The Skill-Content of Green Technologies and Occupations

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This version: 14 July 2014

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Abstract

In the wide spectrum of expected impacts of the transition towards environmentally sustainable economies, those that affect employment are among the most relevant due to their societal importance. We believe that the persistent lack of detailed analyses on the skill content of the jobs created, modified (or destructed) by 'green technological change' is a significant shortcoming of the literature that, ultimately, limits the capacity to define problems and identify possible solutions for the educational and training system.

The present paper seeks to fill this gap by proposing a framework that analyses in detail the task- and skill-content of green occupations. The case of green technologies represents an interesting application for this approach. Not only green technologies are the most direct way to address climate change problems and resource scarcity, but they also involve fundamental changes in the way products are designed, processed and disposed off.

Given the scant of literature on green skills, the main goal of our empirical analysis is to identify the skill profile of green occupation and, as a second step, to explain differences in the skill content using our measure of technology exposure. More in detail, our empirical strategy is designed to compare green and non-green occupations along the four skill dimensions defined above.

Keywords: environmental technology, technological change, jobs, tasks
JEL: O33; Q55; J21

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1 Introduction

In the wide spectrum of expected impacts of the transition towards environmentally sustainable economies, those that affect employment are among the most relevant due to their societal importance. This is due to the opportunities and the threats that job creation, destruction and reconfiguration pose to modern society, especially in turbulent times of crisis. In contrast with the traditional wisdom that environmental protection harms economic growth and job creation, recent evidence suggests that the technological transition towards a greener and low carbon economy engenders opportunities that can exert positive effects on employment (Bazdek et al., 2008). A staple of these studies is that the adoption of environmental innovations is associated with positive employment effects. Further elements emerging from this literature are mostly concerned with the uneven impact of different types of environmental innovation, e.g. end-of-pipe versus cleaner production technologies (e.g. Horbach and Rennings 2013; Licht and Peters, 2013).

We believe that the persistent lack of detailed analyses on the skill content of the jobs created, modified (or destructed) by 'green technological change' is a significant shortcoming of this literature that, ultimately, limits the capacity to define problems and identify possible solutions for the educational and training system.

The present paper seeks to fill this gap by proposing a framework that analyses in detail the task- and skill-content of green occupations. In the framework adopted here skills are individual abilities necessary for performing work and tasks activities in a certain occupation (Autor et al, 2003; Levy and Murnane, 2004). The skill-content of an occupation usually reflects the knowledge mix that is relevant in a particular industrial sector at a specific moment. By the same token, as industry needs change over time, occupations evolve and so do the tasks and the relevant skill mix. The emergence of novel configurations in the skill mix primarily reflects technological changes that redistribute tasks and responsibilities across heterogeneous workers.

2 Our contribution

The case of green technologies represents an interesting application for this approach. Not only green technologies are the most direct way to address climate change problems and resource scarcity, but they also involve fundamental changes in the way products are designed, processed and disposed off. We hence expect the skills required in jobs more exposed to green technologies to differ considerably from the ones in twin jobs not exposed to green technologies.

To test whether skill content of jobs differs depending on the exposure to green technical change, we develop a new and original dataset merging together data on skills and R&D. For the skill part, we rely on the Occupational Information Network (O*NET) electronic database of the U.S. Department of Labour (DOL). O*NET collects information on job characteristics for 900 detailed occupations (8-digit)[1], assigning importance scores to a common set of 98 tasks used at the workplace.

Our first contribution is the characterization of green jobs in terms of their skill contents. In a first step, we compare green occupation with other occupations in terms

[1] Information on number of employees is only available at the 6-digit SOC classification. For that reason, we collapse O*NET measures to the 6-digit level, ending up with 746 occupations.

of classical skill measures (Routine and Non-Routine intensity, offshorability, wage). Then we develop some measures of 'green skills' based on the existing literature and validate it by comparing the intensity of 'green skills' of green occupation with the intensity of other occupation. The O*NET items we identify as 'green skills' are reported in **Tables and figures**

Table 1. In a third step we want to investigate whether green jobs are more exposed to green technological change.

The second contribution consists in investigating the extent to which green technological change is related to our set of skill measures and whether green occupations are affected in a differential way with respect to non-green occupations.

3 Data and methods

O*NET dataset has three main advantages. First, it allows us to distinguish between green and non-green jobs as it includes a list of green occupations (see Dierdorff et al., 2009). Second, the skill content of each occupation is continuously revised over time reflecting task reconfiguration within each occupation. Third, O*NET uses the Standard Occupational Classification (SOC) system and can hence be matched with other sources of occupational information such as the US Bureau of Labor Statistics (BLS). This allowed us to merge O*NET data with BLS employment shares by occupation and 4-digit NAICS sectors. The sectoral dimension is crucial to build our proxies of technology exposure, measured with investments, R&D.

Dierdorff et al. (2009) suggests three different categories of green occupations[2]. Green Increased Demand occupations are the ones for which the green economy is likely to determine an increase in the demand of employment with no significant changes in the skills required for the worker and in the worker context. A second category, that is Green Enhanced Skills occupations, consists in jobs that have been affected substantially by the green economy in their worker requirements and skill content, with no reference to the potential effects of job creation or destruction. Finally, the category labeled as New and Emerging Green occupations groups together those new occupations strictly related to the advent to the green economy. These occupations could be entirely new or born from existing occupations.

We retrieve information on investment (total and in ICT) by NAICS sector for 2009-2010 from US Census data while R&D investment (2008-2010) are made available by the National Science Foundation (NSF). The nice feature of NSF data on R&D is the possibility to identify the amount of R&D related to the improvement of environmental performance and innovation in energy technologies. This is particularly relevant as a measure of the 'green' orientation of NAICS sectors.

