces some output. To perform a set of tasks, the worker will rely on a set of “skills” (i.e., competencies), which are the endowments of capability that allow him to get the task done. As a simple example, “monitor and evaluate the effectiveness of sustainability programs” is one of the tasks in the “Chief Executive” occupation; a skill necessary to perform this task is “economics and accounting.”

As already mentioned above, our methodology was designed to overcome the fundamental lack of data on the green content of EU jobs. In this section, we describe in detail each of the four steps we have to implement in order to characterize the greenness of EU jobs and associated green skills. Specifically, four steps are described:

- a) The computation of greenness and skills by occupation in the US. This step effectively reproduces the methodology adopted in Vona et al., (2018) and Vona et al., (2019) to compute a greenness indicator and to define the skills content of an occupation, with a more recent version of the O*NET database;
- b) The computation of greenness and green skills by occupation in the EU. This step requires matching jobs in the US, which are classified using the SOC⁵ classification, to jobs in the EU, which are classified using the ISCO⁶ classification;
- c) The computation of greenness and green skills by sector in the EU member countries. This step entails attributing EU jobs to specific sectors within the EU;
- d) The descriptive analysis of how EU green jobs correlate with more stringent environmental policies, with emissions reductions and with innovation either at the sector or at the national level.

a. Compute greenness and green skills by occupation in the US

Following Vona et al., (2018) and Vona et al., (2019), to compute greenness and green skills for the US we rely on the US Occupational Information Network (O*NET) database. O*NET is the result of a program developed under the sponsorship of the U.S. Department of Labor/Employment and Training Administration (USDOL/ETA). The O*NET database collects several waves of annual labour force surveys (covering the 80% of the total US working population). In addition, as part of the O*NET Program, firm-level employee's interviews are collected with the aim of identifying specific competencies associated with each job. As a result, from the O*NET database it is possible to retrieve the different mix of skills that are instrumental in each specific occupation to perform a variety of tasks. The O*NET classifies green occupations under three categories: i) existing occupations expected to increase their demand because of the greening of the economy; ii) occupations that are expected to undergo significant changes in their task content because of the greening of the economy and iii) new occupations in the green economy. Following Vona et al. (2018), we will mainly refer to the occupations in the last two groups, as the link with the environmental activities is more clearly identifiable than for the first category, that can at least be considered indirectly green.

We compute a greenness indicator for each US SOC 6-digit occupation following the formula in Vona et al., (2018) and Vona et al., (2019):

$$greenness_k = \frac{green\ tasks_k}{total\ tasks_k} \quad (1)$$

Where greenness is an indicator of the relative weight of the number of green tasks over the total tasks (i.e., the sum of green and non-green tasks) involved in the k -th occupation. This indicator can be interpreted as the relative importance of a set of tasks directly or indirectly related with the environmental sustainability.

Finally, we include in the analysis the set of green skills identified in Vona et al., (2018b). Indeed, as argued by the authors, the greenness indicator alone might not be adequate to compare green jobs, especially when the ultimate goal is to draw policy implications aimed to direct the

⁵ Standard Occupation Classification is the employment taxonomy applied in the US

⁶ International Standard Classification of Occupation is the employment taxonomy by the International Labour Organization and applied in the EU

development of workforce towards certain activities. Table 1 below shows the four categories of skills identified by the authors. Engineering and technical skills include all the abilities related to technology life cycle, such as design, development and installation; these skills can be related to both low and middle-skills occupations (e.g., solar PV installers and technicians) and to high-skill occupations (e.g. engineering) which pertains to the development of new technologies. Operation management group encompasses all the abilities related to the organization of green activities and to supervising the phases of the production cycle. In a sense, this set of skills allows to identify environmental needs and to integrate them in the production process to meet the interest of different stakeholder groups. Like engineering and technical skills, science abilities are also related to the development of new technology, but the focus in this case is more general because science orientation is toward the creation of new knowledge, rather than to the adaptation of knowledge to a specific technology. Lastly, monitoring skills are related to the legal and technical activities which are linked to complying with regulatory standards.

Table 1 - Green General Skill by macro group. Source: Vona, Marin, Consoli and Popp (2018)

Group O*NET code	Description
Engineering and technical:	
2C3b	Engineering and Technology
2C3c	Design
2C3d	Building and Construction
2C3e	Mechanical
4A3b2	Drafting, Laying out, Specifying technical devices, parts and equipment
4A1b3	Estimating the quantifiable characteristics of products, events and information
Operation Management:	
2B4g	System analysis
2B4h	System evaluation
4A2b3	Updating and using relevant knowledge
4A4b6	Provide consultation and advice to others
Science:	
2C4b	Physics
2C4d	Biology
Monitoring:	
2C8b	Law and government
4A2a3	Evaluation information to determine compliance with standards

b. Compute greenness and green skills by occupation in the EU

We extend the analysis of Vona et al., (2018) and Vona et al., (2019)⁷ by exploiting the O*NET information to generate a measure of greenness for European occupations as well as of the importance of green skills.

The first difficulty we need to overcome is that the level of detail available for the US data on occupations differs from that of the EU data. Specifically, for the US, both O*NET and the BLS survey provide statistics at a fine level of details, namely 6-digit SOC occupation (US). For the EU,

⁷ The EU-LFS is a large household sample survey providing quarterly results on labour participation of people aged 15 and over and available from EUROSTAT.

comparable data does not exist. On the one hand, as already argued, there is no database describing the green content of EU jobs. On the other hand, the available database for employment in the EU, namely the EU Labour Force Survey (EU-LFS),⁸ provides information on occupations at the 3-digit level of the International Standard Classification of Occupation (ISCO).

In order to rely on the O*NET data to compute greenness indicators for EU jobs, we therefore have to adapt the information on the greenness of the *NET occupations using a crosswalk to match each 6-digit SOC occupation (US) to a 3-digit ISCO one (EU). Importantly, a given 6-digit SOC occupation is not necessarily fully contained in a 3-digit ISCO one. This is clearly illustrated in Table A1 in Appendix A, which shows the SOC-ISCO crosswalk. The column “Share” shows the share of each SOC 6-digit which falls in a given ISCO 3-digit. For example, only 33 percent of the workers classified under the SOC 11-9032 (Education Administrators) are included in the ISCO sector 134 (Professional Services Managers). Conversely, workers under SOC 11-2011 (Advertising and Promotion Managers) are fully included in the ISCO 122 (Sales, marketing and development managers). In this last case, “Share” is equal to 1.

After matching each SOC 6-digit occupation to ISCO 3-digit occupations, we compute the greenness indicators for each ISCO 3-digit. This is obtained by summing the weighted greenness of the SOC 6-digit occupations contained in the ISCO 3-digit occupation. The weights represent the share of a given SOC 3-digit occupation in the specific ISCO 3-digit occupation.

It is crucial to note that by following this procedure we implicitly assume that the green content of occupations has the same distribution within the US and European labour markets respectively. That is, by using a crosswalk between SOC occupations and ISCO occupations, we attribute to a Professional Services Manager (ISCO 134) in the EU the same set of tasks, and therefore the same green content, as a Financial Manager (SOC 11-3031) in the US.

Given that our approach entails computing the greenness of ISCO 3-digit occupations for the EU as a weighted average of the greenness of the finer-grained SOC occupations, we cannot directly compare the greenness of a US occupation with the one of an EU occupation. Rather, the only appropriate comparison is between the greenness of different ISCO 3-digit occupations.

We use the same approach to extend the analysis of the green US skills to the EU labour market. The results are presented in Table 1.⁹

c. Compute greenness and green skills by sector in the EU

Our second contribution is to describe the greenness and the importance of green skills for the different sectors of the EU Member States. To compute sector level indicators, we aggregate the information on the greenness of the different EU jobs comprised in a given sector. We identify sectors relying on the NACE Rev. 2 classification. In this report, we specifically focus on the sectors listed in Table 1. This is motivated by the fact that the INNOPATHS project focused more strongly on the specific sectors, namely Agriculture, Buildings, Energy, Industry, Transport. The sectors identified in Table 2 are the closest match to the sectors chosen within INNOPATHS.

⁸ The EU-LFS is a large household sample survey providing quarterly results on labour participation of people aged 15 and over and available from EUROSTAT.

⁹ Namely, we multiply the the skill importance of each SOC 6-digits by its share with respect to the other SOC 6-digit included in the same ISCO 3-digit.

Table 2 - Relevant NACE Rev. 2 sections. Adapted from "NACE Rev. 2 - Statistical classification of economic activities in the European Community" European Commission 2008

NACE Rev. 2 section	Sector Title
A	Agriculture, forestry and fishing
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
F	Construction
H	Transportation and storage

Specifically, the sector-level greenness indicator is computed as the weighted average of the 3-digit ISCO greenness; the weights are the shares of the employees of each ISCO 3-digit in NACE k over the total employees of NACE k , as follows:

$$greenness_{NACE_k} = \sum_{i=1}^n (greenness_{ISCO_i} * share_{ISCO_i, NACE_k}) \quad (2)$$

Similarly, we compute the greens skills importance at the sector level:

$$skill_{NACE_k} = \sum_{i=1}^n (skill_{ISCO_i} * share_{ISCO_i, NACE_k}) \quad (3)$$

d. Evolution of greenness and green skills in the EU, and correlations with key energy, emissions, and environmental policy indicators

A final part of this analysis aims to explore the relation between greenness and some key indicators of environmental policy stringency, pollution and innovation.

As policy indicators, we chose both fuel prices and the Environmental Policy Stringency indicator (EPS). Fuel prices, which reflect changes in institutional factors and environmental policies are sourced from Sato et al., (2019). These fuel price indexes varying by country and sector and across time. The prices indicators are computed as the weighted average of different fuel prices (oil, gas, coal and electricity), where the weights are given by the share of a specific fuel consumption over the total sector's energy mix. While the fuel prices vary by country and time, the variation across sectors is given by the different energy mix of each industry. We include two indicators of energy prices: Energy prices (all) and Energy prices. As a way to deal with missing observation, the latter is allowed to be computed on less than four fuel types if the excluded one represents less than 12% of the total sector's fuel consumption. Thus, the indicator Energy prices (all) contain more missing observations (specifically, the 6% more than Energy prices).

The EPS indicator by the OECD (Botta and Kozluk, 2014) provides a measure of policy stringency by country and time. This indicator is a composite indicator of policy, that results from the aggregation of different individual policies indicators, namely taxes and charges, trading schemes, subsidies for environmental activities, deposit and refund schemes, command and control regulations, technology support policies and voluntary programs in places in a country in a given

year. The aim of this indicator is to describe as broadly as possible the stringency of both market and non-market environmental regulation.

As a pollution indicator, we chose CO2 emissions. We gathered information on CO2 by sector from the OECD *Carbon dioxide emission embodied in international trade* database, which provides estimates of the cross-country distribution of final demand (i.e., household consumption and industry) for embodied carbon that has been produced anywhere along the global production chain. We used the demand-based CO2 emission because information on carbon emission from production were available only at the country level. Emissions are calculated by multiplying the intensities of the production-based emissions by a global Leontief inverse and a global final demand matrix from OECD Inter-Country Input-Output database, taking the column sums of the resulting matrix and adding residential and private road emissions.¹⁰

Finally, we selected patents applications to the EPO as indicators of innovation. While patent applications allow to relate greenness to the creation of new knowledge, the stock links a sector greenness to its innovation capacity. Patent applications data are available by IPC class, requiring us to match each application to an economic sector. We do so by applying the methodology developed by Lybbert and Zolas (2012), which employs text analysis software and keyword extraction programs to build a concordance that assigns IPC to economic sectors. Finally, we computed the stock of patent according to formula (4) also found Popp (2011):

$$KStoc k_{NACE_k, i, t} = \sum_{s=0}^{\infty} e^{-\beta_1(s)} (1 - e^{-\beta_2(s+1)}) PAT_{NACE_k, i, t} \quad (4)$$

Where β_1 is the rate of decay, which captures the obsolescence of old patents and β_2 is the rate of diffusion that takes into account the delayed knowledge flow. Consistently with the literature (e.g., Popp, 2011; Lovely and Popp, 2008), the rate of decay is 0.1 while the diffusion one is 0.25. The stock is computed for each NACE section for each country i and year t . The parameter s is computed as the difference between the first year available for patent applications and the year for which we are computing the stock. For example, the first year for this computation is 1999, so to obtain the stock for 2014 we apply a s equal to -15 to the rate of decay. β_2 is multiplied by $s+1$ so that diffusion is not 0 in the first year.

Relatively to the computation of correlations, we first looked at pairwise correlations between greenness and each of the other indicators of interests. We computed the Pearson correlation coefficient which is a simple measure of linear association between two variables. This coefficient can take any value between -1 and 1. The more the coefficient is closer to 1 (or -1) the more we can describe the relation between two variables as linear.

We then focus on conditional correlations (i.e. linear regressions) between greenness and the chosen indicators. This allows to control for the unobserved sector and country fixed effect. For each of the indicators above we run fixed regressions. Conditional correlation using sector-level data between greenness and policy is computed according to equation (5) while those based on country-level data follow equation (6).

$$greenness_{NACE_k, t} = \alpha_{NACE_k, t} + \beta_1 Energy\ prices_{NACE_k, t} + u_{NACE_k} + \varepsilon_{NACE_k, t} \quad (5)$$

¹⁰ Information retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2019#

$$greenness_{c,t} = \alpha_{c,t} + \beta_1 EPS_{c,t} + u_c + \varepsilon_{c,t} \quad (6)$$

Lastly, we computed conditional correlation with emissions and innovation according to (7), where $X_{NACEk,t}$ is either CO2 emissions embedded in trade, the flow of patent applications or its stock

$$X_{NACEk,t} = \alpha_{NACEk,t} + \beta_1 greenness_{NACEk,t} + u_{NACEk,t} + \varepsilon_{NACEk,t} \quad (7)$$

4. Results

a. Greenness and green skills by EU occupation

Table 3 below shows the top 20 occupations by greenness in the EU computed according to equation 2. As for the US case (see Appendix B), a greenness equal to 1 would imply the occupation consists entirely of green tasks, while no environmental-related activity is undertaken in an occupation with a greenness of 0. Yet, differently from the US case, indicators are here presented for a more aggregate level, namely the ISCO 3-digit occupations. Because most ISCO 3-digit occupations are relatively aggregated, and includes different profiles of workers, occupations are characterized by a varying degree of performing environmental tasks, hence by a greenness between 0 and 1.

Table 3 - Top 20 occupation by greenness in the EU

ISCO 3digit	ISCO Title	Greenness
961	Refuse Workers	0.692
314	Life Science Technicians and Related Associate Professionals	0.268
932	Manufacturing Labourers	0.231
711	Building Frame and Related Trades Workers	0.230
122	Sales, Marketing and Development Managers	0.202
214	Engineering Professionals (excluding Electrotechnology)	0.198
132	Manufacturing, Mining, Construction and Distribution Managers	0.168
332	Sales and Purchasing Agents and Brokers	0.166
211	Physical and Earth Science Professionals	0.142
215	Electrotechnology Engineers	0.136
213	Life Science Professionals	0.135
142	Retail and Wholesale Trade Managers	0.118
311	Physical and Engineering Science Technicians	0.107
962	Other Elementary Workers	0.099
216	Architects, Planners, Surveyors and Designers	0.092
313	Process Control Technicians	0.092
723	Machinery Mechanics and Repairers	0.077
243	Sales, Marketing and Public Relations Professionals	0.069
241	Finance Professionals	0.068
242	Administration Professionals	0.064

The greenest job in the EU is that of refuse workers, with a greenness indicator of 0.692. Refuse workers include all the occupations that are related to the collection, disposal and transformation (e.g., personnel at the recycling facilities) of waste. Specifically, according to the ISCO classification this 3-digit level includes sweepers and related labourers, garbage and recycling collectors and refuse sorters.

Apart from this case, note that jobs with a higher greenness involve higher levels of education. For example, Life Science Technicians and Related Associate Professionals (which includes life science, agricultural and forestry technicians) and that score the second higher greenness in the EU (0.268) do require at least a secondary education level. Graduate studies are required for jobs included in the Engineering professions (Mechanical, Chemical, Civil, Environmental and Mining engineers as well as metallurgists and engineering professionals not elsewhere classified) that show a greenness of 0.198.

Table 4 below reports the greenness indicator and the average green skill importance by macro-category of ISCO 1-digit occupation. We chose to report skills importance at a more aggregated level to summarize the main evidence; we included the standard deviation of the importance score for each group to emphasize that there is a considerable variability in the importance scores within the same occupational group. Indeed, in our discussion we will often refer to Table A4 in Appendix C, which presents an ISCO 3-digit version of Table 4.

Because of the difference in the aggregation level between ISCO 3-digit and SOC 6-digit, the relevance of some set of skills, say the engineering and technical ones, to particular occupations, say Environmental engineers or Solar Photovoltaic Technicians, cannot be fully highlighted here, and remains confounded within the more aggregate category of Professionals (Engineering Professionals 214 at ISCO 3-digit).

Table 4 - Greenness and green skills distribution by ISCO 1-digit

ISCO	Occupation Title	Greenness	Eng./Tech	Op. Mngmt	Science	Monitoring
1	Managers (Std. Dev.)	0.062 (0.07)	2.315 (0.3)	3.372 (0.21)	1.678 (0.45)	3.374 (0.21)
2	Professionals (Std. Dev.)	0.035 (0.06)	2.143 (0.50)	3.262 (0.20)	2.086 (0.64)	3.060 (0.40)
3	Technicians and Associate Professionals (Std. Dev.)	0.035 (0.07)	2.145 (0.50)	3.009 (0.18)	1.919 (0.60)	3.174 (0.43)
4	Clerical Support Workers (Std. Dev.)	0.001 (0.004)	1.641 (0.21)	2.581 (0.13)	1.177 (0.09)	2.881 (0.29)
5	Services and Sales Workers (Std. Dev.)	0.001 (0.002)	1.762 (0.18)	2.539 (0.20)	1.438 (0.22)	2.656 (0.41)
6	Skilled Agricultural, Forestry and Fishery Workers (Std. Dev.)	0 (0)	2.214 (0.23)	2.371 (0.24)	2.108 (0.22)	2.479 (0.33)

7	Craft and Related Trade Workers (Std. Dev.)	0.032 (0.06)	2.790 (0.31)	2.609 (0.24)	1.704 (0.21)	2.599 (0.19)
8	Plant and Machine Operators and Assemblers (Std. Dev.)	0.007 (0.01)	2.349 (0.26)	2.495 (0.13)	1.643 (0.27)	2.727 (0.26)
9	Elementary Occupations (Std. Dev.)	0.094 (0.21)	2.119 (0.36)	2.429 (0.24)	1.611 (0.23)	2.603 (0.21)

The importance of engineering and technical skills is highest for industry-related occupations such as Craft Workers (2.790), Machine Operators (2.349), as well as for Skilled Agricultural Workers (2.214). The first two ISCO 1-digit occupational groups include jobs related to construction of building (e.g., Building Frame Workers and Building Finishers, which scores 3.151 and 3.002 respectively), to manufacturing activities (e.g., Metal sheet Workers and Blacksmiths and Toolmakers with an importance of 3.019 and 2.894) and to mining ones, such as Mineral Processing Plant Operators, that scores an importance of 2.655. The Skilled Agricultural Workers group includes occupations related to farming, fishery and forestry (e.g., Market Gardener and Crop Growers show an importance of 2.426). From Table A4, we notice that despite engineering and technical skills are relevant for these occupations, the greenness is 0 for all the 3-digit occupations.

The relevance of the operation management abilities is relatively high and more homogeneous across the diverse occupational groups. Nevertheless, their importance is the greatest for Managers (3.372) and Professionals (3.262) ISCO categories. From Table A4, we note that within the first group the importance is the highest for Directors and Chief executives (3.763) as well as for ICT services managers (3.645) and for Professional services managers (3.499). Within the Professionals ISCO group, operation management are the more relevant to Medical Doctors (3.612), Software Developers (3.533) and Mathematicians and statisticians (2.416).

The importance of “Science” skills appears more delimited, as in the case of the engineering and technical skills. In particular, science skills are more relevant for Skilled Agricultural workers (2.108) as well as for Professionals. In this latter group we note that the relevance of science is first related to healthcare occupation (e.g. Medical doctors and Veterinarians, which score both above 3) and only secondly to engineering and architecture occupations (e.g., Engineering Professionals (2.476) and Architects (1.896)). Within the Skill Agricultural workers, the importance of science is the greatest for Animal Producers (2.533) and Fishery workers (2.26)

Finally, similar to operation management, also monitoring skills are greatly relevant for all the ISCO 1-digit group. However, we identified Managers as the category that relies on those skills the most (3.374), followed by Technicians and Associate Professionals (3.174).

Summarizing, green jobs in the EU are linked to a high level of education (e.g. Engineers), with the only exception of refuse workers, which scores the higher greenness. Technical and scientific skills have a more delimited scope with respect to operation management and monitoring: in fact, the former results particularly relevant for jobs related to the production of physical goods or the use of resources, while the importance of the latter is cross-cutting to all the ISCO categories. Nevertheless, the relevance of operation management and monitoring skills is the highest for jobs in the Managers and Professional groups.

b. Greenness and green skills by EU sector

Table 5 below presents the greenness score computed for industrial sectors for selected EU countries based on sections of the NACE rev. 2 classification. The last two rows of Table 5 show the weighted averages and standard deviations of the sectoral greenness, where weights used are the share of value added generated in that sector by each country, over the sectoral value added of the EU. By the same token, in the last two columns we computed the weighted average of the greenness by country, where weights used are the value added created by a sector over the total value added generated by the five sectors included in the analysis

Construction and Utilities show the highest average greenness in the EU, scoring 0.0909 and 0.074 respectively in Table 5. Manufacturing is the third greenest sector, with an indicator of 0.0583. This evidence finds supports also by the latest EU2020 report (2019), which points out that even though these industries are still the largest emitters in the EU, they are also responsible for the largest reduction in pollution over the period 2008-2018.

Figure 1 shows the sectoral greenness indicator for countries with emissions higher than (resp. lower) the EU emission average. We note a homogeneous trend of the greenness indicator for the Construction sector which, in 2014, was 2% higher than in 2008. This growth was beyond the EU average greenness¹¹ especially for Italy, Poland and Spain among countries included in the higher than average emitters and Greece, Portugal and Denmark among the lower emissions countries.

Conversely, the growth of greenness in the Utility sector is more heterogeneous across countries. High emissions countries such as Italy and Spain experienced a substantial increase in greenness during the period, whereas Germany and France show a flatter trend and UK a slight decrease. Better performances are shown by low emitters: the right panel of the plot in Figure 1 shows that most of these countries experienced an increase in greenness for this sector, while Netherlands, Ireland and Belgium show substantial fall.

In 2014, United Kingdom and Sweden show the highest greenness (0.0735 and 0.0627 respectively) for the Manufacturing sector. The lowest scores appears to be polarized in the southern area with Italy and Portugal being the least, with a greenness of 0.0393 and 0.0359 respectively. While being the third green sector, Figure 1 exhibits that the average EU greenness had a minor decrease during the period. Increases in greenness are clear for Spain and Italy, among high emitters. In the same plot Poland, UK, and Germany show decreasing trends but greenness performs better than the EU overall. The right panel shows that more countries among the low emitters did increase their greenness, specifically the Netherlands, Denmark and Belgium, while Finland shows a slight contraction, while being still above the EU mean.

For what concerns the other sectors, the Netherlands, Germany and Finland show the highest greenness in the Agriculture sector (0.0175, 0.0157 and 0.0154 respectively), while the average EU is 0.003. In several countries this sector is the one where the greenness displays the highest growth: it is the case for France and Poland, among countries in the left panel, where greenness rose up to

¹¹ EU average greenness as well as EU average importance of green skills that will be discussed later, are computed including all the available countries in the sample, namely: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, Sweden, United Kingdom.

almost 20% (see Figure D1 in Appendix D). In the right panel we notice that Finland and Sweden also show very positive changes in this indicator. An exception is Austria, where greenness peaked in 2011 and collapsed afterwards. Besides this performance, we note that many low emissions countries experienced a decrease in the greenness of this sector. Because of this heterogeneity, the average change in EU sectorial greenness is smoothed.

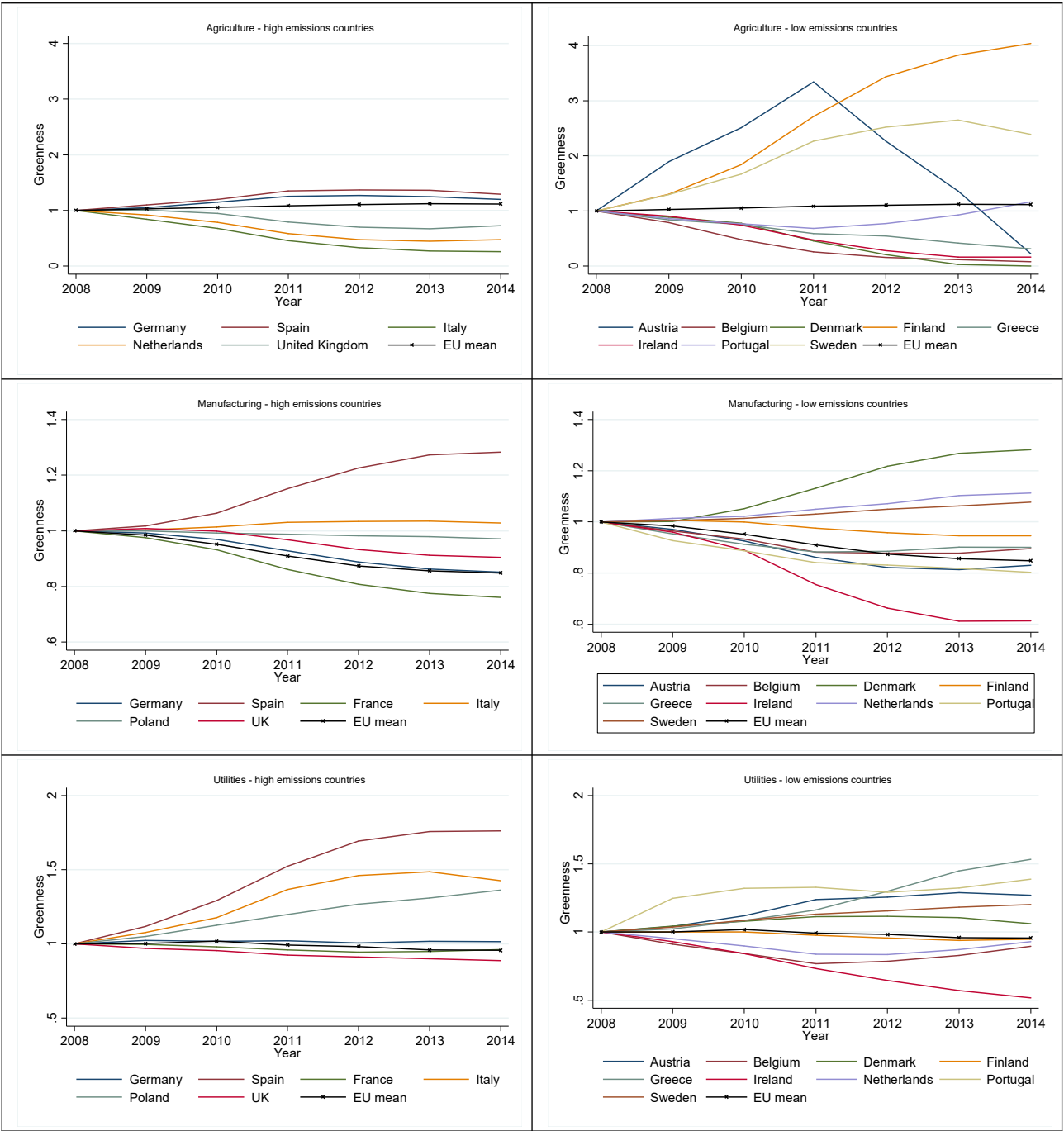
Poland, France and Sweden are the first three countries for greenness in the Transportation sector (0.0342, 0.0317 and 0.0292 respectively) in 2014, as reported in Table 5. Also for this sector, EU Member States show heterogeneous greenness trends, even though the average variation between 2018 and 2014 is positive. Among countries that have a higher than average level of emissions, the increase of greenness has been very positive for Spain and Italy which stayed above the EU mean. On the same plot, Germany, France, the Netherlands and UK show a fall in the indicator. Conversely, lower than average emissions countries perform slightly better, with only three countries (Ireland, Finland and Greece) that show a negative growth and which places below the EU average.

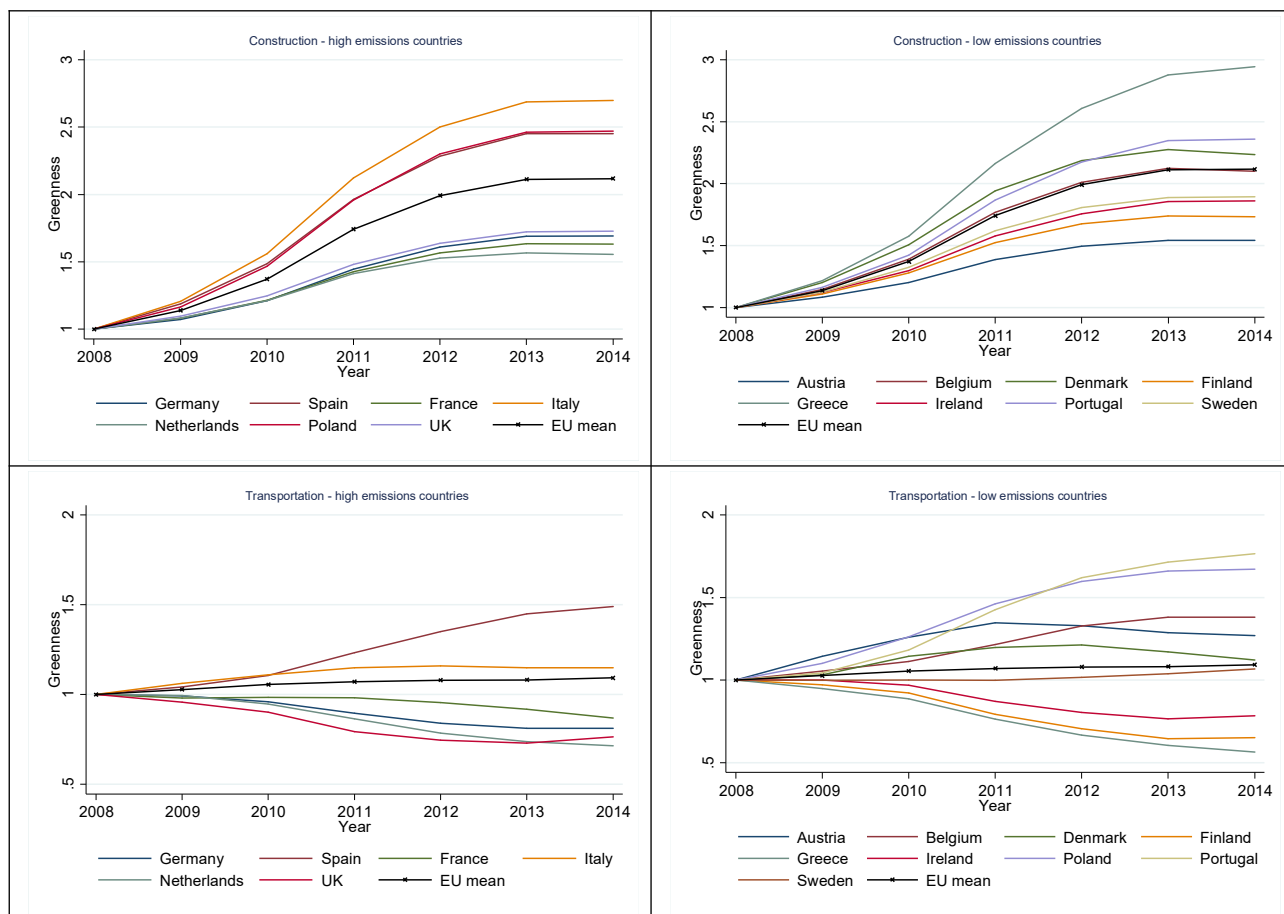
Table 5 – Greenness by NACE

Country	Agriculture, Fishing & Hunting	Manufacture	Utilities	Construction	Transport & Warehousing	Avg. by country	(std.dev)
Austria	0.0001	0.0645	0.0555	0.0700	0.0223	0.0555	0.0151
Belgium	0.0004	0.0493	0.0575	0.0883	0.0270	0.0517	0.0107
Germany	0.0157	0.0479	0.0515	0.0599	0.0236	0.0456	0.0130
Denmark	0.0000	0.0601	0.0851	0.0930	0.0188	0.0546	0.0122
Spain	0.0109	0.0586	0.0947	0.0877	0.0217	0.0573	0.0105
Finland	0.0154	0.0616	0.0910	0.0900	0.0192	0.0585	0.0121
France	0.0123	0.0558	0.0875	0.0764	0.0317	0.0545	0.0103
Greece	0.0001	0.0401	0.0690	0.0986	0.0117	0.0328	0.0059
Ireland	0.0027	0.0580	0.0581	0.0761	0.0288	0.0530	0.0180
Italy	0.0030	0.0393	0.0520	0.0905	0.0251	0.0426	0.0089
Netherlands	0.0177	0.0592	0.0690	0.0846	0.0251	0.0547	0.0114
Poland	0.0091	0.0574	0.0691	0.0997	0.0342	0.0608	0.0117
Portugal	0.0038	0.0359	0.0851	0.0947	0.0194	0.0431	0.0076
Sweden	0.0151	0.0627	0.0859	0.0879	0.0292	0.0604	0.0111
United Kingdom	0.0132	0.0735	0.0636	0.0951	0.0291	0.0678	0.0147
EU mean	0.0090	0.0583	0.0740	0.0909	0.0269		
(std.dev)	0.0005	0.0038	0.0041	0.0048	0.0013		

Note: EU mean by sector is computed as a weighted average where weights used are the relative size of a sector in a country over the total value added created in the same sector in the EU economy. Avg. country is computed as a weighted average within the same country where weight used the relative size of a sector over the total value added generated by the five sectors in each country.

Figure 1 – Greenness trend by selected by NACE Rev.2 Sections. 2008-2014, 2008=100. Data Source: Onet 23.1 and EU Labour Force Survey (2014)





Note: Countries are assigned to the left or the right-hand panel of the figure based on their level of emissions compared to the average EU level in the sector. On the left side, countries with higher-than-average emission are depicted; on the right side, countries with lower-than-average emissions are represented. With respect to the Agriculture sector, greenness trend for France and Poland are presented in Figure D1 of Appendix D, as their growth has been significantly higher than those of the other high emission countries.

Table 6 below and Tables D1 to D3 as well as Figure 2 and Figures D2 to D3 in the Appendix describe the importance of green skills (engineering and technical skills, operation management skills, science skills and monitoring skills) and their variations over time by sectors and countries of the EU economy.

In particular, Table 6 and Figure 2 show the importance ratings of engineering and technical skills and their evolution between 2008 and 2014, respectively. For the aggregate EU economy, this first set of skills is most important for Construction (2.631), Manufacturing (2.284), Utilities (2.336) and Agriculture (2.135). The variability of engineering skills importance between countries is slightly higher in the Utilities sectors than in the others; we note that this might be due to a lower relevance of these abilities in the Netherlands, where their importance is well below the EU average (1.867).

Engineering and technical skills in the Construction sectors are the very relevant in low emissions countries such as Finland (2.771), Belgium (2.759) and Greece (2.748), which are the top three countries by importance in the EU in 2014. Moreover, in these countries the trend of the importance rating has been systematically above the EU average growth. Among the higher than average emissions countries, Germany is the one where this indicator increased the most. Overall, the relevance of engineering and technical abilities has been steadily growing since 2008 in all the Member States included in this analysis.

Lower than average emissions countries show the highest 2014 importance indicator also in the manufacturing sector. Specifically, the first three countries are Belgium (2.483), Austria (2.411) and Sweden (2.532). Figure 2 displays that the average engineering and technical skills importance decreased, especially in the last two years of the period. Nevertheless, in both groups of countries the importance shows a steady positive increase, with the only exceptions of France, which starts recovering only since 2012 and of Greece, where importance has a steadily decreasing pattern. The growth has been remarkable for UK, Spain and Poland in the left panel of the plot and for Belgium, Austria and the Netherlands in the right side of the plot.

Engineering skills importance in the Utility sector in 2014 was highest for Denmark (2.736), Belgium (2.586) and Ireland (2.532). Its growth has been continually positive on average during the period, as shown in Figure 2. While only a few countries are below the EU average growth (France and Italy among the high emitters and the Netherlands and Denmark among the low emitters), engineering skills became increasingly important in all the other Member States.

Poland and France were among the first countries for the importance of engineering and technical skills in agriculture (with a score of 2.244 and 2.318 respectively). In the trend plots, even though the average EU importance has slightly increased over the considered period, there are a few countries which present severe falls, such as the Netherlands in the left panel and Portugal and Belgium in the right one. In this latter group of countries, Sweden is the one that increased its importance the most.

Finally, the importance of these skills for the Transportation sector is the highest in Germany, Belgium and Austria (1.863, 1.899 and 1.84 respectively). We notice that, with respect to the other sectors included in this analysis, these skills are on average less relevant for this sector. Nevertheless, in Figure 2 we appreciate an overall positive increase of this set of skills, both from the single country perspective and for the EU average trend one. We note that a few countries (Italy, UK and Netherlands in the left panel and Finland in the right one) show slightly worse performances with respect to the others and are also below the EU average.

Similarly to the analysis of skills importance by occupation, the relevance operation management and monitoring skills extend to all sectors even though there are industries where their importance is key. Operation management skills importance (Table D1) scores the highest in Utility (2.541) and Construction (2.477). In Figure D3, which displays the trend of their importance in 2008-2014, we note that these sectors relied on operation management skills more and more over time. On the contrary, the importance of operation management skills in Manufacturing and Agriculture has been decreasing over time. This is especially true for Manufacturing, even though we notice that the importance started to increase in most of the Member States in the last three years of the sample period. In the Transportation sector, operation management skills importance has risen especially in countries with a higher than average emission level, such as Germany and France where the growth is outstanding. Among the countries collected in the right panel plot, we notice the case of Ireland, which started to collapse after 2010 and Finland, that show a decreasing trend during the period.

Monitoring skills (Table D2) are especially relevant, in 2014, for Construction (2.613), a sector that also exhibits, on average, an increasing importance of these abilities in Figure D4. Irregular trends are observed only in Belgium, Denmark and Austria in the right panel of the plot. Relatively to the other four sectors, we note that these skills importance is declining, on average for Agriculture, Manufacturing and Transportation. Nevertheless, exceptions are represented by UK,

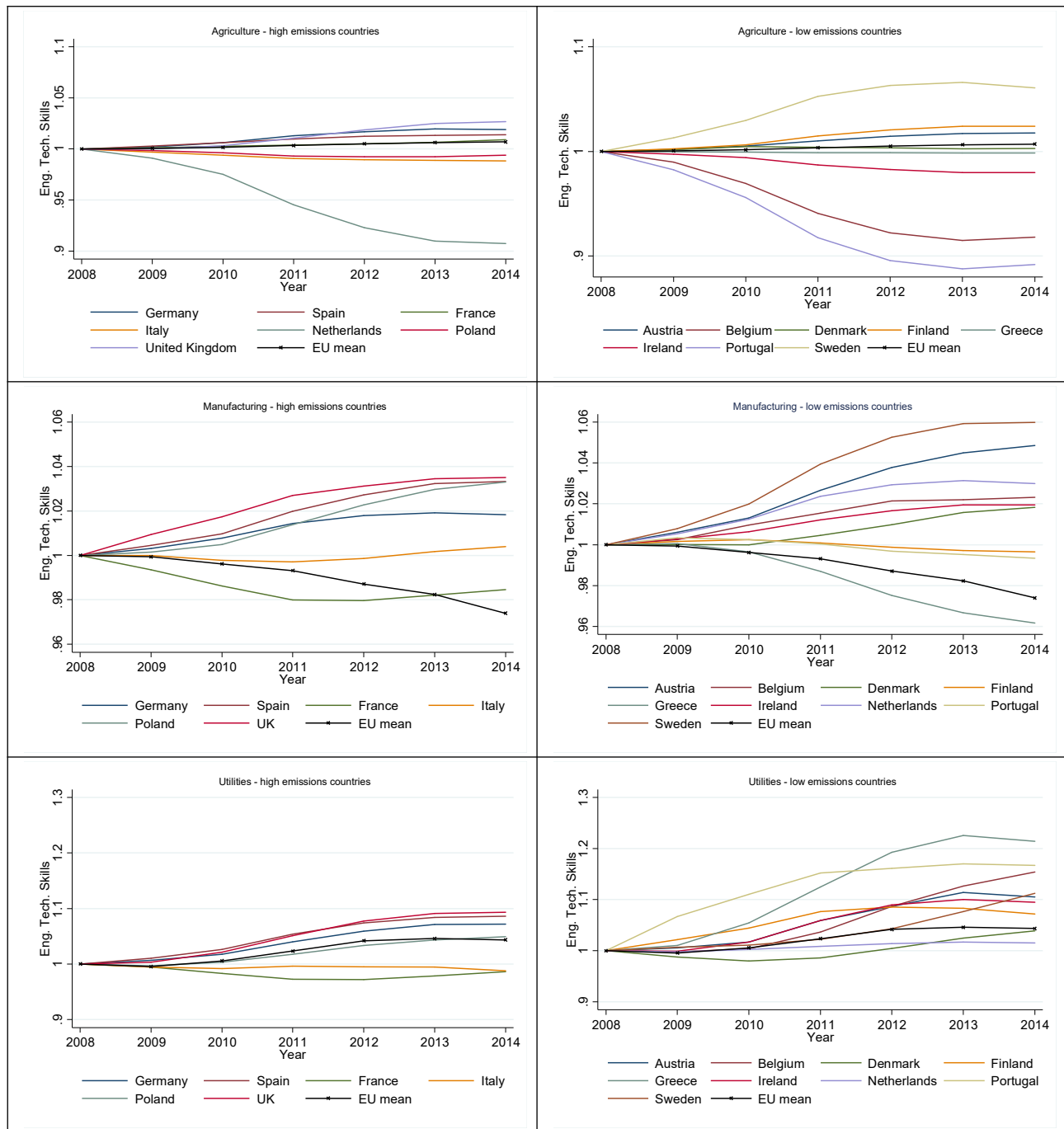
France and Austria where monitoring importance increased in Agriculture, and Spain, UK, Denmark and Poland that show increasing relevance of the skills. In Manufacturing, a negative trend is also present but we notice that monitoring started to become more important between 2013 and 2014.