As regards our measures of skills, we use specific O*NET items and create skill indicator as the average score of single items. When information about both the level and the importance of a task is reported, we use the importance score (scale 1-5). The non-routine index is given by the ratio between the intensity of non-routine skills and

[2] Green occupations are identifiedy at the 8-digit SOC level of disaggregation. Due to the impossibility to obtain employment figures at that level of aggregation, we identify as green occupations at the 6-digit level those occupations with at least 60 percent of green occupations. This allows

the sum of routine and non-routine intensity. Our classical skill measures are mostly based on Acemoglu and Autor (2010).

Given the scant of literature on green skills, the main goal of our empirical analysis is to identify the skill profile of green occupation and, as a second step, to explain differences in the skill content using our measure of technology exposure.

Our empirical strategy is designed to compare green and non-green occupations. A key aspect of this comparison is to identify the right control group for the comparison. In the first exploratory part, we rely in the classification of green occupation proposed by Dierdorff et al. (2009) and test whether the group of green differs from the group of non-green in any of the skill indicators. Our preferred specification aims at comparing green occupation with similar occupations. We do that by excluding all those 2-digit SOC occupation that do not contain any green occupation and by adding 2-digit SOC dummies, thus exploiting only within – macro-occupation variability.

Second, we use our continuous measure of exposure to green and non-green technology to test whether significant skill differences, if any, are explained by technology exposure. Besides some controls (log of total investment exposure, log of ICT investment exposure, 2-digit SOC dummies and 4-digit SOC-dummies as a robustness check), we include our measures of technology exposure (non-environmental R&D and green R&D), a dummy for green occupations and the interaction between the dummy and technology exposure measures. To reduce unobserved heterogeneity and have a credible comparison group, we excluded those 2-digit SOC occupation (4-digit SOC occupations in the robustness checks) that have no green occupation.

4 Main results

Table 2 reports the distribution of occupations and employees (data from the Bureau of Labor Statistics, BLS) across macro-occupations (2-digit of the SOC classification).

For descriptive purpose, we report weighted averages of our skill indicators (Table 3 for routine skills and offshorability, Table 4 for non-routine skills, Table 5 for green skills) and average exposures to investments and R&D (Table 6) by 2-digit SOC occupation.

4.1 Skill profiling of green occupations

Profiling of green occupations is reported in Table 7, Table 8 and Table 9 for, respectively, aggregate classical skill measures, detailed classical skill measures and green skills. Green occupations are both more intensive in routine and non-routine skills, even though there is no significant difference in the content of non-routine interactive contents. This symmetry makes the synthetic indicator of non-routine intensity not significantly different between green and non-green occupations. No difference is found in terms of offshorability while a wage premium (about 12 percent) is found. When looking at green skills, green occupations are substantially more intensive in Maintenance and Repairing skills, Control skills and Engineering and Design skills, while no difference is found for Managerial and Philosophical skills.

When considering the magnitude[3] (ratio between beta coefficient and average score) as in Table 10, we observe that the strongest characterization of green jobs relates to their intensity of Engineering and Design skills, Maintenance and Repair skills and Control skills.

The differences identified by our statistical analysis are confirmed graphically when plotting the density function of skill measures (Figure 1 for classical skill measures and Figure 2 for green skills).

Finally, in Table 11 we report differences between green and non-green occupations in terms of exposure to green R&D. Green occupations are substantially more exposed to green-specific technological change (R&D in our case) than other occupations, even after controlling for overall exposure to R&D. Results are robust to the exclusion of macro-occupations without green occupations and to the inclusion of detailed macro-occupation dummies.

(to be completed)

4.2 Green technological change and skills content of occupations

As a final step of our analysis, we aim at investigating the relationship between the exposure to green technological change and our set of skill measures. Table 12 and Table 13 report, respectively, results for classical aggregate skill measures, respectively without and with the exposure to ICT investments as additional control (Table 16 and Table 17 report the same specifications of Table 12 and Table 13 when excluding 4-digit SOC without any green occupation and including 4-digit SOC dummies instead of 2-digit SOC dummies). When controlling for ICT; green R&D is positively related to Non-Routine, NR index and wage while no significant differential effect is found for green occupations. When looking at more 'stringent' selection of control occupations as we do in our robustness checks, we lose significance for wage and non-routine but we find a positive relationship with offshorability and a negative relationship with routine skills.

We do the same for green skills in Table 14 and Table 15 (robustness checks in Table 18 and Table 19. The relationship between green R&D exposure and green skills is generally positive and weakly significant in most cases, with the strongest relationship occurring between Engineering and Design skills. Here we observe some differential relationship between green R&D and green skills for green occupations, with a negative differential effect with managerial skills.

Finally, we split our green skill measures into sub-categories of green skills as robustness checks. Results are reported in Table 20 and Table 21.

(to be completed)

5 Conclusions

(to be completed)

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[3] The interpretation of the magnitude of the differences is not straightforward because scores for items in O*NET are of ordinal nature. For that reason, the interpretation of the magnitude of observed differences should be taken with caution.

References

Acemoglu, D., Autor, D. H. (2010) Skills, Tasks and Technologies: Implications for Employment and Earnings, in Card, D., Ashenfelter, O. (eds.) *Handbook of Labor Economics,* Vol. 4B, North Holland Publishing.

Autor, D. H., Levy, F. and R.J. Murnane (2003) "The skill content of recent technological change: An empirical exploration". *Quarterly Journal of Economics* 118 (4), 1279-1333.

Bezdek, R. H., Wendling, R. M., and DiPerna, P. (2008) "Environmental protection, the economy, and jobs: National and regional analyses". *Journal of Environmental Management*, 86 (1), 63-79.