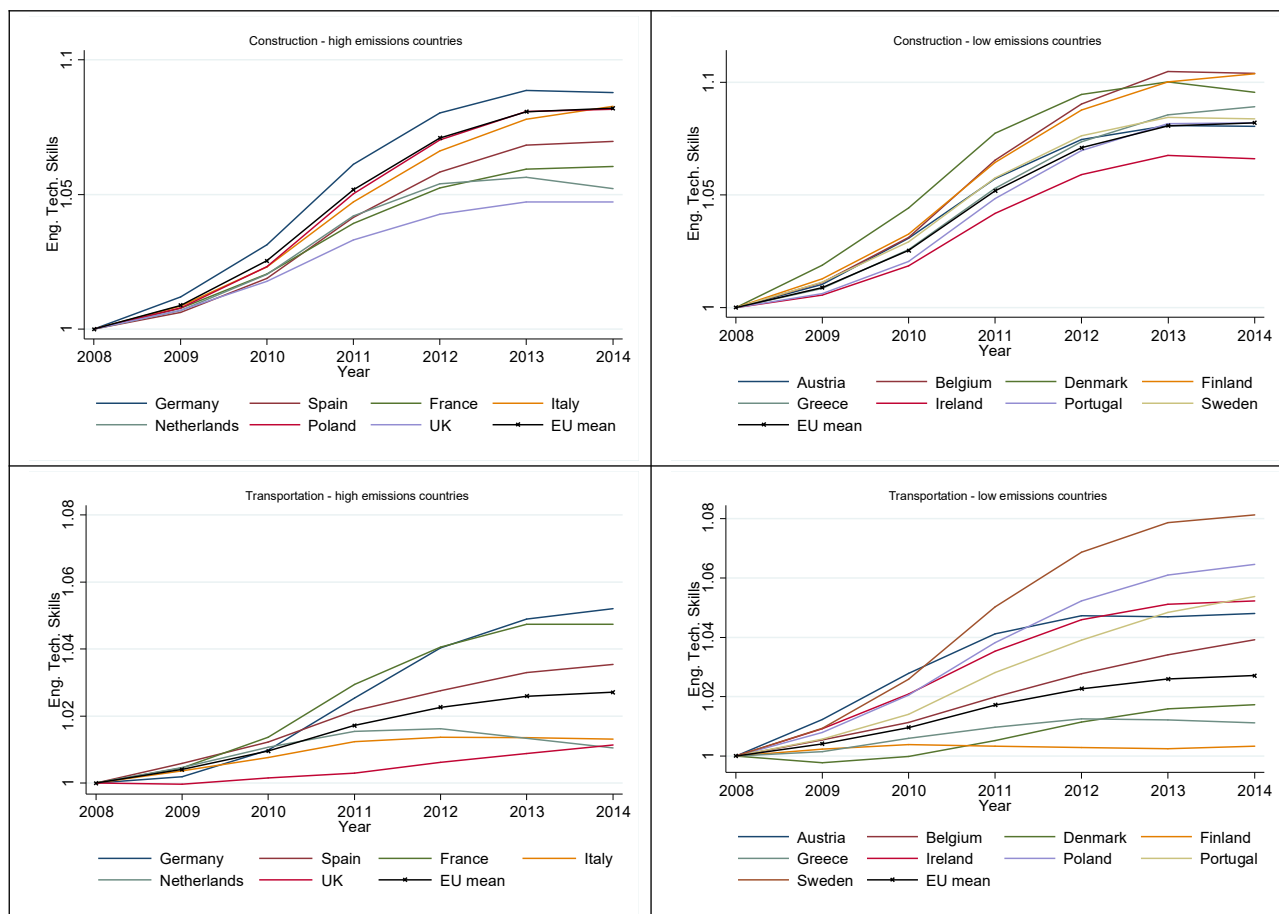
Finally, science skills (Table D3) show an overall lower relevance to the EU economy. In 2014, the higher importance score is computed for Agriculture (1.998), Construction (1.603) and Utilities (1.598). With respect to the trends, science skills importance in Agriculture dropped particularly in the Netherlands, and Portugal (Figure D4) and is negative also for Italy, Poland, Belgium, Ireland and Finland. On the contrary, it rose steadily for the UK and Spain as well as for Denmark and Finland. For what concerns Construction, relevance increased over time with only a few countries showing negative trends: France and the UK among the high emission countries and Finland and Belgium among the lower emission ones. Nevertheless, on average this sector relies more and more on science. Similarly, for Utilities we notice that the major difficulties in integrating science skills are carried by the low emission countries: specifically, Ireland and the Netherlands, that show decreasing trends. Among the high emission countries, France experienced an increase in importance of science skills in the Utility sector. Science skills show a decreasing average trend in Manufacturing sector; however, single countries trends are heterogeneous and we notice that countries in both panels of the plot are above the EU average and show a change to a more positive direction in the last years of the period. The relevance of science for the Transportation sector is on the contrary decreasing both at the aggregate average level and at the Member State level and this trend is common to all countries.

Table 6 - Average engineering and technical skills importance by NACE Rev2 sections. Data Source: Onet 23.1(2017) and European Labour Force Survey (2014)

Country	Agriculture, Fishing & Hunting	Manufactur e	Utilities	Construction	Transport & Warehousing	Accomodation	Avg. by (std.dev)	country
Austria	2.303	2.411	2.422	2.580	1.840	1.597	2.135	(0.356)
Belgium	2.137	2.483	2.586	2.759	1.899	1.597	1.912	(0.815)
Germany	2.048	2.237	2.239	2.578	1.863	1.631	2.141	(0.301)
Denmark	2.039	2.250	2.736	2.720	1.745	1.468	2.162	(0.497)
Spain	1.937	2.294	2.330	2.580	1.769	1.616	2.109	(0.326)
Finland	2.179	2.299	2.468	2.771	1.798	1.415	2.114	(0.418)
France	2.318	2.304	2.300	2.630	1.771	1.550	2.112	(0.334)
Greece	2.318	2.238	2.201	2.748	1.719	1.642	2.131	(0.375)
Ireland	2.219	2.120	2.538	2.492	1.749	1.522	2.085	(0.359)
Italy	1.979	2.276	2.172	2.719	1.794	1.643	2.099	(0.342)
Netherlands	2.104	2.218	1.867	2.546	1.766	1.595	1.966	(0.307)
Poland	2.244	2.337	2.230	2.617	1.818	1.508	2.153	(0.359)
Portugal	1.971	2.323	2.449	2.675	1.806	1.647	2.111	(0.334)
Sweden	2.163	2.374	2.532	2.676	1.796	1.528	2.159	(0.397)
United Kingdom	2.073	2.099	1.968	2.370	1.719	1.589	1.949	(0.232)
EU mean (std.dev)	2.135 (0.128)	2.284 (0.100)	2.336 (0.233)	2.631 (0.111)	1.790 (0.051)	1.570 (0.069)		

Figure 2 – Engineering and Technical Skills by selected by NACE Rev.2 Sections. 2008-2014, 2008=100. Data Source: Onet 23.1(2017) and EU Labour Force Survey (2014)





5. Correlation

Table 7 shows pairwise correlations between greenness and a set of indicators for environmental policy, environmental degradation and innovation. The pairwise correlation highlights if a linear relationship between greenness and each variable of interest is present: the closer the correlation coefficient is to 1, the stronger the linear relation between two variables. A star near the coefficients indicates that the correlation is significant at the 95% level.

Table 7 - Pairwise correlation

Variables	Greenness	Energy prices (all)	Energy prices	EPS	CO2	Patent appl. Stock	Patent applications
Greenness	1.000						
Energy prices (all)	0.057	1.000					
Energy prices	0.126*	1.000*	1.000				
EPS	0.106*	-0.060	0.106	1.000			
CO2	0.146*	0.091	0.165*	0.155*	1.000		
Patent appl. Stock	-0.004	-0.065	0.084	0.291*	0.500*	1.000	
Patent applications	-0.007	-0.081	0.072	0.277*	0.505*	0.988*	1.000

Note: * denotes significant correlation at the 95% level

Overall, we note that the simple correlations of greenness with other variables (first column of Table 7) are low. Nevertheless, in Table 7 the correlation is significant and positive between greenness and energy prices and greenness and EPS as well as between greenness and CO2 emissions.

In Tables 8 to 10 we shed more light on these relationships by computing conditional correlations setting up a simple fixed effect regression which allows also to conditions on unobserved factors that can affect the association.

Table 8 presents the conditional correlations between greenness and the set of policy indicators: columns 1 to 4 show association with energy prices using sector and time fixed effects, while conditional correlation with EPS (columns 5 and 6) are computed at the country level. In fact, while the latter is an indicator designed to capture policy stringency at the country level, energy prices are a better proxy for policy at the sector level. The main idea in Sato et al., (2019) is that energy prices increases as environmental policies become more stringent. As shown in columns 1 to 4, we employ two indicators, Energy prices (all) and Energy prices, which differ for the number of fuels on which the weighted average is computed, as explained in Section 3.

There is a positive association of energy prices with greenness: in column 2, we note that a 1% increase in energy prices is associated with 0.04% increase in greenness. However, when we condition on value added, the coefficient associated with energy prices is no longer significant. Turning to columns 5 and 6, we notice that the EPS indicator shows a positive correlation to greenness, which turns negative if we include countries gross domestic product in the equation. In addition, none of these two relations is significant. Finally, both sectorial value added and country GDP negatively correlates with greenness.

Table 8 - Conditional correlation country-sector FE greenness-policy

	(1) Greenness (sector FE)	(2) Greenness (sector FE)	(3) Greenness (sector FE)	(4) Greenness (sector FE)	(5) Greenness (country FE)	(6) Greenness (country FE)
Energy prices	0.0256 (0.0241)		0.0221 (0.0209)			
Energy prices (all)		0.0381* (0.0188)		0.0239 (0.0215)		
EPS					0.0000297 (0.00242)	-0.00224 (0.00178)
Value added			-0.000254*** (0.0000867)	-0.000220** (0.0000795)		
GDP						-0.0000534** (0.0000181)
Constant	-0.117 (0.156)	-0.202 (0.124)	-0.0721 (0.140)	-0.0889 (0.145)	0.0427*** (0.00630)	0.0928*** (0.0160)
N	286	224	196	168	103	76
R2	0.300	0.413	0.409	0.434	0.424	0.490
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
NACE FE	Yes	Yes	Yes	Yes	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 shows the correlations of greenness with polluting emissions and innovation. We note that, at the sector level, an increase in greenness is associated with a positive change in emissions level, and that the same relation holds also if we include value added in the equation. However, we emphasize that the magnitude and the lack of significance of the coefficient underline that there are factors other than greenness and value added that influence emissions at the sector level. In table 10, which shows the same set of regressions at the country level, we note that at a more aggregate level the relation becomes negative, although not significant.

In Table 9 (columns 2-3 and 5-6), both our technology/knowledge variables are positively correlated with greenness. This means that the greener the jobs, the more it will be necessary to develop new technologies to support the development of green skills and green jobs. This holds also for the stock of knowledge at the country level (Table 10, columns 2-3- and 5-6) while, conversely, greenness negatively relates to patent applications.

Table 9 - Conditional correlations country-sector FE greenness and other variables

	(1) CO2 in trade	(2) Patent Stock	(3) Patents Applications	(4) CO2 in trade	(5) Patent Stock	(6) Patents Applications
Greenness	24.62 (17.64)	537.7 (495.9)	1036.4 (2014.5)	1125.1 (5058.2)	57.21 (39.03)	327.0 (1108.0)
Value added				-6.180 (5.198)	0.0490 (0.0686)	-5.099*** (1.805)
Constant	26.80*** (0.944)	264.5*** (19.88)	1103.0*** (83.68)	2098.3*** (325.9)	37.51*** (3.762)	679.4*** (103.2)
N	869	869	869	525	525	525
R2	0.174	0.0620	0.0386	0.0639	0.239	0.117
NACE FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10 - Conditional correlations (country FE) between greenness and other variables

	(1) CO2 in trade	(2) Patent Stock	(3) Patents Applications	(4) CO2 in trade	(5) Patent Stock	(6) Patents Applications
Greenness	-7.481 (86.51)	5033.5 (5214.7)	-481.1 (21229.2)	-10597.6 (38061.1)	87.44 (128.4)	-1319.4 (6728.1)
GDP				-2.409 (5.186)	0.0416** (0.0157)	-2.393 (1.522)
Constant	25.11*** (3.690)	77.91 (208.4)	1155.8 (799.0)	4056.3 (4721.0)	-0.254 (13.27)	2303.6* (1253.6)
N	175	175	175	98	98	98
R2	0.348	0.0692	0.0394	0.0578	0.550	0.150
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6. Conclusions

This report contributes to the understanding of the evolution of green jobs with a focus on five economic sectors in a sample of fifteen European countries. It does so by providing answers to the following questions: i) To what extent can EU jobs be classified as green? ii) What are the sectors that rely on green jobs the most? In which sectors are abilities and competencies related to green jobs better exploited? iii) How did the greenness of EU jobs change over time? Our main contribution is to develop a taxonomy of green jobs for Europe by matching information on green task content of jobs provided in the US Occupational Information Network (O*NET) with the occupational data in the EU Labour Force Survey (EU-LFS) to overcome the lack of data on greenness of jobs in Europe. We also describe the evolution of the greenness indicator and of the key green skills in different sectors of the EU member countries and provide initial descriptive evidence of whether and how the evolution of the greenness indicator and of green skills correlate with more stringent environmental policies, reduced emissions or higher level of green innovation for the EU.

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Appendix A – Crosswalk SOC 6-digit to ISCO 3-digit

Table A 1 - Crosswalk from 6 digit SOC to 3 digit ISCO. Source: US Bureau of Labour Statistics

SOC digit ⁶	SOC 6 digit title	ISCO digit ³	ISCO 3 digit title	Share
11-2011	Advertising and Promotions Managers	122	Sales, marketing and development managers	1
11-2021	Marketing Managers	122	Sales, marketing and development managers	1
11-2022	Sales Managers	122	Sales, marketing and development managers	1
11-2031	Public Relations and Fundraising Managers	111	Legislators and senior officials	1
11-2031	Public Relations and Fundraising Managers	121	Business services and administration managers	1
11-2031	Public Relations and Fundraising Managers	122	Sales, marketing and development managers	1
11-3011	Administrative Services Managers	121	Business services and administration managers	1
11-3021	Computer and Information Systems Managers	133	Information and communications technology service managers	1
11-3031	Financial Managers	121	Business services and administration managers	1
11-3031	Financial Managers	134	Professional services managers	1
11-3051	Industrial Production Managers	132	Manufacturing, mining, construction, and distribution managers	1
11-3061	Purchasing Managers	121	Business services and administration managers	1
11-3071	Transportation, Storage, and Distribution Managers	132	Manufacturing, mining, construction, and distribution managers	1
11-3111	Compensation and Benefits Managers	121	Business services and administration managers	1
11-3121	Human Resources Managers	121	Business services and administration managers	1
11-3131	Training and Development Managers	121	Business services and administration managers	1
11-9013	Farmers, Ranchers, and Other Agricultural Managers	131	Production managers in agriculture, forestry and fisheries	1
11-9021	Construction Managers	132	Manufacturing, mining, construction, and distribution managers	1
11-9021	Construction Managers	711	Building frame and related trades workers	1
11-9031	Education Administrators, Preschool and Childcare Center/Program	134	Professional services managers	1
11-9032	Education Administrators, Elementary and Secondary School	134	Professional services managers	0.33333 3
11-9033	Education Administrators, Postsecondary	134	Professional services managers	0.2
11-9039	Education Administrators, All Other	134	Professional services managers	0.2
11-9041	Architectural and Engineering Managers	122	Sales, marketing and development managers	0.5
11-9051	Food Service Managers	141	Hotel and restaurant managers	1
11-9061	Funeral Service Managers	121	Business services and administration managers	1
11-9071	Gaming Managers	143	Other services managers	0.2
11-9081	Lodging Managers	141	Hotel and restaurant managers	0.5
11-9111	Medical and Health Services Managers	134	Professional services managers	1
11-9121	Natural Sciences Managers	122	Sales, marketing and development managers	0.33333

					3
11-9131	Postmasters and Mail Superintendents	121	Business services and administration managers	1	
11-9141	Property, Real Estate, and Community Association Managers	333	Business services agents	1	
11-9151	Social and Community Service Managers	134	Professional services managers	1	
11-9161	Emergency Management Directors	111	Legislators and senior officials	0.2	
11-9199	Managers, All Other	111	Legislators and senior officials	0.5	
11-9199	Managers, All Other	121	Business services and administration managers	1	
11-9199	Managers, All Other	132	Manufacturing, mining, construction, and distribution managers	1	
11-9199	Managers, All Other	134	Professional services managers	1	
11-9199	Managers, All Other	143	Other services managers	1	
11-1011	Chief Executives	111	Legislators and senior officials	0.333333	
11-1011	Chief Executives	112	Managing directors and chief executives	1	
11-1021	General and Operations Managers	111	Legislators and senior officials	1	
11-1021	General and Operations Managers	112	Managing directors and chief executives	1	
11-1021	General and Operations Managers	134	Professional services managers	1	
11-1021	General and Operations Managers	142	Retail and wholesale trade managers	1	
11-1021	General and Operations Managers	522	Shop salespersons	0.5	
11-1031	Legislators	111	Legislators and senior officials	1	
13-1011	Agents and Business Managers of Artists, Performers, and Athletes	333	Business services agents	0.2	
13-1021	Buyers and Purchasing Agents, Farm Products	332	Sales and purchasing agents and brokers	1	
13-1022	Wholesale and Retail Buyers, Except Farm Products	332	Sales and purchasing agents and brokers	1	
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	332	Sales and purchasing agents and brokers	0.2	
13-1031	Claims Adjusters, Examiners, and Investigators	331	Financial and mathematical associate professionals	1	
13-1032	Insurance Appraisers, Auto Damage	331	Financial and mathematical associate professionals	1	
13-1041	Compliance Officers	335	Regulatory government associate professionals	1	
13-1051	Cost Estimators	333	Business services agents	1	
13-1071	Human Resources Specialists	242	Administration professionals	1	
13-1071	Human Resources Specialists	333	Business services agents	0.5	
13-1074	Farm Labor Contractors	333	Business services agents	0.2	
13-1075	Labor Relations Specialists	242	Administration professionals	1	
13-1081	Logisticians	242	Administration professionals	1	
13-1111	Management Analysts	242	Administration professionals	1	
13-1121	Meeting, Convention, and Event Planners	333	Business services agents	0.2	
13-1131	Fundraisers	421	Tellers, money collectors and related clerks	0.2	

13-1141	Compensation, Benefits, and Job Analysis Specialists	242	Administration professionals	1
13-1151	Training and Development Specialists	235	Other teaching professionals	1
13-1151	Training and Development Specialists	242	Administration professionals	1
13-1161	Market Research Analysts and Marketing Specialists	243	Sales, marketing and public relations professionals	1
13-1199	Business Operations Specialists, All Other	242	Administration professionals	1
13-1199	Business Operations Specialists, All Other	333	Business services agents	1
13-2011	Accountants and Auditors	241	Finance professionals	0.5
13-2021	Appraisers and Assessors of Real Estate	331	Financial and mathematical associate professionals	1
13-2031	Budget Analysts	241	Finance professionals	1
13-2041	Credit Analysts	241	Finance professionals	1
13-2051	Financial Analysts	241	Finance professionals	1
13-2051	Financial Analysts	241	Finance professionals	1
13-2052	Personal Financial Advisors	241	Finance professionals	1
13-2053	Insurance Underwriters	332	Sales and purchasing agents and brokers	1
13-2061	Financial Examiners	241	Finance professionals	1
13-2071	Credit Counselors	331	Financial and mathematical associate professionals	1
13-2072	Loan Officers	331	Financial and mathematical associate professionals	1
13-2081	Tax Examiners and Collectors, and Revenue Agents	335	Regulatory government associate professionals	1
13-2082	Tax Preparers	241	Finance professionals	1
13-2099	Financial Specialists, All Other	333	Business services agents	1
15-1111	Computer and Information Research Scientists	251	Software and applications developers and analysts	1
15-1121	Computer Systems Analysts	251	Software and applications developers and analysts	1
15-1122	Information Security Analysts	252	Database and network professionals	1
15-1131	Computer Programmers	251	Software and applications developers and analysts	1
15-1132	Software Developers, Applications	251	Software and applications developers and analysts	1
15-1133	Software Developers, Systems Software	251	Software and applications developers and analysts	1
15-1134	Web Developers	251	Software and applications developers and analysts	1
15-1134	Web Developers	351	Information and communications technology operations and user support technicians	1
15-1141	Database Administrators	252	Database and network professionals	1
15-1142	Network and Computer Systems Administrators	252	Database and network professionals	1
15-1142	Network and Computer Systems Administrators	351	Information and communications technology operations and user support technicians	1
15-1143	Computer Network Architects	252	Database and network professionals	1
15-1151	Computer User Support Specialists	351	Information and communications technology operations and user support technicians	1
15-1152	Computer Network Support Specialists	351	Information and communications technology operations and user support technicians	0.5
15-1199	Computer Occupations, All Other	251	Software and applications developers and analysts	1
15-1199	Computer Occupations, All Other	252	Database and network professionals	1