Dierdorff, E.C., Norton, J.J., Drewes, D.W., Kroustalis, C.M., Rivkin, D. and Lewis, P. (2009) *Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations,* The National Center for O*NET Development (http://www.onetcenter.org/dl_files/Green.pdf)

Horbach, J. and Rennings, K. (2013) "Environmental innovation and employment dynamics in different technology fields – an analysis based on the German Community Innovation Survey". *Journal of Cleaner Production*, 57, 158-165.

Levy, F., and R.J. Murnane (2004) *The new division of labor: How computers are creating the next job market*. Princeton University Press.

Lybbert, T. J., and Zolas, N. J. (2013) "Getting patents and economic data to speak to each other: An 'algorithmic links with probabilities' approach for joint analyses of patenting and economic activity". *Research Policy*, 43 (3), 530-542 .

Licht, G., and Peters, B. (2013) "The Impact of Green Innovation on Employment Growth in Europe*"* Working Paper N. 50. WWWforEurope.

Tables and figures

Table 1 – Green skills in O*NET

MAINTENANCE AND REPAIRING	**2.B.3.j**	**Equipment Maintenance**	**4.A.3.b.4**	**Repairing and Maintaining Mechanical Equipment**	**4.A.3.b.5**	**Repairing and Maintaining Electronic Equipment**	2.B.3.d	Installation
CONTROL	**2.B.3.m**	**Quality Control Analysis**	**4.A.1.b.2**	**Inspecting Equipment, Structures, or Material**	1.A.2.b.1	Control Precision	2.B.3.h	Operation and Control
ENGINEERING AND DESIGN	**2.C.3.c**	**Design**	**2.B.3.b**	**Technology Design**	2.A.1.f	Science	2.C.3.b	Engineering and Technology
MANAGERIAL	**4.A.4.a.7**	**Resolving Conflicts and Negotiating with Others**	**2.B.1.d**	**Negotiation**	2.C.1.d	Sales and Marketing	4.A.4.b.6	Provide Consultation and Advice to Others
PHILOSOFICAL	**2.B.1.a**	**Social Perceptiveness**	2.B.4.g	Systems Analysis	2.B.4.h	Systems Evaluation		

Table 2 – Employees (in thousands) in green occupations (SOC 2-digit)

	Total	Green occupations
11 - Management	6158.65 (31)	2988.35 (7)
13 - Business and Financial Operations	5974.95 (30)	982.98 (7)
15 - Computer and Mathematical	2840.54 (16)	387.34 (1)
17 - Architecture and Engineering	2254.27 (34)	1544.3 (16)
19 - Life, Physical, and Social Science	1051.81 (42)	529.13 (16)
21 - Community and Social Service	1647.88 (13)	0 (0)
23 - Legal	954.35 (8)	6.37 (1)
25 - Education, Training, and Library	6967.63 (56)	10.3 (1)
27 - Arts, Design, Entertainment, Sports, and Media	1621.21 (36)	273.77 (3)
29 - Healthcare Practitioners and Technical	5923.53 (54)	67.16 (2)
31 - Healthcare Support	2303.01 (14)	0 (0)
33 - Protective Service	3054.41 (20)	6.76 (1)
35 - Food Preparation and Serving Related	11300 (16)	0 (0)
37 - Building and Grounds Cleaning and Maintenance	4181.71 (8)	0 (0)
39 - Personal Care and Service	3565.41 (30)	0 (0)
41 - Sales and Related	12900 (20)	364.79 (1)
43 - Office and Administrative Support	20800 (52)	1131.34 (3)
45 - Farming, Fishing, and Forestry	399.27 (12)	20.72 (2)
47 - Construction and Extraction	4840.94 (55)	3244.66 (17)
49 - Installation, Maintenance, and Repair	4885.18 (50)	2786.61 (10)
51 - Production	7780.39 (101)	3680.06 (20)
53 - Transportation and Material Moving	8470.48 (48)	4487.63 (7)
Total	119875.58 (746)	22512.24 (115)

Table 3 – Average Routine skills and Offshorability by macro-occupation (SOC 2-digit)

	Routine	R cognitive	R manual	Offshorability
11 - Management	2.57	3.1238	2.0163	3.1115
13 - Business and Financial Operations	2.4741	3.0605	1.8877	3.5261
15 - Computer and Mathematical	2.4393	3.0156	1.8631	3.5354
17 - Architecture and Engineering	2.6728	3.2486	2.097	3.1988
19 - Life, Physical, and Social Science	2.6081	3.0937	2.1226	3.1426
21 - Community and Social Service	2.378	2.8849	1.8711	2.9538
23 - Legal	2.3479	2.9764	1.7194	3.4713
25 - Education, Training, and Library	2.3938	2.7888	1.9988	3.1
27 - Arts, Design, Entertainment, Sports, and Media	2.4511	2.7977	2.1045	3.2769
29 - Healthcare Practitioners and Technical	2.8285	3.1503	2.5067	2.4484
31 - Healthcare Support	2.74	2.8477	2.6323	2.6303
33 - Protective Service	2.7781	2.9561	2.6002	2.5717
35 - Food Preparation and Serving Related	2.6283	2.4148	2.8417	2.8261
37 - Building and Grounds Cleaning and Maintenance	2.7199	2.3828	3.0571	2.7741
39 - Personal Care and Service	2.5664	2.6528	2.4801	2.7648
41 - Sales and Related	2.5572	2.6417	2.4728	2.933
43 - Office and Administrative Support	2.5655	2.9586	2.1725	3.1681
45 - Farming, Fishing, and Forestry	2.6875	2.3622	3.0129	3.0407
47 - Construction and Extraction	3.0686	2.8352	3.3019	2.5842
49 - Installation, Maintenance, and Repair	3.0495	2.9343	3.1646	2.4107
51 - Production	3.0116	2.7868	3.2364	2.8697
53 - Transportation and Material Moving	2.9021	2.7372	3.0669	2.6471
Total	2.6701	2.8252	2.515	2.9337