15-2011	Actuaries	212	Mathematicians, actuaries and statisticians	1
15-2021	Mathematicians	212	Mathematicians, actuaries and statisticians	1
15-2031	Operations Research Analysts	212	Mathematicians, actuaries and statisticians	1
15-2041	Statisticians	212	Mathematicians, actuaries and statisticians	1
15-2091	Mathematical Technicians	331	Financial and mathematical associate professionals	1
15-2099	Mathematical Science Occupations, All Other	331	Financial and mathematical associate professionals	1
17-1011	Architects, Except Landscape and Naval	216	Architects, planners, surveyors and designers	1
17-1012	Landscape Architects	216	Architects, planners, surveyors and designers	1
17-1021	Cartographers and Photogrammetrists	216	Architects, planners, surveyors and designers	1
17-1022	Surveyors	216	Architects, planners, surveyors and designers	1
17-2011	Aerospace Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2021	Agricultural Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2031	Biomedical Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2041	Chemical Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2051	Civil Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2061	Computer Hardware Engineers	215	Electrotechnology engineers	1
17-2071	Electrical Engineers	215	Electrotechnology engineers	1
17-2072	Electronics Engineers, Except Computer	215	Electrotechnology engineers	1
17-2072	Electronics Engineers, Except Computer	215	Electrotechnology engineers	1
17-2081	Environmental Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	214	Engineering professionals (excluding electrotechnology)	1
17-2112	Industrial Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2121	Marine Engineers and Naval Architects	214	Engineering professionals (excluding electrotechnology)	1
17-2131	Materials Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2141	Mechanical Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2161	Nuclear Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2171	Petroleum Engineers	214	Engineering professionals (excluding electrotechnology)	1
17-2199	Engineers, All Other	214	Engineering professionals (excluding electrotechnology)	1
17-3011	Architectural and Civil Drafters	311	Physical and engineering science technicians	1
17-3012	Electrical and Electronics Drafters	311	Physical and engineering science technicians	1
17-3013	Mechanical Drafters	311	Physical and engineering science technicians	1
17-3019	Drafters, All Other	311	Physical and engineering science technicians	1

17-3021	Aerospace Engineering and Operations Technicians	311	Physical and engineering science technicians	1
17-3022	Civil Engineering Technicians	311	Physical and engineering science technicians	0.33333 3
17-3023	Electrical and Electronics Engineering Technicians	311	Physical and engineering science technicians	1
17-3023	Electrical and Electronics Engineering Technicians	315	Ship and aircraft controllers and technicians	1
17-3023	Electrical and Electronics Engineering Technicians	352	Telecommunications and broadcasting technicians	0.33333 3
17-3024	Electro-Mechanical Technicians	311	Physical and engineering science technicians	1
17-3025	Environmental Engineering Technicians	311	Physical and engineering science technicians	1
17-3026	Industrial Engineering Technicians	311	Physical and engineering science technicians	1
17-3027	Mechanical Engineering Technicians	311	Physical and engineering science technicians	1
17-3029	Engineering Technicians, Except Drafters, All Other	311	Physical and engineering science technicians	1
17-3031	Surveying and Mapping Technicians	311	Physical and engineering science technicians	1
19-1011	Animal Scientists	213	Life science professionals	1
19-1012	Food Scientists and Technologists	213	Life science professionals	1
19-1013	Soil and Plant Scientists	213	Life science professionals	1
19-1021	Biochemists and Biophysicists	213	Life science professionals	1
19-1022	Microbiologists	213	Life science professionals	1
19-1023	Zoologists and Wildlife Biologists	213	Life science professionals	1
19-1029	Biological Scientists, All Other	213	Life science professionals	1
19-1031	Conservation Scientists	213	Life science professionals	1
19-1032	Foresters	213	Life science professionals	1
19-1041	Epidemiologists	213	Life science professionals	1
19-1042	Medical Scientists, Except Epidemiologists	213	Life science professionals	1
19-1099	Life Scientists, All Other	213	Life science professionals	1
19-2011	Astronomers	211	Physical and earth science professionals	1
19-2012	Physicists	211	Physical and earth science professionals	1
19-2021	Atmospheric and Space Scientists	211	Physical and earth science professionals	1
19-2031	Chemists	211	Physical and earth science professionals	1
19-2032	Materials Scientists	211	Physical and earth science professionals	1
19-2032	Materials Scientists	214	Engineering professionals (excluding electrotechnology)	1
19-2041	Environmental Scientists and Specialists, Including Health	213	Life science professionals	1
19-2042	Geoscientists, Except Hydrologists and Geographers	211	Physical and earth science professionals	1
19-2043	Hydrologist	211	Physical and earth science professionals	1
19-2099	Physical Scientists, All Other	211	Physical and earth science professionals	1
19-3011	Economists	263	Social and religious professionals	1
19-3022	Survey Researchers	212	Mathematicians, actuaries and statisticians	1
19-3031	Clinical, Counseling, and School Psychologists	263	Social and religious professionals	1

19-3032	Industrial-Organizational Psychologists	263	Social and religious professionals	1
19-3039	Psychologists, All Other	263	Social and religious professionals	1
19-3041	Sociologists	263	Social and religious professionals	1
19-3051	Urban and Regional Planners	216	Architects, planners, surveyors and designers	1
19-3091	Anthropologists and Archeologists	263	Social and religious professionals	1
19-3092	Geographers	263	Social and religious professionals	1
19-3093	Historians	263	Social and religious professionals	1
19-3094	Political Scientists	263	Social and religious professionals	1
19-3099	Social Scientists and Related Workers, All Other	263	Social and religious professionals	1
19-3099	Social Scientists and Related Workers, All Other	264	Authors, journalists and linguists	1
19-4011	Agricultural and Food Science Technicians	314	Life science technicians and related associate professionals	1
19-4021	Biological Technicians	314	Life science technicians and related associate professionals	1
19-4031	Chemical Technicians	311	Physical and engineering science technicians	1
19-4041	Geological and Petroleum Technicians	311	Physical and engineering science technicians	1
19-4051	Nuclear Technicians	311	Physical and engineering science technicians	1
19-4061	Social Science Research Assistants	331	Financial and mathematical associate professionals	1
19-4091	Environmental Science and Protection Technicians, Including Health	314	Life science technicians and related associate professionals	1
19-4092	Forensic Science Technicians	311	Physical and engineering science technicians	1
19-4093	Forest and Conservation Technicians	314	Life science technicians and related associate professionals	1
19-4099	Life, Physical, and Social Science Technicians, All Other	311	Physical and engineering science technicians	1
21-1011	Substance Abuse and Behavioral Disorder Counselors	263	Social and religious professionals	1
21-1012	Educational, Guidance, School, and Vocational Counselors	235	Other teaching professionals	1
21-1012	Educational, Guidance, School, and Vocational Counselors	242	Administration professionals	1
21-1013	Marriage and Family Therapists	263	Social and religious professionals	1
21-1014	Mental Health Counselors	263	Social and religious professionals	1
21-1015	Rehabilitation Counselors	263	Social and religious professionals	1
21-1019	Counselors, All Other	263	Social and religious professionals	1
21-1021	Child, Family, and School Social Workers	263	Social and religious professionals	1
21-1022	Healthcare Social Workers	263	Social and religious professionals	1
21-1023	Mental Health and Substance Abuse Social Workers	263	Social and religious professionals	1
21-1029	Social Workers, All Other	263	Social and religious professionals	1
21-1091	Health Educators	226	Other health professionals	1
21-1092	Probation Officers and Correctional Treatment Specialists	263	Social and religious professionals	1
21-1093	Social and Human Service	341	Legal, social and religious associate professionals	1

	Assistants			
21-1094	Community Health Workers	325	Other health associate professionals	1
21-1099	Community and Social Service Specialists, All Other	263	Social and religious professionals	1
21-2011	Clergy	263	Social and religious professionals	1
21-2021	Directors, Religious Activities and Education	263	Social and religious professionals	1
21-2099	Religious Workers, All Other	341	Legal, social and religious associate professionals	1
23-1011	Lawyers	261	Legal professionals	1
23-1012	Judicial Law Clerks	341	Legal, social and religious associate professionals	0.5
23-1021	Administrative Law Judges, Adjudicators, and Hearing Officers	261	Legal professionals	1
23-1022	Arbitrators, Mediators, and Conciliators	261	Legal professionals	1
23-1023	Judges, Magistrate Judges, and Magistrates	261	Legal professionals	1
23-2011	Paralegals and Legal Assistants	341	Legal, social and religious associate professionals	1
23-2091	Court Reporters	334	Administrative and specialised secretaries	0.5
23-2093	Title Examiners, Abstractors, and Searchers	341	Legal, social and religious associate professionals	1
23-2099	Legal Support Workers, All Other	341	Legal, social and religious associate professionals	1
25-1011	Business Teachers, Postsecondary	231	University and higher education teachers	1
25-1021	Computer Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1022	Mathematical Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1031	Architecture Teachers, Postsecondary	231	University and higher education teachers	1
25-1032	Engineering Teachers, Postsecondary	231	University and higher education teachers	1
25-1041	Agricultural Sciences Teachers, Postsecondary	231	University and higher education teachers	1
25-1042	Biological Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1043	Forestry and Conservation Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1051	Atmospheric, Earth, Marine, and Space Sciences Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1052	Chemistry Teachers, Postsecondary	231	University and higher education teachers	1
25-1053	Environmental Science Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1054	Physics Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1061	Anthropology and Archeology Teachers, Postsecondary	231	University and higher education teachers	1
25-1062	Area, Ethnic, and Cultural Studies Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1063	Economics Teachers, Postsecondary	231	University and higher education teachers	1
25-1064	Geography Teachers, Postsecondary	231	University and higher education teachers	1

25-1065	Political Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1066	Psychology Teachers, Postsecondary	231	University and higher education teachers	0.2
25-1067	Sociology Teachers, Postsecondary	231	University and higher education teachers	1
25-1069	Social Sciences Teachers, Postsecondary, All Other	231	University and higher education teachers	1
25-1071	Health Specialties Teachers, Postsecondary	231	University and higher education teachers	1
25-1072	Nursing Instructors and Teachers, Postsecondary	231	University and higher education teachers	1
25-1081	Education Teachers, Postsecondary	231	University and higher education teachers	1
25-1082	Library Science Teachers, Postsecondary	231	University and higher education teachers	1
25-1111	Criminal Justice and Law Enforcement Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1112	Law Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1113	Social Work Teachers, Postsecondary	231	University and higher education teachers	1
25-1121	Art, Drama, and Music Teachers, Postsecondary	231	University and higher education teachers	1
25-1122	Communications Teachers, Postsecondary	231	University and higher education teachers	1
25-1123	English Language and Literature Teachers, Postsecondary	231	University and higher education teachers	1
25-1124	Foreign Language and Literature Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1125	History Teachers, Postsecondary	231	University and higher education teachers	1
25-1126	Philosophy and Religion Teachers, Postsecondary	231	University and higher education teachers	0.5
25-1191	Graduate Teaching Assistants	231	University and higher education teachers	1
25-1192	Home Economics Teachers, Postsecondary	231	University and higher education teachers	1
25-1193	Recreation and Fitness Studies Teachers, Postsecondary	231	University and higher education teachers	1
25-1194	Vocational Education Teachers, Postsecondary	232	Vocational education teachers	1
25-1199	Postsecondary Teachers, All Other	231	University and higher education teachers	1
25-2011	Preschool Teachers, Except Special Education	234	Primary school and early childhood teachers	1
25-2012	Kindergarten Teachers, Except Special Education	234	Primary school and early childhood teachers	1
25-2021	Elementary School Teachers, Except Special Education	234	Primary school and early childhood teachers	1
25-2022	Middle School Teachers, Except Special and Career/Technical Education	234	Primary school and early childhood teachers	1
25-2023	Career/Technical Education Teachers, Middle School	232	Vocational education teachers	1
25-2031	Secondary School Teachers, Except Special and Career/Technical Education	233	Secondary education teachers	1

25-2032	Career/Technical Education Teachers, Secondary School	232	Vocational education teachers	1
25-2051	Special Education Teachers, Preschool	235	Other teaching professionals	1
25-2052	Special Education Teachers, Kindergarten and Elementary School	235	Other teaching professionals	1
25-2053	Special Education Teachers, Middle School	235	Other teaching professionals	1
25-2054	Special Education Teachers, Secondary School	235	Other teaching professionals	1
25-2059	Special Education Teachers, All Other	235	Other teaching professionals	1
25-3011	Adult Basic and Secondary Education and Literacy Teachers and Instructors	235	Other teaching professionals	1
25-3021	Self-Enrichment Education Teachers	235	Other teaching professionals	1
25-3021	Self-Enrichment Education Teachers	342	Sports and fitness workers	1
25-3021	Self-Enrichment Education Teachers	516	Other personal services workers	1
25-3099	Teachers and Instructors, All Other	235	Other teaching professionals	1
25-3099	Teachers and Instructors, All Other	235	Other teaching professionals	1
25-4011	Archivists	262	Librarians, archivists and curators	1
25-4012	Curators	262	Librarians, archivists and curators	1
25-4013	Museum Technicians and Conservators	343	Artistic, cultural and culinary associate professionals	1
25-4021	Librarians	262	Librarians, archivists and curators	1
25-4031	Library Technicians	343	Artistic, cultural and culinary associate professionals	1
25-4031	Library Technicians	441	Other clerical support workers	1
25-9011	Audio-Visual and Multimedia Collections Specialists	262	Librarians, archivists and curators	1
25-9021	Farm and Home Management Advisors	213	Life science professionals	1
25-9031	Instructional Coordinators	235	Other teaching professionals	1
25-9041	Teacher Assistants	531	Child care workers and teachers' aides	1
25-9099	Education, Training, and Library Workers, All Other	235	Other teaching professionals	1
27-1011	Art Directors	265	Creative and performing artists	1
27-1012	Craft Artists	265	Creative and performing artists	1
27-1012	Craft Artists	343	Artistic, cultural and culinary associate professionals	1
27-1012	Craft Artists	731	Handicraft workers	1
27-1013	Fine Artists, Including Painters, Sculptors, and Illustrators	265	Creative and performing artists	1
27-1013	Fine Artists, Including Painters, Sculptors, and Illustrators	311	Physical and engineering science technicians	1
27-1014	Multimedia Artists and Animators	216	Architects, planners, surveyors and designers	1
27-1019	Artists and Related Workers, All Other	343	Artistic, cultural and culinary associate professionals	1
27-1021	Commercial and Industrial Designers	216	Architects, planners, surveyors and designers	1

27-1022	Fashion Designers	216	Architects, planners, surveyors and designers	1
27-1023	Floral Designers	754	Other craft and related workers	1
27-1024	Graphic Designers	216	Architects, planners, surveyors and designers	0.33333 3
27-1025	Interior Designers	343	Artistic, cultural and culinary associate professionals	1
27-1026	Merchandise Displayers and Window Trimmers	343	Artistic, cultural and culinary associate professionals	1
27-1027	Set and Exhibit Designers	343	Artistic, cultural and culinary associate professionals	1
27-1029	Designers, All Other	216	Architects, planners, surveyors and designers	1
27-2011	Actors	265	Creative and performing artists	1
27-2012	Producers and Directors	265	Creative and performing artists	1
27-2021	Athletes and Sports Competitors	342	Sports and fitness workers	1
27-2022	Coaches and Scouts	342	Sports and fitness workers	1
27-2023	Umpires, Referees, and Other Sports Officials	342	Sports and fitness workers	1
27-2031	Dancers	265	Creative and performing artists	1
27-2032	Choreographers	265	Creative and performing artists	1
27-2041	Music Directors and Composers	265	Creative and performing artists	1
27-2042	Musicians and Singers	265	Creative and performing artists	1
27-2099	Entertainers and Performers, Sports and Related Workers, All Other	265	Creative and performing artists	1
27-2099	Entertainers and Performers, Sports and Related Workers, All Other	343	Artistic, cultural and culinary associate professionals	1
27-2099	Entertainers and Performers, Sports and Related Workers, All Other	516	Other personal services workers	0.33333 3
27-3011	Radio and Television Announcers	265	Creative and performing artists	1
27-3012	Public Address System and Other Announcers	265	Creative and performing artists	1
27-3021	Broadcast News Analysts	265	Creative and performing artists	1
27-3022	Reporters and Correspondents	264	Authors, journalists and linguists	1
27-3031	Public Relations Specialists	243	Sales, marketing and public relations professionals	1
27-3041	Editors	264	Authors, journalists and linguists	1
27-3042	Technical Writers	264	Authors, journalists and linguists	1
27-3043	Writers and Authors	264	Authors, journalists and linguists	1
27-3043	Writers and Authors	243	Sales, marketing and public relations professionals	1
27-3091	Interpreters and Translators	264	Authors, journalists and linguists	1
27-3099	Media and Communication Workers, All Other	343	Artistic, cultural and culinary associate professionals	1
27-4011	Audio and Video Equipment Technicians	352	Telecommunications and broadcasting technicians	0.5
27-4012	Broadcast Technicians	352	Telecommunications and broadcasting technicians	1
27-4013	Radio Operators	352	Telecommunications and broadcasting technicians	1
27-4014	Sound Technicians Engineering	352	Telecommunications and broadcasting technicians	1
27-4021	Photographers	343	Artistic, cultural and culinary associate professionals	0.5

27-4031	Camera Operators, Television, Video, and Motion Picture	352	Telecommunications and broadcasting technicians	0.5
27-4032	Film and Video Editors	265	Creative and performing artists	1
27-4099	Media and Communication Equipment Workers, All Other	343	Artistic, cultural and culinary associate professionals	1
27-4099	Media and Communication Equipment Workers, All Other	352	Telecommunications and broadcasting technicians	1
29-1011	Chiropractors	226	Other health professionals	1
29-1021	Dentists, General	226	Other health professionals	0.5
29-1022	Oral and Maxillofacial Surgeons	226	Other health professionals	1
29-1023	Orthodontists	226	Other health professionals	1
29-1024	Prosthodontists	226	Other health professionals	0.5
29-1029	Dentists, All Other Specialists	226	Other health professionals	1
29-1031	Dietitians and Nutritionists	226	Other health professionals	1
29-1041	Optometrists	226	Other health professionals	1
29-1051	Pharmacists	226	Other health professionals	0.5
29-1061	Anesthesiologists	221	Medical doctors	1
29-1062	Family and General Practitioners	221	Medical doctors	1
29-1063	Internists, General	221	Medical doctors	1
29-1064	Obstetricians and Gynecologists	221	Medical doctors	1
29-1065	Pediatricians, General	221	Medical doctors	0.333333
29-1066	Psychiatrists	221	Medical doctors	1
29-1067	Surgeons	221	Medical doctors	1
29-1069	Physicians and Surgeons, All Other	221	Medical doctors	0.111111
29-1071	Physician Assistants	224	Paramedical practitioners	1
29-1081	Podiatrists	226	Other health professionals	1
29-1122	Occupational Therapists	226	Other health professionals	1
29-1123	Physical Therapists	226	Other health professionals	1
29-1124	Radiation Therapists	321	Medical and pharmaceutical technicians	1
29-1125	Recreational Therapists	226	Other health professionals	1
29-1126	Respiratory Therapists	325	Other health associate professionals	1
29-1127	Speech-Language Pathologists	226	Other health professionals	1
29-1128	Exercise Physiologists	226	Other health professionals	1
29-1129	Therapists, All Other	226	Other health professionals	1
29-1131	Veterinarians	225	Veterinarians	1
29-1141	Registered Nurses	222	Nursing and midwifery professionals	1
29-1151	Nurse Anesthetists	222	Nursing and midwifery professionals	1
29-1161	Nurse Midwives	222	Nursing and midwifery professionals	1
29-1171	Nurse Practitioners	222	Nursing and midwifery professionals	1
29-1181	Audiologists	226	Other health professionals	1
29-1199	Health Diagnosing and Treating Practitioners, All Other	223	Traditional and complementary medicine professionals	0.333333
29-1199	Health Diagnosing and Treating Practitioners, All Other	226	Other health professionals	1
29-1199	Health Diagnosing and Treating Practitioners, All Other	325	Other health associate professionals	0.333333