Weighted average (employees by occupation in 2011-2012 from BLS)

Table 4 – Average Non-Routine skills by macro-occupation (SOC 2-digit)

	Non-Routine	NR cognitive	NR interactive	NR index
11 - Management	3.6211	3.4378	3.8044	0.585
13 - Business and Financial Operations	3.4206	3.3871	3.4541	0.5801
15 - Computer and Mathematical	3.2494	3.3749	3.1239	0.5714
17 - Architecture and Engineering	3.285	3.3515	3.2185	0.5511
19 - Life, Physical, and Social Science	3.2935	3.3588	3.2283	0.5582
21 - Community and Social Service	3.5375	3.3664	3.7086	0.5978
23 - Legal	3.3949	3.4072	3.3826	0.5892
25 - Education, Training, and Library	3.3483	3.2359	3.4607	0.5827
27 - Arts, Design, Entertainment, Sports, and Media	3.154	3.0852	3.2228	0.562
29 - Healthcare Practitioners and Technical	3.3971	3.3668	3.4273	0.5452
31 - Healthcare Support	2.9432	2.8456	3.0409	0.5175
33 - Protective Service	3.1599	2.9906	3.3292	0.5314
35 - Food Preparation and Serving Related	2.7589	2.4978	3.02	0.5112
37 - Building and Grounds Cleaning and Maintenance	2.4472	2.3635	2.5309	0.4721
39 - Personal Care and Service	2.8571	2.7027	3.0115	0.5262
41 - Sales and Related	3.0458	2.7727	3.3188	0.5429
43 - Office and Administrative Support	2.8729	2.7614	2.9843	0.5269
45 - Farming, Fishing, and Forestry	2.4158	2.2654	2.5662	0.4716
47 - Construction and Extraction	2.9345	2.8818	2.9872	0.4882
49 - Installation, Maintenance, and Repair	3.0073	2.9853	3.0292	0.496
51 - Production	2.7391	2.774	2.7042	0.4754
53 - Transportation and Material Moving	2.7306	2.6214	2.8398	0.4843
Total	3.0185	2.905	3.132	0.5293

Weighted average (employees by occupation in 2011-2012 from BLS)

Table 5 – Average Green skills by macro-occupation (SOC 2-digit)

	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
11 - Management	1.4049	2.1228	2.0097	3.4585	3.4192
13 - Business and Financial Operations	1.1493	1.6506	1.7677	3.0775	3.1012
15 - Computer and Mathematical	1.7388	2.3758	2.7494	2.5931	3.2845
17 - Architecture and Engineering	1.8833	2.6436	3.4384	2.7419	3.1153
19 - Life, Physical, and Social Science	1.636	2.4188	2.5385	2.6535	3.1239
21 - Community and Social Service	1.1721	1.6962	1.6266	3.1389	3.3661
23 - Legal	1.0712	1.4175	1.4366	3.1423	3.0245
25 - Education, Training, and Library	1.2172	1.7435	1.72	2.6512	3.0517
27 - Arts, Design, Entertainment, Sports, and Media	1.3678	1.9613	1.8988	2.8722	2.875
29 - Healthcare Practitioners and Technical	1.5182	2.6323	2.0341	2.8144	3.0624
31 - Healthcare Support	1.5534	2.3546	1.5154	2.5051	2.6174
33 - Protective Service	1.4588	2.6418	1.4967	2.6792	2.6303
35 - Food Preparation and Serving Related	1.4349	2.3028	1.3209	2.6343	2.3698
37 - Building and Grounds Cleaning and Maintenance	1.9315	2.657	1.3376	1.9738	2.0708
39 - Personal Care and Service	1.3164	2.273	1.4831	2.5689	2.692
41 - Sales and Related	1.2709	1.9907	1.4924	3.2513	2.6346
43 - Office and Administrative Support	1.2722	1.7749	1.2669	2.4823	2.5436
45 - Farming, Fishing, and Forestry	1.901	2.9055	1.5435	2.1049	2.1363
47 - Construction and Extraction	2.423	3.2583	2.2854	2.4081	2.3999
49 - Installation, Maintenance, and Repair	3.3457	3.5128	2.3842	2.502	2.6374
51 - Production	2.1858	3.2329	1.8497	2.1594	2.3752
53 - Transportation and Material Moving	2.1088	3.2331	1.4902	2.4155	2.3866
Total	1.6071	2.3459	1.6863	2.6751	2.6842

Weighted average (employees by occupation in 2011-2012 from BLS)

Table 6 – Average exposure indicators and employment shares by macro-occupation (SOC 2-digit)

	Tot R&D	Env R&D	Inv tot	Inv ICT	Hourly wage	Share empl
11 - Management	4.2634	0.3542	12.7506	1.8306	50.70	0.05
13 - Business and Financial Operations	3.8510	0.3158	14.9391	2.7983	33.45	0.05
15 - Computer and Mathematical	9.8287	0.7086	13.0214	4.3581	39.81	0.02
17 - Architecture and Engineering	14.2216	1.5790	26.1264	2.3873	37.55	0.02
19 - Life, Physical, and Social Science	12.7328	0.6084	22.6171	1.5749	32.51	0.01
21 - Community and Social Service	0.1867	0.0216	4.0467	0.4939	21.09	0.01
23 - Legal	1.4409	0.0692	6.3900	1.4575	48.16	0.01
25 - Education, Training, and Library	0.1485	0.0191	7.6161	0.7917	3.38	0.06
27 - Arts, Design, Entertainment, Sports, and Media	5.0268	0.2037	7.2412	2.0897	23.33	0.01
29 - Healthcare Practitioners and Technical	0.3231	0.0288	6.2019	1.1327	35.92	0.05
31 - Healthcare Support	0.2000	0.0211	3.5284	0.6864	13.74	0.02
33 - Protective Service	0.4888	0.0507	6.2969	0.6681	20.69	0.03
35 - Food Preparation and Serving Related	0.1288	0.0178	2.3555	0.2052	10.28	0.09
37 - Building and Grounds Cleaning and Maintenance	0.3721	0.0390	5.2935	0.4995	12.29	0.03
39 - Personal Care and Service	0.1587	0.0188	3.8461	0.3773	11.74	0.03
41 - Sales and Related	0.9116	0.0707	6.9651	1.2377	17.57	0.11
43 - Office and Administrative Support	1.7036	0.1379	10.4804	1.9150	16.46	0.17
45 - Farming, Fishing, and Forestry	0.9179	0.0471	14.6838	0.7380	11.52	0.00
47 - Construction and Extraction	0.7211	0.0932	12.4232	0.4204	21.58	0.04
49 - Installation, Maintenance, and Repair	2.5972	0.2326	18.6156	2.7771	20.97	0.04
51 - Production	10.7656	1.1547	15.5441	1.2118	16.65	0.06
53 - Transportation and Material Moving	1.4837	0.1276	10.3094	0.7798	15.22	0.07
Total	2.5112	0.2261	9.7109	1.3511	20.37	1.00

Weighted average (employees by occupation in 2011-2012 from BLS)

Table 7 – Profiling of green occupations: classical skills measures

	(1)	(2)	(3)	(4)	(5)
	Non-Routine	Routine	NR index	Offshorability	log(wage)
Green occupation	0.0588*	0.0843***	-0.00151	-0.0172	0.120***
	(0.0319)	(0.0187)	(0.00280)	(0.0306)	(0.0357)
N	665	665	665	665	613

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 8 – Profiling of green occupations: classical skills measures (detailed)

	(1)	(2)	(3)	(4)
	R cognitive	R manual	NR cognitive	NR interactive
Green occupation	0.105***	0.0634*	0.0751**	0.0426
	(0.0225)	(0.0342)	(0.0320)	(0.0349)
N	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 9 – Profiling of green occupations: green skills measures

	(1)	(2)	(3)	(4)	(5)
	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
Green occupation	0.146***	0.177***	0.235***	0.0341	0.0315
	(0.0337)	(0.0398)	(0.0332)	(0.0398)	(0.0353)
N	665	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 10 – Profiling of green occupations: relative differences

Skill	Beta	Mean	Beta/Mean
Non-Routine	0.0588	3.02	0.02
Routine	0.0843	2.67	0.03
NR index	-0.00151	0.53	0.00
Offshorability	-0.0172	2.93	-0.01
log(wage)	0.12	2.92	0.04
Mainten-Repair	0.146	1.61	0.09
Control	0.177	2.35	0.08
Engineer-Design	0.235	1.69	0.14
Managerial	0.0341	2.68	0.01
Philosophical	0.0315	2.68	0.01
R cognitive	0.105	2.83	0.04
R manual	0.0634	2.52	0.03
NR cognitive	0.0751	2.91	0.03
NR interactive	0.0426	3.13	0.01

N=665 (wage N=613), 2-digit SOC dummies included.

Figure 1 – Distribution of classical skills measures for green and non-green occupations

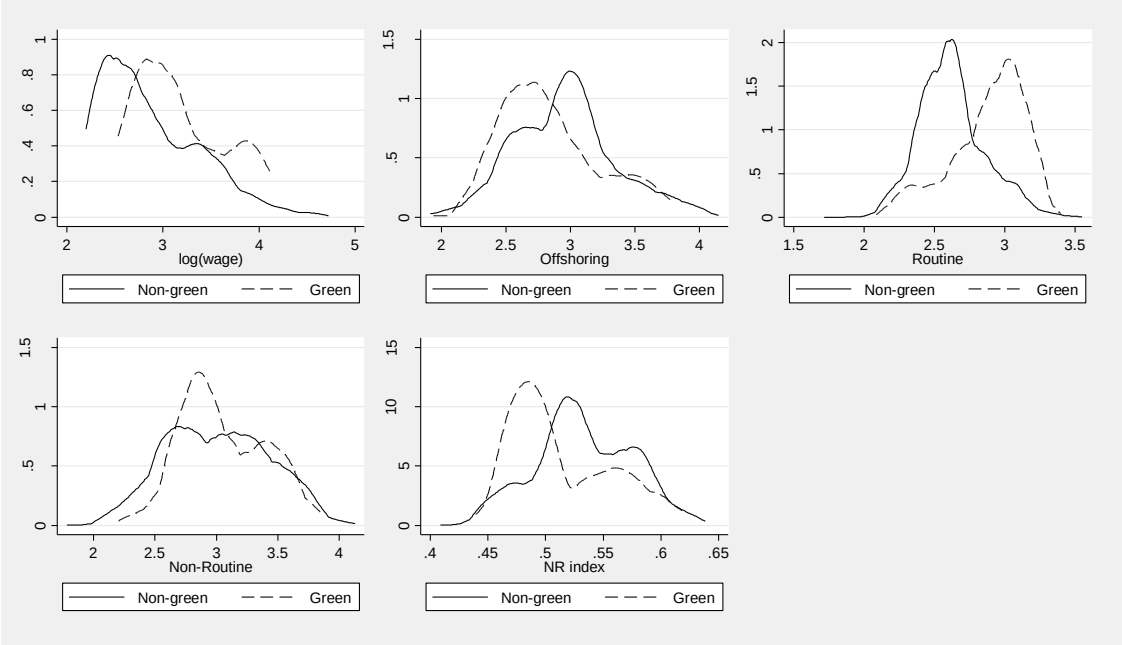

Figure 2 – Distribution of green skills measures for green and non-green occupations