	Treating Practitioners, All Other			3
29-2011	Medical and Clinical Laboratory Technologists	321	Medical and pharmaceutical technicians	0.5
29-2012	Medical and Clinical Laboratory Technicians	321	Medical and pharmaceutical technicians	1
29-2021	Dental Hygienists	325	Other health associate professionals	0.333333
29-2031	Cardiovascular Technologists and Technicians	325	Other health associate professionals	1
29-2032	Diagnostic Medical Sonographers	321	Medical and pharmaceutical technicians	1
29-2033	Nuclear Medicine Technologists	321	Medical and pharmaceutical technicians	0.111111
29-2034	Radiologic Technologists	321	Medical and pharmaceutical technicians	1
29-2035	Magnetic Resonance Imaging Technologists	321	Medical and pharmaceutical technicians	1
29-2041	Emergency Medical Technicians and Paramedics	325	Other health associate professionals	1
29-2051	Dietetic Technicians	325	Other health associate professionals	1
29-2052	Pharmacy Technicians	321	Medical and pharmaceutical technicians	1
29-2053	Psychiatric Technicians	325	Other health associate professionals	1
29-2054	Respiratory Therapy Technicians	325	Other health associate professionals	1
29-2055	Surgical Technologists	325	Other health associate professionals	1
29-2056	Veterinary Technologists and Technicians	324	Veterinary technicians and assistants	0.5
29-2057	Ophthalmic Medical Technicians	325	Other health associate professionals	1
29-2061	Licensed Practical and Licensed Vocational Nurses	322	Nursing and midwifery associate professionals	1
29-2071	Medical Records and Health Information Technicians	325	Other health associate professionals	0.5
29-2081	Opticians, Dispensing	325	Other health associate professionals	1
29-2091	Orthotists and Prosthetists	321	Medical and pharmaceutical technicians	1
29-2092	Hearing Aid Specialists	321	Medical and pharmaceutical technicians	1
29-2099	Health Technologists and Technicians, All Other	325	Other health associate professionals	1
29-9011	Occupational Health and Safety Specialists	226	Other health professionals	1
29-9012	Occupational Health and Safety Technicians	325	Other health associate professionals	1
29-9091	Athletic Trainers	342	Sports and fitness workers	0.333333
29-9092	Genetic Counselors	226	Other health professionals	0.5
29-9099	Healthcare Practitioners and Technical Workers, All Other	322	Nursing and midwifery associate professionals	1
29-9099	Healthcare Practitioners and Technical Workers, All Other	323	Traditional and complementary medicine associate professionals	1
29-9099	Healthcare Practitioners and Technical Workers, All Other	325	Other health associate professionals	1
31-1011	Home Health Aides	532	Personal care workers in health services	0.5
31-1013	Psychiatric Aides	532	Personal care workers in health services	1
31-1014	Nursing Assistants	532	Personal care workers in health services	1
31-1015	Orderlies	532	Personal care workers in health services	1
31-2011	Occupational Therapy	325	Other health associate professionals	1

	Assistants			
31-2012	Occupational Therapy Aides	532	Personal care workers in health services	0.2
31-2021	Physical Therapist Assistants	325	Other health associate professionals	1
31-2022	Physical Therapist Aides	532	Personal care workers in health services	0.5
31-9011	Massage Therapists	325	Other health associate professionals	1
31-9091	Dental Assistants	325	Other health associate professionals	1
31-9091	Dental Assistants	532	Personal care workers in health services	1
31-9092	Medical Assistants	325	Other health associate professionals	1
31-9093	Medical Equipment Preparers	532	Personal care workers in health services	1
31-9094	Medical Transcriptionists	334	Administrative and specialised secretaries	1
31-9095	Pharmacy Aides	532	Personal care workers in health services	1
31-9096	Veterinary Assistants and Laboratory Animal Caretakers	324	Veterinary technicians and assistants	0.5
31-9096	Veterinary Assistants and Laboratory Animal Caretakers	516	Other personal services workers	0.2
31-9097	Phlebotomists	532	Personal care workers in health services	0.5
31-9099	Healthcare Support Workers, All Other	325	Other health associate professionals	1
31-9099	Healthcare Support Workers, All Other	532	Personal care workers in health services	1
33-1011	First-Line Supervisors of Correctional Officers	541	Protective services workers	1
33-1012	First-Line Supervisors of Police and Detectives	335	Regulatory government associate professionals	1
33-1012	First-Line Supervisors of Police and Detectives	541	Protective services workers	0.5
33-1021	First-Line Supervisors of Fire Fighting and Prevention Workers	311	Physical and engineering science technicians	1
33-1021	First-Line Supervisors of Fire Fighting and Prevention Workers	541	Protective services workers	1
33-1099	First-Line Supervisors of Protective Service Workers, All Other	541	Protective services workers	1
33-2011	Firefighters	541	Protective services workers	0.33333 3
33-2021	Fire Inspectors and Investigators	311	Physical and engineering science technicians	1
33-2022	Forest Fire Inspectors and Prevention Specialists	311	Physical and engineering science technicians	1
33-3011	Bailiffs	341	Legal, social and religious associate professionals	0.5
33-3012	Correctional Officers and Jailers	541	Protective services workers	0.2
33-3021	Detectives and Criminal Investigators	335	Regulatory government associate professionals	0.5
33-3031	Fish and Game Wardens	541	Protective services workers	0.5
33-3041	Parking Enforcement Workers	541	Protective services workers	1
33-3051	Police and Sheriff's Patrol Officers	335	Regulatory government associate professionals	1
33-3051	Police and Sheriff's Patrol Officers	541	Protective services workers	1
33-3052	Transit and Railroad Police	541	Protective services workers	0.5
33-9011	Animal Control Workers	541	Protective services workers	1
33-9021	Private Detectives and	341	Legal, social and religious associate professionals	1

	Investigators			
33-9031	Gaming Surveillance Officers and Gaming Investigators	341	Legal, social and religious associate professionals	1
33-9031	Gaming Surveillance Officers and Gaming Investigators	541	Protective services workers	1
33-9032	Security Guards	541	Protective services workers	1
33-9091	Crossing Guards	541	Protective services workers	1
33-9092	Lifeguards, Ski Patrol, and Other Recreational Protective Service Workers	541	Protective services workers	0.5
33-9093	Transportation Security Screeners	541	Protective services workers	1
33-9099	Protective Service Workers, All Other	541	Protective services workers	1
35-1011	Chefs and Head Cooks	343	Artistic, cultural and culinary associate professionals	1
35-1012	First-Line Supervisors of Food Preparation and Serving Workers	343	Artistic, cultural and culinary associate professionals	0.5
35-1012	First-Line Supervisors of Food Preparation and Serving Workers	512	Cooks	1
35-2011	Cooks, Fast Food	941	Food preparation assistants	1
35-2012	Cooks, Institution and Cafeteria	512	Cooks	0.5
35-2013	Cooks, Private Household	512	Cooks	1
35-2014	Cooks, Restaurant	512	Cooks	1
35-2015	Cooks, Short Order	512	Cooks	1
35-2015	Cooks, Short Order	941	Food preparation assistants	1
35-2019	Cooks, All Other	512	Cooks	1
35-2021	Food Preparation Workers	941	Food preparation assistants	1
35-3011	Bartenders	513	Waiters and bartenders	1
35-3021	Combined Food Preparation and Serving Workers, Including Fast Food	524	Other sales workers	1
35-3022	Counter Attendants, Cafeteria, Food Concession, and Coffee Shop	524	Other sales workers	0.5
35-3031	Waiters and Waitresses	513	Waiters and bartenders	1
35-3041	Food Servers, Nonrestaurant	521	Street and market salespersons	1
35-3041	Food Servers, Nonrestaurant	513	Waiters and bartenders	0.5
35-9011	Dining Room and Cafeteria Attendants and Bartender Helpers	524	Other sales workers	1
35-9011	Dining Room and Cafeteria Attendants and Bartender Helpers	941	Food preparation assistants	0.142857
35-9021	Dishwashers	941	Food preparation assistants	1
35-9031	Hosts and Hostesses, Restaurant, Lounge, and Coffee Shop	516	Other personal services workers	1
35-9099	Food Preparation and Serving Related Workers, All Other	941	Food preparation assistants	1
37-1011	First-Line Supervisors of Housekeeping and Janitorial Workers	515	Building and housekeeping supervisors	0.333333

37-1012	First-line Supervisor of Landscaping, Lawn Service, and Groundskeeping Workers	611	Market gardeners and crop growers	1
37-1012	First-line Supervisor of Landscaping, Lawn Service, and Groundskeeping Workers	754	Other craft and related workers	0.5
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	515	Building and housekeeping supervisors	1
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	911	Domestic, hotel and office cleaners and helpers	1
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	912	Vehicle, window, laundry and other hand cleaning workers	1
37-2012	Maids and Housekeeping Cleaners	911	Domestic, hotel and office cleaners and helpers	1
37-2019	Building Cleaning Workers, All Other	713	Painters, building structure cleaners and related trades workers	1
37-2019	Building Cleaning Workers, All Other	912	Vehicle, window, laundry and other hand cleaning workers	0.5
37-2021	Pest Control Workers	754	Other craft and related workers	0.5
37-3011	Landscaping and Groundskeeping Workers	921	Agricultural, forestry and fishery labourers	0.5
37-3012	Pesticide Handlers, Sprayers, and Applicators, Vegetation	754	Other craft and related workers	1
37-3013	Tree Trimmers and Pruners	611	Market gardeners and crop growers	1
37-3019	Grounds Maintenance Workers, All Other	921	Agricultural, forestry and fishery labourers	1
37-3019	Grounds Maintenance Workers, All Other	961	Refuse workers	1
37-3019	Grounds Maintenance Workers, All Other	962	Other elementary workers	0.5
39-1011	Gaming Supervisors	421	Tellers, money collectors and related clerks	0.5
39-1012	Slot Supervisors	421	Tellers, money collectors and related clerks	1
39-1021	First-Line Supervisors of Personal Service Workers	342	Sports and fitness workers	1
39-1021	First-Line Supervisors of Personal Service Workers	441	Other clerical support workers	1
39-1021	First-Line Supervisors of Personal Service Workers	511	Travel attendants, conductors and guides	0.5
39-1021	First-Line Supervisors of Personal Service Workers	514	Hairdressers, beauticians and related workers	1
39-1021	First-Line Supervisors of Personal Service Workers	516	Other personal services workers	0.333333
39-1021	First-Line Supervisors of Personal Service Workers	531	Child care workers and teachers' aides	1
39-1021	First-Line Supervisors of Personal Service Workers	532	Personal care workers in health services	1
39-2011	Animal Trainers	516	Other personal services workers	1
39-2021	Nonfarm Animal Caretakers	516	Other personal services workers	1
39-3011	Gaming Dealers	421	Tellers, money collectors and related clerks	1
39-3012	Gaming and Sports Book Writers and Runners	421	Tellers, money collectors and related clerks	1
39-3019	Gaming Service Workers, All Other	421	Tellers, money collectors and related clerks	1
39-3021	Motion Picture Projectionists	962	Other elementary workers	1

39-3031	Ushers, Lobby Attendants, and Ticket Takers	962	Other elementary workers	1
39-3091	Amusement and Recreation Attendants	834	Mobile plant operators	0.5
39-3091	Amusement and Recreation Attendants	962	Other elementary workers	1
39-3092	Costume Attendants	343	Artistic, cultural and culinary associate professionals	1
39-3093	Locker Room, Coatroom, and Dressing Room Attendants	962	Other elementary workers	1
39-3099	Entertainment Attendants and Related Workers, All Other	343	Artistic, cultural and culinary associate professionals	1
39-4011	Embalmers	516	Other personal services workers	1
39-4021	Funeral Attendants	516	Other personal services workers	1
39-4031	Morticians, Undertakers and Funeral Directors	516	Other personal services workers	1
39-5011	Barbers	514	Hairdressers, beauticians and related workers	0.333333
39-5012	Hairdressers, Hairstylists, and Cosmetologists	514	Hairdressers, beauticians and related workers	1
39-5091	Makeup Artists, Theatrical and Performance	514	Hairdressers, beauticians and related workers	1
39-5092	Manicurists and Pedicurists	514	Hairdressers, beauticians and related workers	1
39-5093	Shampooers	514	Hairdressers, beauticians and related workers	1
39-5094	Skincare Specialists	514	Hairdressers, beauticians and related workers	1
39-6011	Baggage Porters and Bellhops	962	Other elementary workers	0.5
39-6012	Concierges	422	Client information workers	1
39-7011	Tour Guides and Escorts	511	Travel attendants, conductors and guides	1
39-7012	Travel Guides	511	Travel attendants, conductors and guides	0.2
39-9011	Childcare Workers	531	Child care workers and teachers' aides	0.5
39-9021	Personal Care Aides	532	Personal care workers in health services	1
39-9021	Personal Care Aides	441	Other clerical support workers	1
39-9021	Personal Care Aides	516	Other personal services workers	1
39-9031	Fitness Trainers and Aerobics Instructors	342	Sports and fitness workers	1
39-9032	Recreation Workers	516	Other personal services workers	0.5
39-9041	Residential Advisors	516	Other personal services workers	1
39-9099	Personal Care and Service Workers, All Other	516	Other personal services workers	1
39-9099	Personal Care and Service Workers, All Other	951	Street and related service workers	1
39-9099	Personal Care and Service Workers, All Other	515	Building and housekeeping supervisors	1
41-1011	First-Line Supervisors of Retail Sales Workers	522	Shop salespersons	1
41-1012	First-Line Supervisors of Non-Retail Sales Workers	243	Sales, marketing and public relations professionals	1
41-1012	First-Line Supervisors of Non-Retail Sales Workers	331	Financial and mathematical associate professionals	1
41-1012	First-Line Supervisors of Non-Retail Sales Workers	332	Sales and purchasing agents and brokers	1
41-1012	First-Line Supervisors of Non-Retail Sales Workers	333	Business services agents	0.5
41-1012	First-Line Supervisors of Non-Retail Sales Workers	422	Client information workers	0.5

41-2011	Cashiers	523	Cashiers and ticket clerks	1
41-2012	Gaming Change Persons and Booth Cashiers	523	Cashiers and ticket clerks	1
41-2021	Counter and Rental Clerks	524	Other sales workers	0.5
41-2022	Parts Salespersons	522	Shop salespersons	1
41-2031	Retail Salespersons	522	Shop salespersons	1
41-3011	Advertising Sales Agents	333	Business services agents	0.5
41-3021	Insurance Sales Agents	332	Sales and purchasing agents and brokers	1
41-3031	Securities, Commodities, and Financial Services Sales Agents	331	Financial and mathematical associate professionals	1
41-3031	Securities, Commodities, and Financial Services Sales Agents	332	Sales and purchasing agents and brokers	0.5
41-3041	Travel Agents	333	Business services agents	0.25
41-3041	Travel Agents	422	Client information workers	1
41-3099	Energy Brokers	332	Sales and purchasing agents and brokers	0.5
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	243	Sales, marketing and public relations professionals	1
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	332	Sales and purchasing agents and brokers	1
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	332	Sales and purchasing agents and brokers	1
41-9011	Demonstrators and Product Promoters	524	Other sales workers	0.5
41-9012	Models	524	Other sales workers	1
41-9021	Real Estate Brokers	333	Business services agents	1
41-9022	Real Estate Sales Agents	333	Business services agents	0.5
41-9031	Sales Engineers	243	Sales, marketing and public relations professionals	1
41-9041	Telemarketers	524	Other sales workers	1
41-9091	Door-to-Door Sales Workers, News and Street Vendors, and Related Workers	521	Street and market salespersons	0.142857
41-9091	Door-to-Door Sales Workers, News and Street Vendors, and Related Workers	524	Other sales workers	1
41-9091	Door-to-Door Sales Workers, News and Street Vendors, and Related Workers	952	Street vendors (excluding food)	1
41-9099	Sales and Related Workers, All Other	333	Business services agents	0.111111
41-9099	Sales and Related Workers, All Other	421	Tellers, money collectors and related clerks	1
41-9099	Sales and Related Workers, All Other	524	Other sales workers	1
43-1011	First-Line Supervisors of Office and Administrative Support Workers	334	Administrative and specialised secretaries	0.142857
43-2011	Switchboard Operators, Including Answering Service	422	Client information workers	1

43-2021	Telephone Operators	422	Client information workers	1
43-2099	Communications Equipment Operators, All Other	422	Client information workers	1
43-3011	Bill and Account Collectors	421	Tellers, money collectors and related clerks	1
43-3021	Billing and Posting Clerks	431	Numerical clerks	0.5
43-3031	Bookkeeping, Accounting, and Auditing Clerks	331	Financial and mathematical associate professionals	0.5
43-3031	Bookkeeping, Accounting, and Auditing Clerks	431	Numerical clerks	1
43-3041	Gaming Cage Workers	421	Tellers, money collectors and related clerks	1
43-3051	Payroll and Timekeeping Clerks	431	Numerical clerks	1
43-3061	Procurement Clerks	411	General office clerks	1
43-3071	Tellers	421	Tellers, money collectors and related clerks	1
43-3099	Financial Clerks, All Other	421	Tellers, money collectors and related clerks	1
43-3099	Financial Clerks, All Other	431	Numerical clerks	0.142857
43-4011	Brokerage Clerks	431	Numerical clerks	1
43-4021	Correspondence Clerks	422	Client information workers	1
43-4021	Correspondence Clerks	441	Other clerical support workers	1
43-4031	Court, Municipal, and License Clerks	335	Regulatory government associate professionals	1
43-4041	Credit Authorizers, Checkers, and Clerks	431	Numerical clerks	1
43-4051	Customer Service Representatives	422	Client information workers	1
43-4061	Eligibility Interviewers, Government Programs	335	Regulatory government associate professionals	0.5
43-4061	Eligibility Interviewers, Government Programs	422	Client information workers	1
43-4071	File Clerks	441	Other clerical support workers	1
43-4081	Hotel, Motel, and Resort Desk Clerks	422	Client information workers	0.142857
43-4111	Interviewers, Except Eligibility and Loan	422	Client information workers	1
43-4121	Library Assistants, Clerical	441	Other clerical support workers	0.5
43-4131	Loan Interviewers and Clerks	431	Numerical clerks	0.5
43-4141	New Accounts Clerks	431	Numerical clerks	0.5
43-4151	Order Clerks	441	Other clerical support workers	1
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	441	Other clerical support workers	1
43-4171	Receptionists and Information Clerks	422	Client information workers	0.333333
43-4171	Receptionists and Information Clerks	422	Client information workers	1
43-4181	Reservation and Transportation Ticket Agents and Travel Clerks	422	Client information workers	1
43-4199	Information and Record Clerks, All Other	422	Client information workers	0.5
43-4199	Information and Record Clerks, All Other	441	Other clerical support workers	1
43-5011	Cargo and Freight Agents	332	Sales and purchasing agents and brokers	0.333333

43-5011	Cargo and Freight Agents	333	Business services agents	1
43-5021	Couriers and Messengers	441	Other clerical support workers	1
43-5021	Couriers and Messengers	832	Car, van and motorcycle drivers	1
43-5021	Couriers and Messengers	933	Transport and storage labourers	1
43-5021	Couriers and Messengers	962	Other elementary workers	0.2
43-5031	Police, Fire, and Ambulance Dispatchers	541	Protective services workers	1
43-5032	Dispatchers, Except Police, Fire, and Ambulance	432	Material-recording and transport clerks	1
43-5041	Meter Readers, Utilities	962	Other elementary workers	0.33333 3
43-5051	Postal Service Clerks	441	Other clerical support workers	1
43-5051	Postal Service Clerks	421	Tellers, money collectors and related clerks	1
43-5052	Postal Service Mail Carriers	441	Other clerical support workers	0.33333 3
43-5053	Postal Service Mail Sorters, Processors, and Processing Machine Operators	441	Other clerical support workers	1
43-5061	Production, Planning, and Expediting Clerks	432	Material-recording and transport clerks	1
43-5071	Shipping, Receiving, and Traffic Clerks	333	Business services agents	0.11111 1
43-5071	Shipping, Receiving, and Traffic Clerks	432	Material-recording and transport clerks	1
43-5081	Stock Clerks and Order Fillers	432	Material-recording and transport clerks	0.5
43-5081	Stock Clerks and Order Fillers	933	Transport and storage labourers	1
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	432	Material-recording and transport clerks	1
43-6011	Executive Secretaries and Executive Administrative Assistants	334	Administrative and specialised secretaries	1
43-6012	Legal Secretaries	334	Administrative and specialised secretaries	1
43-6013	Medical Secretaries	334	Administrative and specialised secretaries	0.14285 7
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	412	Secretaries (general)	1
43-9011	Computer Operators	351	Information and communications technology operations and user support technicians	0.5
43-9021	Data Entry Keyers	413	Keyboard operators	1
43-9022	Word Processors and Typists	413	Keyboard operators	1
43-9031	Desktop Publishers	732	Printing trades workers	1
43-9041	Insurance Claims and Policy Processing Clerks	431	Numerical clerks	1
43-9051	Mail Clerks and Mail Machine Operators, Except Postal Service	441	Other clerical support workers	1
43-9061	Office Clerks, General	411	General office clerks	1
43-9071	Office Machine Operators, Except Computer	441	Other clerical support workers	1
43-9081	Proofreaders and Copy Markers	441	Other clerical support workers	0.5
43-9111	Statistical Assistants	331	Financial and mathematical associate professionals	1
43-9199	Office and Administrative Support Workers, All Other	441	Other clerical support workers	1

45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	611	Market gardeners and crop growers	0.142857
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	612	Animal producers	1
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	613	Mixed crop and animal producers	0.5
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	621	Forestry and related workers	1
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	622	Fishery workers, hunters and trappers	0.5
45-2011	Agricultural Inspectors	751	Food processing and related trades workers	1
45-2011	Agricultural Inspectors	325	Other health associate professionals	1
45-2011	Agricultural Inspectors	335	Regulatory government associate professionals	1
45-2021	Animal Breeders	612	Animal producers	1
45-2021	Animal Breeders	613	Mixed crop and animal producers	1
45-2021	Animal Breeders	622	Fishery workers, hunters and trappers	1
45-2041	Graders and Sorters, Agricultural Products	751	Food processing and related trades workers	1
45-2041	Graders and Sorters, Agricultural Products	753	Garment and related trades workers	1
45-2091	Agricultural Equipment Operators	611	Market gardeners and crop growers	1
45-2091	Agricultural Equipment Operators	613	Mixed crop and animal producers	1
45-2091	Agricultural Equipment Operators	834	Mobile plant operators	1
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	631	Subsistence crop farmers	0.5
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	633	Subsistence mixed crop and livestock farmers	0.5
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	921	Agricultural, forestry and fishery labourers	1
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	632	Subsistence livestock farmers	1
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	633	Subsistence mixed crop and livestock farmers	0.5
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	921	Agricultural, forestry and fishery labourers	0.2
45-2099	Agricultural Workers, All Other	921	Agricultural, forestry and fishery labourers	0.333333
45-3011	Fishers and Related Fishing Workers	622	Fishery workers, hunters and trappers	0.333333
45-3011	Fishers and Related Fishing Workers	634	Subsistence fishers, hunters, trappers and gatherers	0.2
45-3011	Fishers and Related Fishing Workers	921	Agricultural, forestry and fishery labourers	0.333333
45-3021	Hunters and Trappers	622	Fishery workers, hunters and trappers	0.2
45-3021	Hunters and Trappers	634	Subsistence fishers, hunters, trappers and gatherers	0.333333
45-4011	Forest and Conservation Workers	621	Forestry and related workers	0.5
45-4011	Forest and Conservation Workers	921	Agricultural, forestry and fishery labourers	1

45-4021	Fallers	621	Forestry and related workers	1
45-4022	Logging Equipment Operators	621	Forestry and related workers	1
45-4022	Logging Equipment Operators	834	Mobile plant operators	0.2
45-4023	Log Graders and Scalers	621	Forestry and related workers	1
45-4029	Logging Workers, All Other	621	Forestry and related workers	0.2
45-4029	Logging Workers, All Other	921	Agricultural, forestry and fishery labourers	0.33333 3
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	312	Mining, manufacturing and construction supervisors	0.33333 3
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	312	Mining, manufacturing and construction supervisors	0.5
47-2011	Boilermakers	721	Sheet and structural metal workers, moulders and welders, and related workers	0.33333 3
47-2021	Brickmasons and Blockmasons	711	Building frame and related trades workers	0.33333 3
47-2022	Stonemasons	711	Building frame and related trades workers	0.33333 3
47-2031	Carpenters	711	Building frame and related trades workers	0.33333 3
47-2041	Carpet Installers	712	Building finishers and related trades workers	0.5
47-2042	Floor Layers, Except Carpet, Wood, and Hard Tiles	712	Building finishers and related trades workers	0.33333 3
47-2043	Floor Sanders and Finishers	712	Building finishers and related trades workers	1
47-2044	Tile and Marble Setters	712	Building finishers and related trades workers	1
47-2051	Cement Masons and Concrete Finishers	711	Building frame and related trades workers	1
47-2053	Terrazzo Workers and Finishers	711	Building frame and related trades workers	0.5
47-2061	Construction Laborers	931	Mining and construction labourers	1
47-2071	Paving, Surfacing, and Tamping Equipment Operators	834	Mobile plant operators	0.5
47-2072	Pile-Driver Operators	834	Mobile plant operators	0.5
47-2073	Operating Engineers and Other Construction Equipment Operators	834	Mobile plant operators	1
47-2081	Drywall and Ceiling Tile Installers	712	Building finishers and related trades workers	1
47-2082	Tapers	712	Building finishers and related trades workers	1
47-2111	Electricians	741	Electrical equipment installers and repairers	1
47-2121	Glaziers	712	Building finishers and related trades workers	1
47-2131	Insulation Workers, Floor, Ceiling, and Wall	712	Building finishers and related trades workers	1
47-2132	Insulation Workers, Mechanical	712	Building finishers and related trades workers	1
47-2141	Painters, Construction and Maintenance	713	Painters, building structure cleaners and related trades workers	1
47-2142	Paperhangers	713	Painters, building structure cleaners and related trades workers	1
47-2151	Pipelayers	712	Building finishers and related trades workers	0.2
47-2152	Plumbers, Pipefitters, and Steamfitters	712	Building finishers and related trades workers	1
47-2161	Plasterers and Stucco Masons	712	Building finishers and related trades workers	1
47-2171	Reinforcing Iron and Rebar	721	Sheet and structural metal workers, moulders and	1

	Workers		welders, and related workers	
47-2181	Roofers	712	Building finishers and related trades workers	1
47-2211	Sheet Metal Workers	721	Sheet and structural metal workers, moulders and welders, and related workers	1
47-2221	Structural Iron and Steel Workers	721	Sheet and structural metal workers, moulders and welders, and related workers	1
47-2231	Solar Photovoltaic Installers	711	Building frame and related trades workers	1
47-2231	Solar Photovoltaic Installers	741	Electrical equipment installers and repairers	1
47-3011	Helpers--Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	931	Mining and construction labourers	1
47-3012	Helpers--Carpenters	931	Mining and construction labourers	1
47-3013	Helpers--Electricians	931	Mining and construction labourers	1
47-3014	Helpers--Painters, Paperhangers, Plasterers, and Stucco Masons	931	Mining and construction labourers	1
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	931	Mining and construction labourers	1
47-3016	Helpers--Roofers	931	Mining and construction labourers	1
47-3019	Helpers, Construction Trades, All Other	931	Mining and construction labourers	1
47-4011	Construction and Building Inspectors	311	Physical and engineering science technicians	1
47-4021	Elevator Installers and Repairers	741	Electrical equipment installers and repairers	0.5
47-4031	Fence Erectors	711	Building frame and related trades workers	1
47-4041	Hazardous Materials Removal Workers	711	Building frame and related trades workers	1
47-4051	Highway Maintenance Workers	931	Mining and construction labourers	1
47-4061	Rail-Track Laying and Maintenance Equipment Operators	931	Mining and construction labourers	1
47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	912	Vehicle, window, laundry and other hand cleaning workers	1
47-4091	Segmental Pavers	711	Building frame and related trades workers	1
47-4091	Segmental Pavers	711	Building frame and related trades workers	0.5
47-4099	Construction and Related Workers, All Other	711	Building frame and related trades workers	1
47-5011	Derrick Operators, Oil and Gas	811	Mining and mineral processing plant operators	0.5
47-5012	Rotary Drill Operators, Oil and Gas	811	Mining and mineral processing plant operators	1
47-5013	Service Unit Operators, Oil, Gas, and Mining	811	Mining and mineral processing plant operators	1
47-5021	Earth Drillers, Except Oil and Gas	811	Mining and mineral processing plant operators	1
47-5031	Explosives Workers, Ordnance Handling Experts, and Blasters	754	Other craft and related workers	0.333333
47-5041	Continuous Mining Machine Operators	811	Mining and mineral processing plant operators	0.5
47-5042	Mine Cutting and Channeling Machine Operators	811	Mining and mineral processing plant operators	1
47-5049	Mining Machine Operators, All Other	811	Mining and mineral processing plant operators	1
47-5051	Rock Splitters, Quarry	811	Mining and mineral processing plant operators	1
47-5061	Roof Bolters, Mining	811	Mining and mineral processing plant operators	1

47-5071	Roustabouts, Oil and Gas	811	Mining and mineral processing plant operators	1
47-5081	Helpers--Extraction Workers	931	Mining and construction labourers	0.33333 3
47-5099	Extraction Workers, All Other	931	Mining and construction labourers	1
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	712	Building finishers and related trades workers	0.5
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	723	Machinery mechanics and repairers	0.5
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	731	Handicraft workers	1
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	741	Electrical equipment installers and repairers	1
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	742	Electronics and telecommunications installers and repairers	1
49-2011	Computer, Automated Teller, and Office Machine Repairers	742	Electronics and telecommunications installers and repairers	1
49-2021	Radio, Cellular, and Tower Equipment Installers and Repairs	742	Electronics and telecommunications installers and repairers	1
49-2022	Telecommunications Equipment Installers and Repairers, Except Line Installers	742	Electronics and telecommunications installers and repairers	0.5
49-2091	Avionics Technicians	742	Electronics and telecommunications installers and repairers	0.5
49-2092	Electric Motor, Power Tool, and Related Repairers	741	Electrical equipment installers and repairers	1
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	741	Electrical equipment installers and repairers	1
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	742	Electronics and telecommunications installers and repairers	0.5
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	741	Electrical equipment installers and repairers	1
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	742	Electronics and telecommunications installers and repairers	1
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	741	Electrical equipment installers and repairers	0.5
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	742	Electronics and telecommunications installers and repairers	1
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	741	Electrical equipment installers and repairers	1
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	742	Electronics and telecommunications installers and repairers	1
49-2097	Electronic Home Entertainment Equipment Installers and Repairers	742	Electronics and telecommunications installers and repairers	1
49-2098	Security and Fire Alarm Systems Installers	741	Electrical equipment installers and repairers	1

49-3011	Aircraft Mechanics and Service Technicians	723	Machinery mechanics and repairers	1
49-3021	Automotive Body and Related Repairers	723	Machinery mechanics and repairers	0.2
49-3022	Automotive Glass Installers and Repairers	723	Machinery mechanics and repairers	1
49-3023	Automotive Service Technicians and Mechanics	723	Machinery mechanics and repairers	1
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	723	Machinery mechanics and repairers	1
49-3041	Farm Equipment Mechanics and Service Technicians	723	Machinery mechanics and repairers	1
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	723	Machinery mechanics and repairers	1
49-3043	Rail Car Repairers	723	Machinery mechanics and repairers	1
49-3051	Motorboat Mechanics and Service Technicians	723	Machinery mechanics and repairers	1
49-3052	Motorcycle Mechanics	723	Machinery mechanics and repairers	1
49-3053	Outdoor Power Equipment and Other Small Engine Mechanics	741	Electrical equipment installers and repairers	1
49-3053	Outdoor Power Equipment and Other Small Engine Mechanics	723	Machinery mechanics and repairers	1
49-3091	Bicycle Repairers	723	Machinery mechanics and repairers	1
49-3092	Recreational Vehicle Service Technicians	723	Machinery mechanics and repairers	0.5
49-3093	Tire Repairers and Changers	723	Machinery mechanics and repairers	1
49-9011	Mechanical Door Repairers	741	Electrical equipment installers and repairers	1
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	741	Electrical equipment installers and repairers	1
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	712	Building finishers and related trades workers	0.5
49-9031	Home Appliance Repairers	741	Electrical equipment installers and repairers	1
49-9041	Industrial Machinery Mechanics	723	Machinery mechanics and repairers	0.5
49-9043	Maintenance Workers, Machinery	723	Machinery mechanics and repairers	1
49-9044	Millwrights	723	Machinery mechanics and repairers	0.333333
49-9045	Refractory Materials Repairers, Except Brickmasons	711	Building frame and related trades workers	0.2
49-9045	Refractory Materials Repairers, Except Brickmasons	723	Machinery mechanics and repairers	1
49-9051	Electrical Power-Line Installers and Repairers	741	Electrical equipment installers and repairers	1
49-9052	Telecommunications Line Installers and Repairers	742	Electronics and telecommunications installers and repairers	0.5
49-9061	Camera and Photographic Equipment Repairers	731	Handicraft workers	0.5
49-9062	Medical Equipment Repairers	731	Handicraft workers	1
49-9063	Musical Instrument Repairers and Tuners	731	Handicraft workers	1
49-9064	Watch Repairers	731	Handicraft workers	1
49-9069	Precision Instrument and Equipment Repairers, All Other	731	Handicraft workers	1

49-9071	Maintenance and Repair Workers, General	962	Other elementary workers	1
49-9081	Wind Turbine Service Technicians	723	Machinery mechanics and repairers	1
49-9091	Coin, Vending, and Amusement Machine Servicers and Repairers	962	Other elementary workers	1
49-9092	Commercial Divers	754	Other craft and related workers	0.2
49-9093	Fabric Menders, Except Garment	753	Garment and related trades workers	1
49-9094	Locksmiths and Safe Repairers	722	Blacksmiths, toolmakers and related trades workers	1
49-9095	Manufactured Building and Mobile Home Installers	711	Building frame and related trades workers	1
49-9096	Riggers	721	Sheet and structural metal workers, moulders and welders, and related workers	1
49-9097	Signal and Track Switch Repairers	741	Electrical equipment installers and repairers	0.5
49-9098	Helpers--Installation, Maintenance, and Repair Workers	962	Other elementary workers	1
49-9099	Geothermal Technicians	962	Other elementary workers	0.5
51-1011	First-Line Supervisors of Production and Operating Workers	312	Mining, manufacturing and construction supervisors	1
51-1011	First-Line Supervisors of Production and Operating Workers	313	Process control technicians	0.5
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	821	Assemblers	1
51-2021	Coil Winders, Tapers, and Finishers	821	Assemblers	0.5
51-2022	Electrical and Electronic Equipment Assemblers	821	Assemblers	0.5
51-2023	Electromechanical Equipment Assemblers	821	Assemblers	1
51-2031	Engine and Other Machine Assemblers	821	Assemblers	0.5
51-2041	Structural Metal Fabricators and Fitters	721	Sheet and structural metal workers, moulders and welders, and related workers	1
51-2091	Fiberglass Laminators and Fabricators	814	Rubber, plastic and paper products machine operators	1
51-2092	Team Assemblers	821	Assemblers	1
51-2093	Timing Device Assemblers and Adjusters	821	Assemblers	1
51-2099	Assemblers and Fabricators, All Other	821	Assemblers	0.5
51-3011	Bakers	751	Food processing and related trades workers	0.5
51-3021	Butchers and Meat Cutters	751	Food processing and related trades workers	0.2
51-3022	Meat, Poultry, and Fish Cutters and Trimmers	751	Food processing and related trades workers	0.5
51-3023	Slaughterers and Meat Packers	751	Food processing and related trades workers	1
51-3091	Food and Tobacco Roasting, Baking, and Drying Machine Operators and Tenders	816	Food and related products machine operators	0.5
51-3091	Food and Tobacco Roasting, Baking, and Drying Machine	751	Food processing and related trades workers	0.33333 3

	Operators and Tenders			
51-3092	Food Batchmakers	816	Food and related products machine operators	1
51-3092	Food Batchmakers	751	Food processing and related trades workers	0.5
51-3093	Food Cooking Machine Operators and Tenders	751	Food processing and related trades workers	0.5
51-3093	Food Cooking Machine Operators and Tenders	816	Food and related products machine operators	0.5
51-3099	Food Processing Workers, All Other	751	Food processing and related trades workers	1
51-3099	Food Processing Workers, All Other	816	Food and related products machine operators	1
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	313	Process control technicians	1
51-4012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	812	Metal processing and finishing plant operators	1
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	0.5
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	0.333333
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	812	Metal processing and finishing plant operators	1
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	0.5
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4032	Drilling and Boring Machine	814	Rubber, plastic and paper products machine	1

	Tool Setters, Operators, and Tenders, Metal and Plastic		operators	
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	0.5
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	0.5
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	0.5
51-4041	Machinists	722	Blacksmiths, toolmakers and related trades workers	1
51-4051	Metal-Refining Furnace Operators and Tenders	313	Process control technicians	1
51-4051	Metal-Refining Furnace Operators and Tenders	812	Metal processing and finishing plant operators	1
51-4052	Pourers and Casters, Metal	812	Metal processing and finishing plant operators	1
51-4061	Model Makers, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4062	Patternmakers, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4071	Foundry Mold and Coremakers	721	Sheet and structural metal workers, moulders and welders, and related workers	1
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	721	Sheet and structural metal workers, moulders and welders, and related workers	0.5
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4111	Tool and Die Makers	722	Blacksmiths, toolmakers and related trades workers	1
51-4121	Welders, Cutters, Solderers, and Brazers	721	Sheet and structural metal workers, moulders and welders, and related workers	1
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	721	Sheet and structural metal workers, moulders and welders, and related workers	1
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	812	Metal processing and finishing plant operators	1
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4192	Layout Workers, Metal and	721	Sheet and structural metal workers, moulders and	0.5

	Plastic		welders, and related workers	
51-4192	Layout Workers, Metal and Plastic	722	Blacksmiths, toolmakers and related trades workers	1
51-4193	Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	812	Metal processing and finishing plant operators	1
51-4193	Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-4194	Tool Grinders, Filers, and Sharpeners	722	Blacksmiths, toolmakers and related trades workers	1
51-4199	Metal Workers and Plastic Workers, All Other	722	Blacksmiths, toolmakers and related trades workers	0.33333 3
51-4199	Metal Workers and Plastic Workers, All Other	722	Blacksmiths, toolmakers and related trades workers	1
51-4199	Metal Workers and Plastic Workers, All Other	814	Rubber, plastic and paper products machine operators	1
51-5111	Prepress Technicians and Workers	732	Printing trades workers	1
51-5112	Printing Press Operators	732	Printing trades workers	1
51-5113	Print Binding and Finishing Workers	732	Printing trades workers	0.5
51-6011	Laundry and Dry-Cleaning Workers	815	Textile, fur and leather products machine operators	0.5
51-6021	Pressers, Textile, Garment, and Related Materials	912	Vehicle, window, laundry and other hand cleaning workers	1
51-6031	Sewing Machine Operators	815	Textile, fur and leather products machine operators	0.33333 3
51-6041	Shoe and Leather Workers and Repairers	731	Handicraft workers	0.5
51-6041	Shoe and Leather Workers and Repairers	753	Garment and related trades workers	0.5
51-6042	Shoe Machine Operators and Tenders	815	Textile, fur and leather products machine operators	0.33333 3
51-6051	Sewers, Hand	753	Garment and related trades workers	0.5
51-6052	Tailors, Dressmakers, and Custom Sewers	753	Garment and related trades workers	1
51-6061	Textile Bleaching and Dyeing Machine Operators and Tenders	815	Textile, fur and leather products machine operators	0.5
51-6062	Textile Cutting Machine Setters, Operators, and Tenders	753	Garment and related trades workers	1
51-6063	Textile Knitting and Weaving Machine Setters, Operators, and Tenders	815	Textile, fur and leather products machine operators	0.5
51-6064	Textile Winding, Twisting, and Drawing Out Machine Setters, Operators, and Tenders	815	Textile, fur and leather products machine operators	0.5
51-6091	Extruding and Forming Machine Setters, Operators, and Tenders, Synthetic and Glass Fibers	818	Other stationary plant and machine operators	1
51-6092	Fabric and Apparel Patternmakers	753	Garment and related trades workers	0.5
51-6093	Upholsterers	753	Garment and related trades workers	1
51-6099	Textile, Apparel, and Furnishings Workers, All Other	753	Garment and related trades workers	1
51-6099	Textile, Apparel, and Furnishings Workers, All Other	815	Textile, fur and leather products machine operators	0.5

51-7011	Cabinetmakers and Bench Carpenters	752	Wood treaters, cabinet-makers and related trades workers	1
51-7021	Furniture Finishers	752	Wood treaters, cabinet-makers and related trades workers	1
51-7031	Model Makers, Wood	752	Wood treaters, cabinet-makers and related trades workers	0.33333 3
51-7032	Patternmakers, Wood	752	Wood treaters, cabinet-makers and related trades workers	0.5
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood	817	Wood processing and papermaking plant operators	0.5
51-7042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	752	Wood treaters, cabinet-makers and related trades workers	0.33333 3
51-7099	Woodworkers, All Other	731	Handicraft workers	0.33333 3
51-8011	Nuclear Power Reactor Operators	313	Process control technicians	1
51-8012	Power Distributors and Dispatchers	313	Process control technicians	1
51-8013	Power Plant Operators	313	Process control technicians	1
51-8021	Stationary Engineers and Boiler Operators	818	Other stationary plant and machine operators	0.5
51-8031	Water and Wastewater Treatment Plant and System Operators	313	Process control technicians	1
51-8091	Chemical Plant and System Operators	313	Process control technicians	0.33333 3
51-8092	Gas Plant Operators	313	Process control technicians	0.5
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	313	Process control technicians	0.33333 3
51-8099	Plant and System Operators, All Other	313	Process control technicians	0.5
51-8099	Plant and System Operators, All Other	811	Mining and mineral processing plant operators	0.5
51-9011	Chemical Equipment Operators and Tenders	813	Chemical and photographic products plant and machine operators	1
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	751	Food processing and related trades workers	1
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	813	Chemical and photographic products plant and machine operators	1
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	811	Mining and mineral processing plant operators	1
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	811	Mining and mineral processing plant operators	1
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	814	Rubber, plastic and paper products machine operators	1
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	818	Other stationary plant and machine operators	0.33333 3
51-9022	Grinding and Polishing Workers, Hand	722	Blacksmiths, toolmakers and related trades workers	0.5

51-9022	Grinding and Polishing Workers, Hand	731	Handicraft workers	1
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	811	Mining and mineral processing plant operators	0.5
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	818	Other stationary plant and machine operators	0.5
51-9031	Cutters and Trimmers, Hand	731	Handicraft workers	1
51-9031	Cutters and Trimmers, Hand	753	Garment and related trades workers	1
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	811	Mining and mineral processing plant operators	1
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	814	Rubber, plastic and paper products machine operators	1
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	816	Food and related products machine operators	1
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	818	Other stationary plant and machine operators	1
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	751	Food processing and related trades workers	0.33333 3
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	814	Rubber, plastic and paper products machine operators	0.33333 3
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	752	Wood treaters, cabinet-makers and related trades workers	1
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	818	Other stationary plant and machine operators	0.5
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	754	Other craft and related workers	0.5
51-9071	Jewelers and Precious Stone and Metal Workers	731	Handicraft workers	0.33333 3
51-9081	Dental Laboratory Technicians	321	Medical and pharmaceutical technicians	0.33333 3
51-9082	Medical Appliance Technicians	321	Medical and pharmaceutical technicians	1
51-9083	Ophthalmic Laboratory Technicians	754	Other craft and related workers	1
51-9111	Packaging and Filling Machine Operators and Tenders	818	Other stationary plant and machine operators	1
51-9121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	812	Metal processing and finishing plant operators	0.5
51-9121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	713	Painters, building structure cleaners and related trades workers	1
51-9122	Painters, Transportation Equipment	713	Painters, building structure cleaners and related trades workers	1
51-9123	Painting, Coating, and Decorating Workers	731	Handicraft workers	1
51-9141	Semiconductor Processors	818	Other stationary plant and machine operators	1
51-9151	Photographic Process Workers and Processing Machine Operators	813	Chemical and photographic products plant and machine operators	1
51-9191	Adhesive Bonding Machine Operators and Tenders	752	Wood treaters, cabinet-makers and related trades workers	1
51-9191	Adhesive Bonding Machine Operators and Tenders	814	Rubber, plastic and paper products machine operators	1
51-9191	Adhesive Bonding Machine Operators and Tenders	818	Other stationary plant and machine operators	1