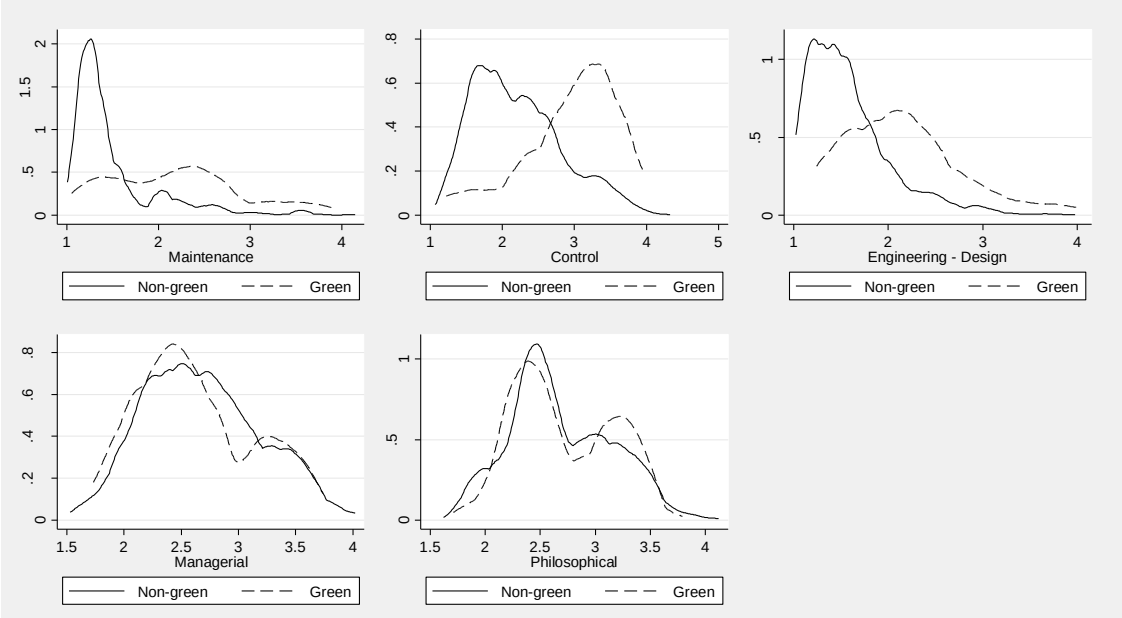

Table 11 – Differential exposure of green occupations to green R&D

	(1)	(2)	(3)
	log(Env R&D)	log(Env R&D)	log(Env R&D)
Green occupation	0.261***	0.254***	0.153***
	(0.0529)	(0.0526)	(0.0469)
log(Tot R&D)	0.810***	0.817***	0.815***
	(0.0147)	(0.0149)	(0.0210)
R sq	0.968	0.963	0.973
F	1696.6	1744.6	1169.7
N	746	665	394

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included in column 1 and 2, SOC 4-digit dummies in cluded in column 3.

Table 12 – Baseline estimates for classical skills measures

	Offshorability	Routine	Non-Routine	NR index	log(wage)
Green occupation	0.343**	-0.136	-0.0874	0.00421	0.106
	(0.173)	(0.140)	(0.227)	(0.0179)	(0.234)
log(Env R&D)	0.00886	0.0269	0.0368	0.000601	0.0785+
	(0.0450)	(0.0314)	(0.0418)	(0.00382)	(0.0498)
log(Non-env R&D)	0.0779**	-0.0270	-0.0305	0.000129	0.0119
	(0.0369)	(0.0279)	(0.0392)	(0.00345)	(0.0437)
log(Env R&D)	0.0117	-0.0777	0.00651	0.00696	-0.0953
X Green occupation	(0.0782)	(0.0551)	(0.0730)	(0.00730)	(0.0871)
log(Non-env R&D)	-0.0639	0.0839*	0.0100	-0.00609	0.0589
X Green occupation	(0.0713)	(0.0507)	(0.0712)	(0.00690)	(0.0789)
log(Inv tot)	-0.0126	-0.0137	0.0802***	0.00821***	0.00709
	(0.0113)	(0.0111)	(0.0147)	(0.00121)	(0.0311)
R sq	0.622	0.646	0.520	0.710	0.646
F	41.68	37.54	20.80	79.11	46.25
N	665	665	665	665	613

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 13 –Estimates with ICT investments for classical skills measures

	Offshorability	Routine	Non-Routine	NR index	log(wage)
Green occupation	0.316*	-0.0875	-0.185	-0.00853	-0.00921
	(0.179)	(0.140)	(0.233)	(0.0183)	(0.241)
log(Env R&D)	0.0245	-0.00149	0.0940**	0.00806**	0.144***
	(0.0471)	(0.0342)	(0.0418)	(0.00385)	(0.0507)
log(Non-env R&D)	0.0601+	0.00533	-0.0956**	-0.00836**	-0.0633
	(0.0417)	(0.0314)	(0.0404)	(0.00356)	(0.0486)
log(Env R&D)	-0.00807	-0.0417	-0.0660	-0.00249	-0.180*
X Green occupation	(0.0830)	(0.0575)	(0.0726)	(0.00729)	(0.0920)
log(Non-env R&D)	-0.0462	0.0515	0.0751	0.00239	0.135+
X Green occupation	(0.0762)	(0.0527)	(0.0704)	(0.00683)	(0.0827)
log(Inv tot)	-0.0403	0.0367*	-0.0212	-0.00501+	-0.110**
	(0.0345)	(0.0204)	(0.0350)	(0.00318)	(0.0474)
log(inv_ICT)	0.0379	-0.0689***	0.139***	0.0181***	0.161***
	(0.0452)	(0.0259)	(0.0496)	(0.00456)	(0.0615)
R sq	0.623	0.654	0.536	0.732	0.660
F	41.67	38.83	19.24	71.82	49.75
N	665	665	665	665	613

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 14 – Baseline estimates for green skills measures

	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
Green occupation	-0.0957	0.0470	0.289	-0.104	-0.340
	(0.271)	(0.311)	(0.284)	(0.286)	(0.275)
log(Env R&D)	0.0927**	0.0962*	0.147***	0.0224	0.0715
	(0.0441)	(0.0556)	(0.0486)	(0.0468)	(0.0572)
log(Non-env R&D)	-0.0392	-0.0952*	-0.0475	-0.0328	-0.0520
	(0.0375)	(0.0495)	(0.0416)	(0.0434)	(0.0523)
log(Env R&D)	-0.194*	-0.159	0.0638	-0.133	-0.0995
X Green occupation	(0.115)	(0.140)	(0.155)	(0.0932)	(0.0941)
log(Non-env R&D)	0.163+	0.131	-0.0671	0.112	0.113
X Green occupation	(0.103)	(0.122)	(0.130)	(0.0908)	(0.0909)
log(Inv tot)	-0.000770	-0.0201	0.0185*	0.0790***	0.0670***
	(0.0130)	(0.0292)	(0.0109)	(0.0166)	(0.0204)
R sq	0.786	0.776	0.751	0.551	0.547
F	55.95	73.40	50.35	25.46	23.35
N	665	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 15 –Estimates with ICT for green skills measures

	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
Green occupation	-0.0788	0.134	0.271	-0.229	-0.448+
	(0.270)	(0.302)	(0.290)	(0.287)	(0.278)
log(Env R&D)	0.0828+	0.0451	0.157***	0.0953*	0.135**
	(0.0506)	(0.0638)	(0.0504)	(0.0501)	(0.0531)
log(Non-env R&D)	-0.0279	-0.0370	-0.0598	-0.116***	-0.124**
	(0.0437)	(0.0589)	(0.0442)	(0.0432)	(0.0517)
log(Env R&D)	-0.181+	-0.0944	0.0501	-0.225**	-0.180*
X Green occupation	(0.116)	(0.138)	(0.155)	(0.0971)	(0.0923)
log(Non-env R&D)	0.151+	0.0727	-0.0547	0.195**	0.185**
X Green occupation	(0.104)	(0.121)	(0.130)	(0.0916)	(0.0894)
log(Inv tot)	0.0168	0.0705*	-0.000755	-0.0501	-0.0452
	(0.0313)	(0.0422)	(0.0349)	(0.0465)	(0.0409)
log(inv_ICT)	-0.0240	-0.124**	0.0263	0.177***	0.153***
	(0.0381)	(0.0564)	(0.0451)	(0.0619)	(0.0540)
R sq	0.786	0.780	0.751	0.566	0.561
F	54.63	71.21	48.93	23.46	22.03
N	665	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Appendix

Table 16 –Estimates for selected 4-digit occupations – classical skills measures

	Offshorability	Routine	Non-Routine	NR index	log(wage)
Green occupation	0.338**	-0.0482	0.178	0.0180	0.306**
	(0.153)	(0.146)	(0.204)	(0.0165)	(0.152)
log(Env R&D)	0.121**	-0.0570+	-0.0299	0.00314	0.0208
	(0.0531)	(0.0364)	(0.0432)	(0.00371)	(0.0575)
log(Non-env R&D)	-0.00922	0.0542+	0.0308	-0.00268	0.0364
	(0.0479)	(0.0368)	(0.0419)	(0.00351)	(0.0502)
log(Env R&D)	0.0781	-0.0971*	-0.0584	0.00295	0.0319
X Green occupation	(0.0725)	(0.0547)	(0.0632)	(0.00593)	(0.0576)
log(Non-env R&D)	-0.107*	0.0836*	0.0303	-0.00411	-0.0515
X Green occupation	(0.0644)	(0.0477)	(0.0605)	(0.00554)	(0.0528)
log(Inv tot)	-0.0196**	-0.0166*	0.0328***	0.00445***	-0.0318
	(0.00978)	(0.00907)	(0.0123)	(0.00115)	(0.0248)
R sq	0.800	0.805	0.788	0.895	0.895
F	68.84	101.7	39.02	169.4	190.8
N	394	394	394	394	391

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 4-digit dummies included.

Table 17 –Estimates for selected 4-digit occupations with ICT – classical skills measures

	Offshorability	Routine	Non-Routine	NR index	log(wage)
Green occupation	0.317**	-0.0257	0.154	0.0140	0.281*
	(0.152)	(0.145)	(0.208)	(0.0164)	(0.147)
log(Env R&D)	0.145**	-0.0832**	-0.00149	0.00790**	0.0478
	(0.0577)	(0.0422)	(0.0467)	(0.00373)	(0.0553)
log(Non-env R&D)	-0.0343	0.0819**	0.000874	-0.00770**	0.00774
	(0.0509)	(0.0415)	(0.0469)	(0.00361)	(0.0496)
log(Env R&D)	0.0607	-0.0780	-0.0790	-0.000512	0.0120
X Green occupation	(0.0741)	(0.0543)	(0.0652)	(0.00587)	(0.0560)
log(Non-env R&D)	-0.0919	0.0670	0.0482	-0.00110	-0.0340
X Green occupation	(0.0655)	(0.0478)	(0.0624)	(0.00548)	(0.0513)
log(Inv tot)	-0.0597+	0.0277	-0.0151	-0.00356	-0.0766***
	(0.0367)	(0.0277)	(0.0329)	(0.00329)	(0.0280)
log(inv_ICT)	0.0540	-0.0595*	0.0644+	0.0108**	0.0605*
	(0.0455)	(0.0351)	(0.0405)	(0.00417)	(0.0332)
R sq	0.801	0.809	0.791	0.899	0.897
F	71.20	94.73	39.06	163.4	234.4
N	394	394	394	394	391

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 4-digit dummies included.