51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	817	Wood processing and papermaking plant operators	1
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	811	Mining and mineral processing plant operators	1
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	812	Metal processing and finishing plant operators	1
51-9193	Cooling and Freezing Equipment Operators and Tenders	816	Food and related products machine operators	0.5
51-9193	Cooling and Freezing Equipment Operators and Tenders	818	Other stationary plant and machine operators	1
51-9194	Etchers and Engravers	731	Handicraft workers	1
51-9194	Etchers and Engravers	821	Assemblers	0.11111 1
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	731	Handicraft workers	1
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	751	Food processing and related trades workers	1
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	818	Other stationary plant and machine operators	1
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	813	Chemical and photographic products plant and machine operators	0.25
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	814	Rubber, plastic and paper products machine operators	1
51-9196	Paper Goods Machine Setters, Operators, and Tenders	817	Wood processing and papermaking plant operators	1
51-9196	Paper Goods Machine Setters, Operators, and Tenders	814	Rubber, plastic and paper products machine operators	1
51-9197	Tire Builders	814	Rubber, plastic and paper products machine operators	0.11111 1
51-9198	Helpers--Production Workers	932	Manufacturing labourers	1
51-9199	Recycling and Remediation Workers	932	Manufacturing labourers	1
53-1011	Aircraft Cargo Handling Supervisors	933	Transport and storage labourers	1
53-1021	First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand	933	Transport and storage labourers	0.5
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	315	Ship and aircraft controllers and technicians	0.11111 1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	325	Other health associate professionals	1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	511	Travel attendants, conductors and guides	1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	524	Other sales workers	1
53-1031	First-Line Supervisors of	831	Locomotive engine drivers and related workers	0.11111

	Transportation and Material-Moving Machine and Vehicle Operators			1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	832	Car, van and motorcycle drivers	0.5
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	833	Heavy truck and bus drivers	1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	834	Mobile plant operators	1
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	961	Refuse workers	0.5
53-2011	Airline Pilots, Copilots, and Flight Engineers	315	Ship and aircraft controllers and technicians	1
53-2012	Commercial Pilots	315	Ship and aircraft controllers and technicians	1
53-2021	Air Traffic Controllers	315	Ship and aircraft controllers and technicians	1
53-2022	Airfield Operations Specialists	315	Ship and aircraft controllers and technicians	0.5
53-2031	Flight Attendants	511	Travel attendants, conductors and guides	0.33333 3
53-3011	Ambulance Drivers and Attendants, Except Emergency Medical Technicians	832	Car, van and motorcycle drivers	1
53-3021	Bus Drivers, Transit and Intercity	833	Heavy truck and bus drivers	1
53-3022	Bus Drivers, School or Special Client	833	Heavy truck and bus drivers	1
53-3031	Driver/Sales Workers	832	Car, van and motorcycle drivers	0.5
53-3032	Heavy and Tractor-Trailer Truck Drivers	833	Heavy truck and bus drivers	0.5
53-3033	Light Truck or Delivery Services Drivers	832	Car, van and motorcycle drivers	1
53-3041	Taxi Drivers and Chauffeurs	832	Car, van and motorcycle drivers	0.5
53-3099	Motor Vehicle Operators, All Other	832	Car, van and motorcycle drivers	1
53-4011	Locomotive Engineers	831	Locomotive engine drivers and related workers	1
53-4012	Locomotive Firers	831	Locomotive engine drivers and related workers	0.5
53-4013	Rail Yard Engineers, Dinkey Operators, and Hostlers	831	Locomotive engine drivers and related workers	1
53-4021	Railroad Brake, Signal, and Switch Operators	831	Locomotive engine drivers and related workers	1
53-4031	Railroad Conductors and Yardmasters	831	Locomotive engine drivers and related workers	1
53-4041	Subway and Streetcar Operators	831	Locomotive engine drivers and related workers	1
53-4041	Subway and Streetcar Operators	833	Heavy truck and bus drivers	0.33333 3
53-4099	Rail Transportation Workers, All Other	831	Locomotive engine drivers and related workers	0.33333 3
53-5011	Sailors and Marine Oilers	835	Ships' deck crews and related workers	0.33333 3
53-5021	Captains, Mates, and Pilots of	315	Ship and aircraft controllers and technicians	0.33333

	Water Vessels			3
53-5022	Motorboat Operators	835	Ships' deck crews and related workers	1
53-5031	Ship Engineers	315	Ship and aircraft controllers and technicians	1
53-6011	Bridge and Lock Tenders	834	Mobile plant operators	1
53-6021	Parking Lot Attendants	962	Other elementary workers	1
53-6031	Automotive and Watercraft Service Attendants	524	Other sales workers	1
53-6041	Traffic Technicians	311	Physical and engineering science technicians	1
53-6051	Transportation Inspectors	325	Other health associate professionals	1
53-6061	Transportation Attendants, Except Flight Attendants	511	Travel attendants, conductors and guides	1
53-6099	Transportation Workers, All Other	933	Transport and storage labourers	1
53-7011	Conveyor Operators and Tenders	818	Other stationary plant and machine operators	1
53-7021	Crane and Tower Operators	834	Mobile plant operators	1
53-7031	Dredge Operators	834	Mobile plant operators	1
53-7032	Excavating and Loading Machine and Dragline Operators	811	Mining and mineral processing plant operators	1
53-7032	Excavating and Loading Machine and Dragline Operators	834	Mobile plant operators	1
53-7033	Loading Machine Operators, Underground Mining	811	Mining and mineral processing plant operators	1
53-7041	Hoist and Winch Operators	834	Mobile plant operators	0.33333 3
53-7051	Industrial Truck and Tractor Operators	834	Mobile plant operators	1
53-7061	Cleaners of Vehicles and Equipment	911	Domestic, hotel and office cleaners and helpers	1
53-7061	Cleaners of Vehicles and Equipment	912	Vehicle, window, laundry and other hand cleaning workers	0.33333 3
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	932	Manufacturing labourers	1
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	933	Transport and storage labourers	0.25
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	962	Other elementary workers	0.5
53-7063	Machine Feeders and Offbearers	932	Manufacturing labourers	1
53-7064	Packers and Packagers, Hand	932	Manufacturing labourers	1
53-7071	Gas Compressor and Gas Pumping Station Operators	313	Process control technicians	1
53-7072	Pump Operators, Except Wellhead Pumpers	313	Process control technicians	1
53-7073	Wellhead Pumpers	811	Mining and mineral processing plant operators	1
53-7081	Refuse and Recyclable Material Collectors	961	Refuse workers	1
53-7111	Mine Shuttle Car Operators	831	Locomotive engine drivers and related workers	1
53-7121	Tank Car, Truck, and Ship Loaders	933	Transport and storage labourers	0.5
53-7199	Material Moving Workers, All Other	933	Transport and storage labourers	1
55-1011	Air Crew Officers	011	Commissioned armed forces officers	0.5
55-1012	Aircraft Launch and Recovery	011	Commissioned armed forces officers	0.5

	Officers					
55-1013	Armored Officers	Assault	Vehicle	011	Commissioned armed forces officers	0.33333 3
55-1014	Artillery and Missile Officers			011	Commissioned armed forces officers	1
55-1015	Command and Control Center Officers			011	Commissioned armed forces officers	0.11111 1
55-1016	Infantry Officers			011	Commissioned armed forces officers	0.33333 3
55-1017	Special Forces Officers			011	Commissioned armed forces officers	1
55-1019	Military Officer Tactical All Other	Special Operations	and Leaders,	011	Commissioned armed forces officers	0.33333 3
55-2011	First-Line Supervisors of Air Crew Members			021	Non-commissioned armed forces officers	0.33333 3
55-2012	First-Line Weapons Specialists/Crew Members	Supervisors of		021	Non-commissioned armed forces officers	0.25
55-2013	First-Line Supervisors of All Other Tactical Operations Specialists			021	Non-commissioned armed forces officers	1
55-3011	Air Crew Members			031	Armed forces occupations, other ranks	1
55-3012	Aircraft Launch and Recovery Specialists			031	Armed forces occupations, other ranks	1
55-3013	Armored Assault Vehicle Crew Members			031	Armed forces occupations, other ranks	1
55-3014	Artillery and Missile Crew Members			031	Armed forces occupations, other ranks	1
55-3015	Command and Control Center Specialists			031	Armed forces occupations, other ranks	1
55-3016	Infantry			031	Armed forces occupations, other ranks	1
55-3017	Radar and Sonar Technicians			031	Armed forces occupations, other ranks	0.5
55-3018	Special Forces			031	Armed forces occupations, other ranks	1
55-3019	Military Operations Specialists and Crew Members, All Other	Enlisted	Tactical Air/Weapons	031	Armed forces occupations, other ranks	1

Appendix B – Green Occupation and Green Skills in the US

Table A 2 - Top 20 occupation by greenness based on O*NET version 23.1 data

SOC Code	Occupation Title	Greenness
17-2081	Environmental Engineers	1
17-3025	Environmental Engineering Technicians	1
19-4091	Environmental Science and Protection Technicians, Including Health	1
41-3099	Energy Brokers	1
47-2231	Solar Photovoltaic Installers	1
47-4041	Hazardous Materials Removal Workers	1
47-4099	Solar and Weatherization Installers and Technicians	1
49-9081	Wind Turbine Service Technicians	1
49-9099	Geothermal Technicians	1
51-8099	Plant and System Operators, All Other	1
51-9199	Recycling and Reclamation Workers	1
53-7081	Refuse and Recyclable Material Collectors	1
19-2041	Environmental Scientists and Specialists, Including Health	0.771
19-1013	Soil and Plant Scientists	0.630
11-9041	Architectural and Engineering Managers	0.575
17-2141	Mechanical Engineers	0.532
17-2011	Aerospace Engineers	0.5
19-2021	Atmospheric and Space Scientists	0.5
19-1031	Conservation Scientists	0.493
19-2042	Geoscientists, Except Hydrologists and Geographers	0.484

Table A 3 - Green skills importance by two-digit SOC macro occupation

SOC	Occupation Title	Greenness	Eng./Tech	Op. Mngnt	Science	Monitoring
11	Management Occupations	0.079	2.239	3.404	1.646	3.297
13	Business and Financial Operations Occupations	0.052	1.865	3.058	1.273	3.481
15	Computer and Mathematical Occupations	0.002	2.391	3.454	1.473	2.709
17	Architecture and Engineering Occupations	0.185	3.487	3.269	2.325	3.023
19	Life, Physical, and Social Science Occupations	0.148	2.356	3.258	2.630	3.178
21	Community and Social Service Occupations	0.000	1.436	3.374	1.352	3.149
23	Legal Occupations	0.006	1.504	3.030	1.118	4.208
25	Education, Training, and Library Occupations	0	1.786	3.130	1.800	2.789
27	Arts, Design, Entertainment, Sports, and Media Occupations	0.011	2.215	2.894	1.487	2.546
29	Healthcare Practitioners and Technical Occupations	0.013	1.884	3.215	2.695	3.254
31	Healthcare Support Occupations	0	1.749	2.713	1.845	3.022

33	Protective Service Occupations	0	2.047	2.920	1.696	3.694
35	Food Preparation and Serving Related Occupations	0	1.838	2.439	1.413	2.584
37	Building and Grounds Cleaning and Maintenance Occupations	0	2.149	2.481	1.894	2.709
39	Personal Care and Service Occupations	0	1.709	2.604	1.494	2.537
41	Sales and Related Occupations	0.072	1.851	2.797	1.278	2.588
43	Office and Administrative Support Occupations	0.003	1.660	2.635	1.220	2.889
45	Farming, Fishing, and Forestry Occupations	0	2.225	2.434	2.015	2.520
47	Construction and Extraction Occupations	0.072	3.102	2.534	1.851	2.796
49	Installation, Maintenance, and Repair Occupations	0.064	3.017	2.889	1.958	2.744
51	Production Occupations	0.045	2.558	2.554	1.665	2.564
53	Transportation and Material Moving Occupations	0.025	2.203	2.469	1.648	2.878

Appendix C – Occupation analysis in the EU

Table A 4 - Distribution of the greenness indicator and of the green skill importance by ISCO 3-digit occupation

ISCO	Occupation Title	Greenness	Eng. Tech.	Op. Man	Science	Monitoring
111	Legislators and senior officials	0.028	2.157	3.482	1.536	3.474
112	Managing directors and chief executives	0.034	2.274	3.763	1.391	3.901
121	Business services and administration managers	0.008	2.083	3.284	1.546	3.360
122	Sales, marketing and development managers	0.202	2.317	3.390	1.802	3.018
131	Production managers in agriculture, forestry and fisheries	0.061	2.877	3.114	2.895	3.215
132	Manufacturing, mining, construction, and distribution managers	0.168	2.602	3.366	1.971	3.500
133	Information and communications technology service managers	0	2.392	3.645	1.310	2.920
134	Professional services managers	0.013	2.000	3.499	1.551	3.549
141	Hotel and restaurant managers	0	1.925	3.070	1.438	2.978
142	Retail and wholesale trade managers	0.118	2.630	3.200	1.655	3.480
143	Other services managers	0.055	2.214	3.281	1.364	3.721
211	Physical and earth science professionals	0.142	2.391	3.353	2.730	3.155
212	Mathematicians, actuaries and statisticians	0	2.416	3.434	1.778	2.829
213	Life science professionals	0.135	2.348	3.382	2.850	3.252
214	Engineering professionals (excluding electrotechnology)	0.198	3.498	3.391	2.476	3.065
215	Electrotechnology engineers	0.136	3.458	3.364	2.301	3.029
216	Architects, planners, surveyors and designers	0.092	2.871	3.163	1.896	2.857
221	Medical doctors	0	1.898	3.612	3.291	3.339
222	Nursing and midwifery professionals	0	1.865	3.271	2.712	3.275
223	Traditional and complementary medicine professionals	0	1.672	2.965	2.595	2.590
224	Paramedical practitioners	0	2.178	3.260	3.050	3.085
225	Veterinarians	0	1.827	3.390	3.285	2.910
226	Other health professionals	0	1.989	3.333	2.868	3.209
231	University and higher education teachers	0	1.902	3.401	2.202	2.953
232	Vocational education teachers	0	2.348	3.287	1.817	3.168
233	Secondary education teachers	0	1.858	3.288	2.120	2.875
234	Primary school and early childhood teachers	0	1.663	3.136	1.894	2.981
235	Other teaching professionals	0.005	1.698	3.248	1.811	3.051
241	Finance professionals	0.068	1.792	3.042	1.230	3.515
242	Administration professionals	0.064	1.832	3.003	1.252	3.235
243	Sales, marketing and public relations professionals	0.069	2.252	3.104	1.425	2.746
251	Software and applications developers and analysts	0.002	2.381	3.533	1.692	2.633
252	Database and network professionals	0.003	2.434	3.423	1.460	2.977
261	Legal professionals	0.013	1.575	3.287	1.339	4.654
262	Librarians, archivists and curators	0	2.045	3.330	1.576	2.734

263	Social and religious professionals	0.003	1.719	3.378	1.735	3.227
264	Authors, journalists and linguists	0.021	2.002	2.923	1.580	2.856
265	Creative and performing artists	0	1.943	2.767	1.372	2.417
311	Physical and engineering science technicians	0.107	3.119	3.086	2.244	3.203
312	Mining, manufacturing and construction supervisors	0	3.369	3.136	1.740	3.028
313	Process control technicians	0.092	2.743	2.916	2.192	3.104
314	Life science technicians and related associate professionals	0.268	2.370	3.153	2.882	3.201
315	Ship and aircraft controllers and technicians	0.006	2.523	3.134	2.051	3.454
321	Medical and pharmaceutical technicians	0	2.209	2.989	2.861	3.097
322	Nursing and midwifery associate professionals	0	1.773	3.251	2.329	3.713
323	Traditional and complementary medicine associate professionals	0	1.850	3.248	2.865	3.720
324	Veterinary technicians and assistants	0	1.792	2.827	2.672	2.780
325	Other health associate professionals	0.024	1.932	3.048	2.315	3.252
331	Financial and mathematical associate professionals	0.002	1.980	3.048	1.401	3.251
332	Sales and purchasing agents and brokers	0.166	1.918	2.986	1.370	3.088
333	Business services agents	0.029	1.865	2.909	1.287	3.036
334	Administrative and specialised secretaries	0	1.384	2.592	1.168	2.970
335	Regulatory government associate professionals	0.008	1.775	2.976	1.507	4.112
341	Legal, social and religious associate professionals	0	1.481	2.855	1.180	3.916
342	Sports and fitness workers	0	1.965	3.065	1.934	2.728
343	Artistic, cultural and culinary associate professionals	0	2.139	2.747	1.485	2.462
351	Information and communications technology operations and user support technicians	0	2.329	3.321	1.247	2.657
352	Telecommunications and broadcasting technicians	0.007	2.379	2.892	1.654	2.716
411	General office clerks	0	1.657	2.404	1.123	2.618
412	Secretaries (general)	0	1.532	2.605	1.100	2.760
413	Keyboard operators	0	1.539	2.479	1.108	3.373
421	Tellers, money collectors and related clerks	0	1.633	2.575	1.172	2.944
422	Client information workers	0	1.542	2.643	1.270	2.725
431	Numerical clerks	0	1.453	2.633	1.088	3.264
432	Material-recording and transport clerks	0.011	2.139	2.832	1.350	2.754
441	Other clerical support workers	0	1.635	2.481	1.208	2.611
511	Travel attendants, conductors and guides	0	1.549	2.385	1.300	2.402
512	Cooks	0	1.876	2.566	1.403	2.668
513	Waiters and bartenders	0	1.737	2.387	1.301	2.658
514	Hairdressers, beauticians and related workers	0	1.719	2.503	1.517	2.303
515	Building and housekeeping supervisors	0	2.073	2.545	1.520	2.607
516	Other personal services workers	0	1.815	2.844	1.844	2.879
521	Street and market salespersons	0	1.675	2.426	1.220	2.358
522	Shop salespersons	0.007	1.885	2.765	1.214	2.525
523	Cashiers and ticket clerks	0	1.627	2.311	1.145	2.718

524	Other sales workers	0	1.733	2.288	1.311	2.244
531	Child care workers and teachers' aides	0	1.432	2.438	1.468	2.356
532	Personal care workers in health services	0	1.769	2.616	1.664	3.040
541	Protective services workers	0	2.010	2.931	1.787	3.771
611	Market gardeners and crop growers	0	2.426	2.575	2.160	2.733
612	Animal producers	0	2.353	2.725	2.533	2.805
613	Mixed crop and animal producers	0	2.327	2.407	2.211	2.276
621	Forestry and related workers	0	2.366	2.455	1.959	2.761
622	Fishery workers, hunters and trappers	0	2.304	2.433	2.260	2.733
631	Subsistence crop farmers	0	1.738	1.885	1.758	1.913
632	Subsistence livestock farmers	0	2.178	2.448	2.085	2.300
633	Subsistence mixed crop and livestock farmers	0	1.958	2.166	1.921	2.106
634	Subsistence fishers, hunters, trappers and gatherers	0	2.272	2.246	2.085	2.688
711	Building frame and related trades workers	0.230	3.151	2.681	1.775	2.867
712	Building finishers and related trades workers	0.053	3.002	2.441	1.692	2.638
713	Painters, building structure cleaners and related trades workers	0	2.479	2.395	1.614	2.717
721	Sheet and structural metal workers, moulders and welders, and related workers	0.025	3.019	2.317	1.676	2.452
722	Blacksmiths, toolmakers and related trades workers	0.005	2.894	2.663	1.711	2.470
723	Machinery mechanics and repairers	0.077	2.955	2.818	1.890	2.673
731	Handicraft workers	0	2.695	2.534	1.681	2.510
732	Printing trades workers	0	2.484	2.843	1.361	2.350
741	Electrical equipment installers and repairers	0.041	3.196	2.956	1.971	2.921
742	Electronics and telecommunications installers and repairers	0	3.010	3.088	1.833	2.744
751	Food processing and related trades workers	0.003	2.183	2.408	1.727	2.652
752	Wood treaters, cabinet-makers and related trades workers	0	2.985	2.389	1.411	2.337
753	Garment and related trades workers	0	2.515	2.360	1.443	2.334
754	Other craft and related workers	0.008	2.486	2.638	2.077	2.726
811	Mining and mineral processing plant operators	0.045	2.655	2.486	1.873	2.837
812	Metal processing and finishing plant operators	0	2.447	2.528	1.796	2.682
813	Chemical and photographic products plant and machine operators	0.009	2.464	2.800	1.750	2.843
814	Rubber, plastic and paper products machine operators	0	2.502	2.532	1.596	2.511
815	Textile, fur and leather products machine operators	0	2.123	2.298	1.496	2.362
816	Food and related products machine operators	0	2.378	2.539	1.650	2.648
817	Wood processing and papermaking plant operators	0	2.344	2.358	1.278	2.205
818	Other stationary plant and machine operators	0	2.465	2.616	1.631	2.711
821	Assemblers	0.018	2.635	2.555	1.548	2.647
831	Locomotive engine drivers and related workers	0	2.122	2.505	1.552	3.182
832	Car, van and motorcycle drivers	0	1.833	2.364	1.428	2.955

833	Heavy truck and bus drivers	0.027	1.920	2.304	1.343	3.047
834	Mobile plant operators	0	2.608	2.441	1.685	2.630
835	Ships' deck crews and related workers	0	2.389	2.600	2.370	2.915
911	Domestic, hotel and office cleaners and helpers	0	1.723	2.075	1.296	2.299
912	Vehicle, window, laundry and other hand cleaning workers	0	2.124	2.175	1.709	2.441
921	Agricultural, forestry and fishery labourers	0	2.249	2.380	2.087	2.625
931	Mining and construction labourers	0.015	3.032	2.488	1.820	2.823
932	Manufacturing labourers	0.231	2.166	2.167	1.528	2.448
933	Transport and storage labourers	0	2.186	2.706	1.615	2.959
941	Food preparation assistants	0	1.901	2.406	1.487	2.584
951	Street and related service workers	0	1.724	2.659	1.472	2.634
952	Street vendors (excluding food)	0	1.857	2.884	1.304	2.610
961	Refuse workers	0.692	2.234	2.442	1.773	2.864
962	Other elementary workers	0.099	2.116	2.332	1.625	2.348

Appendix D – Sector analysis EU

Figure D 1 – Greenness trend in the Agriculture sector. 2008-2014, 2008=100. Data Source: Onet 23.1(2017) and EU Labour Force Survey (2014)

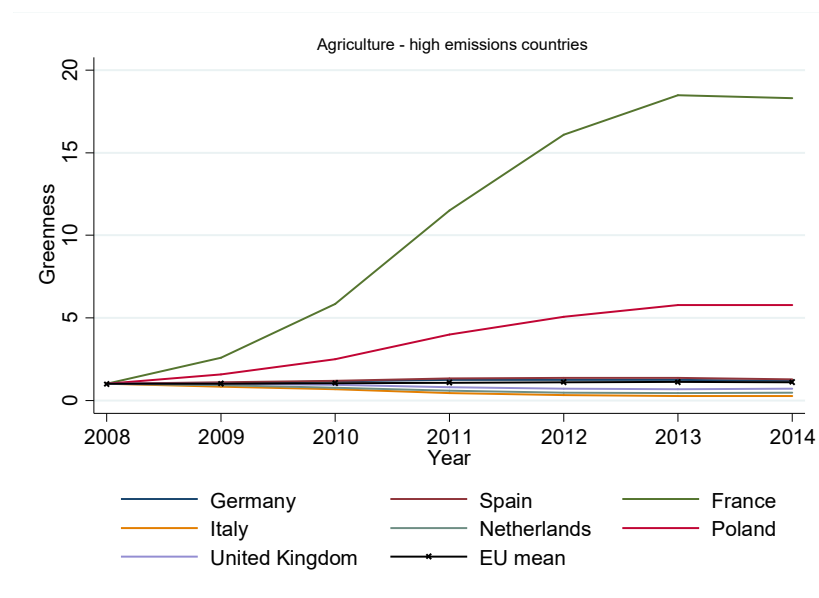


Table D 1 - Average operation management skills importance by NACE Rev2 sections. Data Source: Onet 23.1(2017) and European Labour Force Survey (2014)

Country	Agriculture, Fishing & Hunting	Manufacture	Utilities	Construction	Transport & Warehousing
Austria	2.506	2.482	2.659	2.482	2.294
Belgium	2.322	2.502	2.644	2.573	2.376
Germany	2.266	2.471	2.551	2.530	2.362
Denmark	2.131	2.389	2.806	2.469	2.254
Spain	2.104	2.408	2.498	2.455	2.260
Finland	2.356	2.341	2.526	2.502	2.246
France	2.553	2.459	2.567	2.531	2.252
Greece	2.479	2.320	2.337	2.428	2.224
Ireland	2.301	2.269	2.725	2.338	2.165
Italy	2.127	2.437	2.617	2.523	2.300
Netherlands	2.407	2.409	2.295	2.521	2.297
Poland	2.367	2.388	2.373	2.426	2.250
Portugal	2.127	2.354	2.531	2.453	2.342
Sweden	2.301	2.471	2.676	2.545	2.261
United Kingdom	2.341	2.282	2.311	2.381	2.232
EU mean	2.312	2.399	2.541	2.477	2.274
(std.dev)	(0.143)	(0.073)	(0.156)	(0.065)	(0.056)

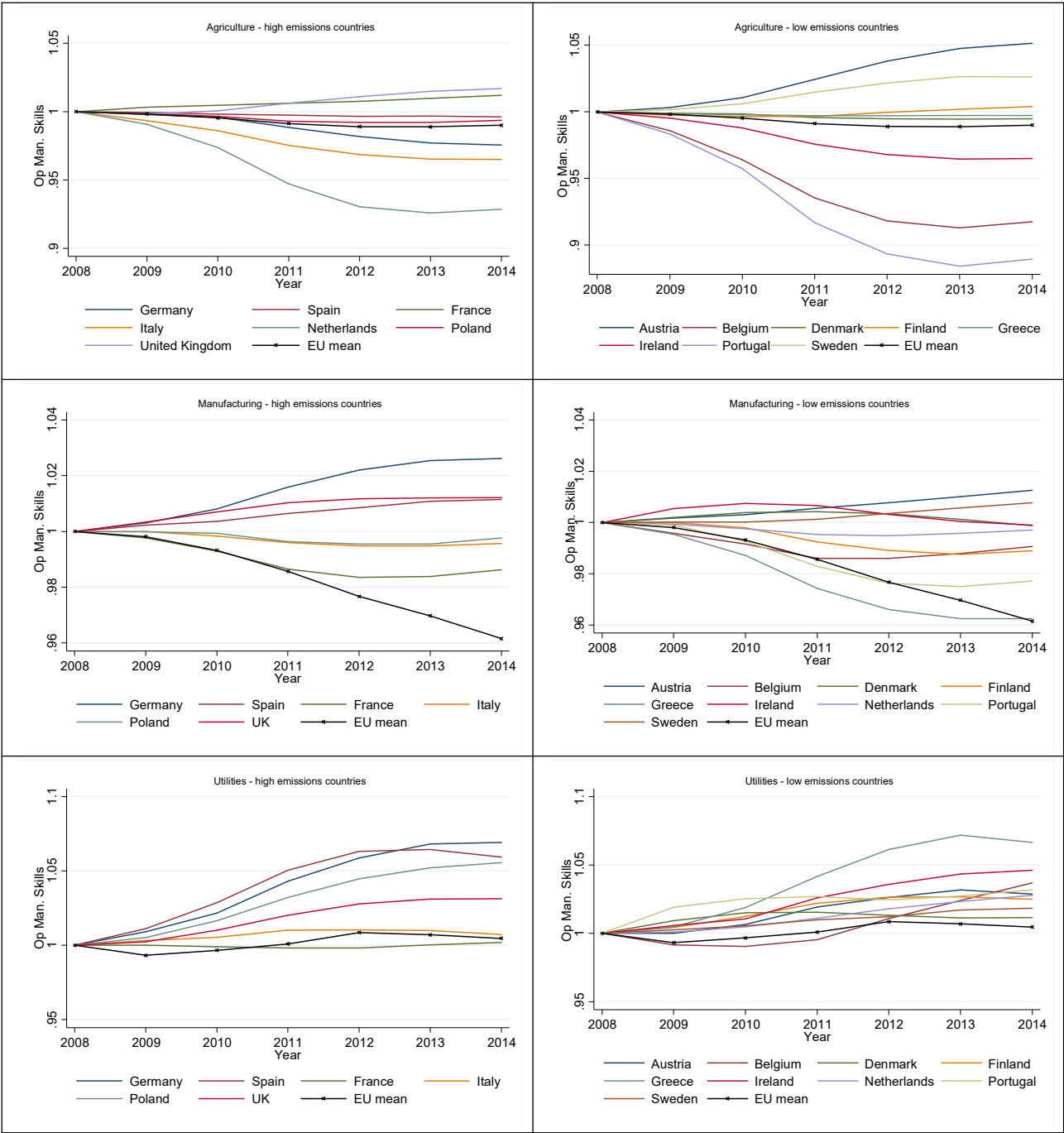
Table D 2 – Science Average science skills importance by NACE Rev2 sections. Data Source: Onet 23.1(2017) and European Labour Force Survey (2014)

<i>Country</i>	Agriculture, Fishing & Hunting	Manufacture	Utilities	Construction	Transport & Warehousing
Austria	2.233	1.580	1.629	1.580	1.301
Belgium	2.084	1.598	1.673	1.638	1.345
Germany	1.862	1.467	1.480	1.555	1.309
Denmark	1.891	1.516	1.918	1.673	1.276
Spain	1.797	1.517	1.625	1.578	1.286
Finland	2.065	1.481	1.724	1.663	1.309
France	2.235	1.522	1.656	1.594	1.258
Greece	2.134	1.477	1.481	1.643	1.280
Ireland	2.091	1.409	1.533	1.524	1.291
Italy	1.807	1.479	1.591	1.647	1.287
Netherlands	1.862	1.468	1.290	1.566	1.289
Poland	2.088	1.493	1.524	1.602	1.297
Portugal	1.884	1.493	1.698	1.632	1.307
Sweden	1.923	1.558	1.820	1.655	1.304
United Kingdom	2.020	1.416	1.333	1.490	1.260
<i>EU mean</i>	1.998	1.498	1.598	1.603	1.293
<i>(std.dev)</i>	(0.147)	(0.053)	(0.167)	(0.054)	(0.022)

Table D 3 - Average monitoring skills importance by NACE Rev2 sections. Data Source: Onet 23.1(2017) and European Labour Force Survey (2014)

<i>Country</i>	Agriculture, Fishing & Hunting	Manufacture	Utilities	Construction	Transport & Warehousing
Austria	2.551	2.507	2.783	2.617	2.573
Belgium	2.350	2.511	2.669	2.731	2.649
Germany	2.287	2.462	2.553	2.628	2.609
Denmark	2.169	2.395	2.912	2.642	2.564
Spain	2.259	2.455	2.494	2.581	2.612
Finland	2.438	2.268	2.525	2.606	2.601
France	2.668	2.474	2.612	2.641	2.541
Greece	2.607	2.381	2.397	2.601	2.638
Ireland	2.227	2.314	2.446	2.489	2.492
Italy	2.262	2.484	2.766	2.682	2.594
Netherlands	2.529	2.411	2.199	2.619	2.579
Poland	2.356	2.424	2.418	2.591	2.605
Portugal	2.185	2.394	2.517	2.598	2.691
Sweden	2.374	2.476	2.747	2.679	2.596
United Kingdom	2.466	2.268	2.258	2.490	2.491
<i>EU mean</i>	2.382	2.415	2.553	2.613	2.589
<i>(std.dev)</i>	(0.156)	(0.080)	(0.199)	(0.064)	(0.054)

Figure D 2 - Trend in Operation Management skills importance by NACE Rev. 2 Section. 2008 – 2014, 2008=100. Data Source: Onet 23.1 and EU Labour Force Survey (2014)



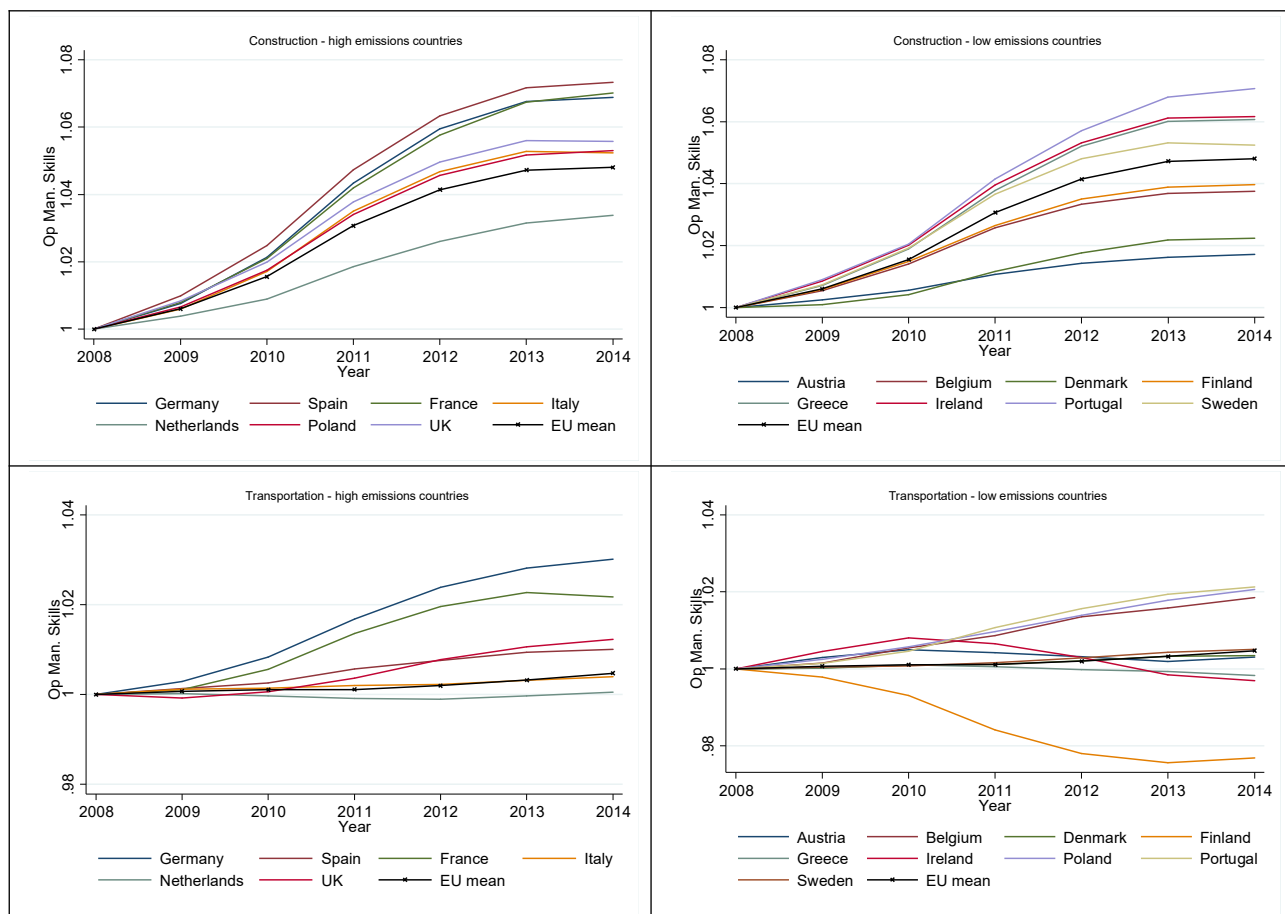
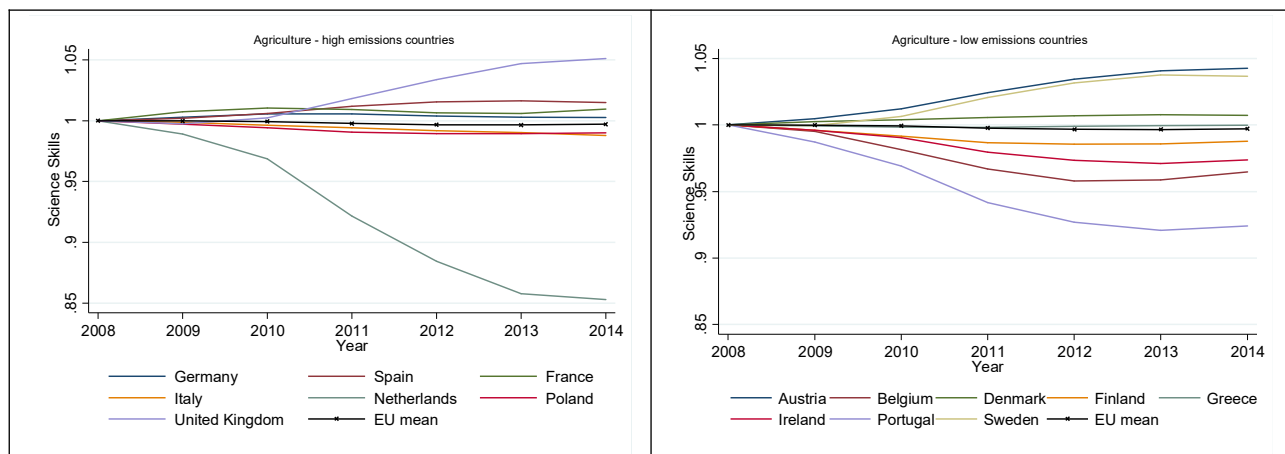


Figure D 3 - Trend in Science skills importance by NACE Rev. 2 Section. 2008 – 2014, 2008=100. Data Source: Onet 23.1 and EU Labour Force Survey (2014)



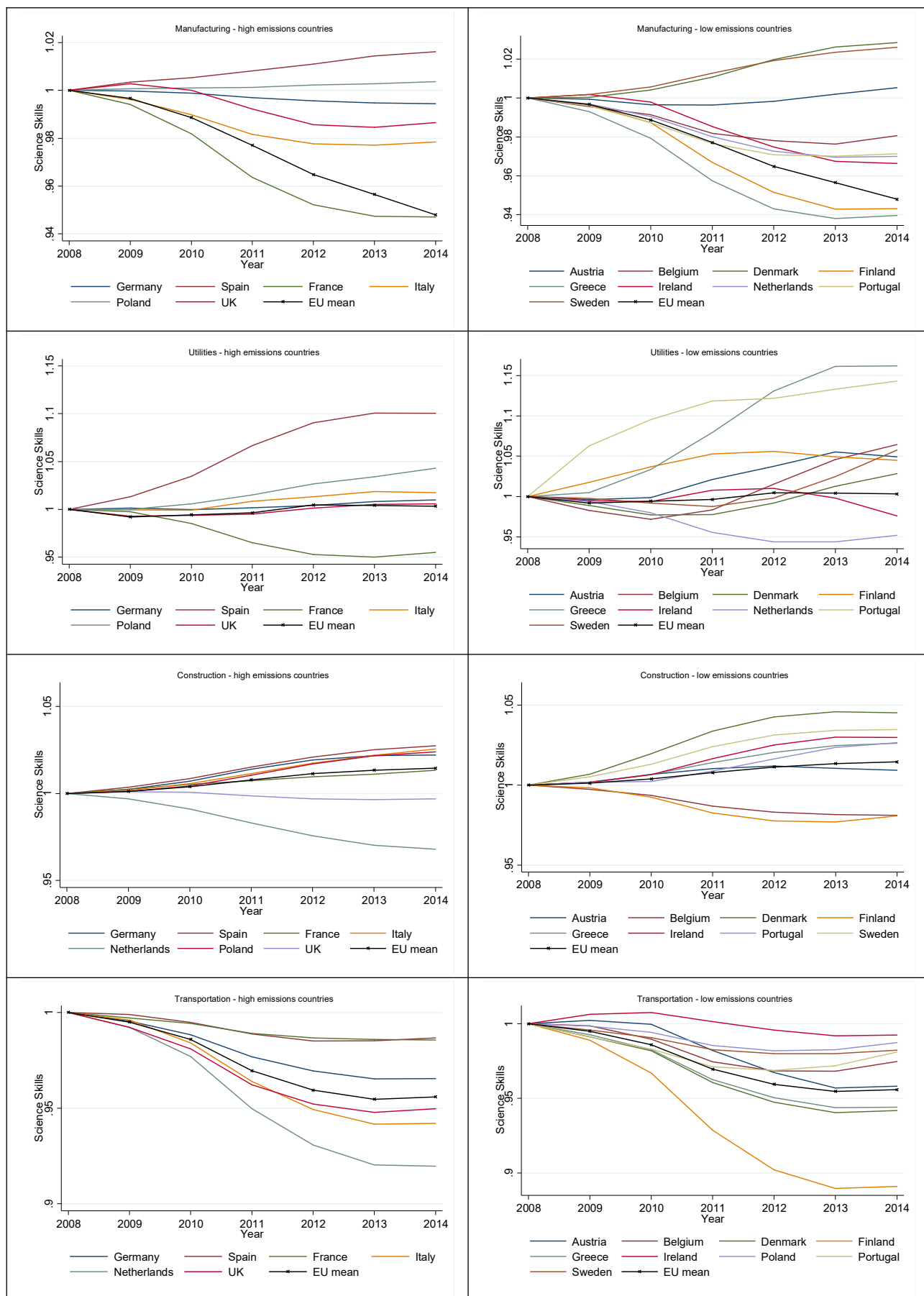


Figure D 4 - Trend in Monitoring skills importance by NACE Rev. 2 Section. 2008 – 2014, 2008=100. Data Source: Onet 23.1 and EU Labour Force Survey (2014)