Table 18 –Estimates for selected 4-digit occupations – green skills measures

	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
Green occupation	-0.267	0.0640	0.601**	0.265	0.313+
	(0.304)	(0.273)	(0.247)	(0.235)	(0.207)
log(Env R&D)	0.0576	0.0228	0.154**	-0.0575	-0.0640
	(0.0654)	(0.0971)	(0.0716)	(0.0524)	(0.0461)
log(Non-env R&D)	-0.0355	-0.0318	-0.0190	0.0176	0.0952**
	(0.0580)	(0.0882)	(0.0576)	(0.0489)	(0.0443)
log(Env R&D)	-0.288**	-0.143	0.126	-0.116+	0.0207
X Green occupation	(0.127)	(0.130)	(0.119)	(0.0760)	(0.0744)
log(Non-env R&D)	0.255**	0.116	-0.147+	0.0600	-0.0399
X Green occupation	(0.115)	(0.112)	(0.0978)	(0.0706)	(0.0704)
log(Inv tot)	0.00416	-0.00550	-0.00633	0.0507***	-0.0137
	(0.0146)	(0.0309)	(0.0103)	(0.0122)	(0.0157)
R sq	0.837	0.848	0.840	0.848	0.828
F	112.3	218.5	73.15	180.8	44.97
N	394	394	394	394	394

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 4-digit dummies included.

Table 19 –Estimates for selected 4-digit occupations with ICT – green skills measures

	Mainten-Repair	Control	Engineer-Design	Managerial	Philosophical
Green occupation	-0.226	0.146	0.618**	0.237	0.270
	(0.301)	(0.265)	(0.248)	(0.237)	(0.200)
log(Env R&D)	0.00991	-0.0731	0.134*	-0.0250	-0.0141
	(0.0715)	(0.0981)	(0.0769)	(0.0569)	(0.0469)
log(Non-env R&D)	0.0147	0.0691	0.00168	-0.0167	0.0427
	(0.0628)	(0.0894)	(0.0615)	(0.0562)	(0.0473)
log(Env R&D)	-0.254**	-0.0735	0.140	-0.140*	-0.0156
X Green occupation	(0.127)	(0.127)	(0.118)	(0.0777)	(0.0765)
log(Non-env R&D)	0.225**	0.0550	-0.160+	0.0805	-0.00840
X Green occupation	(0.114)	(0.111)	(0.0969)	(0.0724)	(0.0721)
log(Inv tot)	0.0845+	0.156**	0.0267	-0.00413	-0.0976**
	(0.0529)	(0.0643)	(0.0553)	(0.0342)	(0.0432)
log(inv_ICT)	-0.108*	-0.217***	-0.0444	0.0737*	0.113**
	(0.0635)	(0.0796)	(0.0682)	(0.0440)	(0.0514)
R sq	0.839	0.855	0.840	0.850	0.833
F	113.0	147.4	73.59	237.7	43.54
N	394	394	394	394	394

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 4-digit dummies included.

Table 20 – Estimates for detailed green skills measures (1)

	Maintenance	Install	Quality Control Analysis, Inspecting Equipment, Structures, or Material	Control Precision, Operation and Control
Green occupation	-0.205	0.234	-0.0646	0.159
	(0.303)	(0.337)	(0.373)	(0.337)
log(Env R&D)	0.110**	0.0423	0.0762	0.116*
	(0.0543)	(0.0389)	(0.0651)	(0.0608)
log(Non-env R&D)	-0.0509	-0.00404	-0.0742	-0.116**
	(0.0461)	(0.0328)	(0.0556)	(0.0558)
log(Env R&D)	-0.267**	0.0261	0.0422	-0.361**
X Green occupation	(0.121)	(0.160)	(0.138)	(0.176)
log(Non-env R&D)	0.228**	-0.0344	0.00776	0.254*
X Green occupation	(0.111)	(0.137)	(0.129)	(0.146)
log(Inv tot)	0.00595	-0.0209**	-0.00400	-0.0361
	(0.0177)	(0.00959)	(0.0243)	(0.0381)
R sq	0.764	0.698	0.696	0.747
F	67.42	13.04	52.47	52.77
N	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.

Table 21 – Estimates for detailed green skills measures (2)

	Design, Technology design	Engineering and Technology, Science	Resolving Conflicts and Negotiating with Others, Negotiation	Sales and Marketing, Provide Consultation and Advice to Others	Social Perceptiveness	Systems Analysis, Systems Evaluation
Green occupation	0.619**	-0.0402	-0.317	0.108	-0.246	-0.387
	(0.282)	(0.347)	(0.304)	(0.337)	(0.231)	(0.380)
log(Env R&D)	0.164***	0.129**	0.0504	-0.00556	-0.0150	0.115+
	(0.0511)	(0.0531)	(0.0569)	(0.0515)	(0.0496)	(0.0737)
log(Non-env R&D)	-0.0476	-0.0473	-0.0902*	0.0246	-0.0182	-0.0690
	(0.0436)	(0.0457)	(0.0507)	(0.0521)	(0.0459)	(0.0657)
log(Env R&D)	0.101	0.0269	-0.0634	-0.202*	-0.0139	-0.142
X Green occupation	(0.177)	(0.152)	(0.0947)	(0.121)	(0.0770)	(0.123)
log(Non-env R&D)	-0.134	-0.000324	0.0860	0.137	0.0333	0.153
X Green occupation	(0.143)	(0.136)	(0.0930)	(0.112)	(0.0763)	(0.119)
log(Inv tot)	0.00680	0.0302*	0.112***	0.0458**	0.0588***	0.0710***
	(0.00994)	(0.0163)	(0.0193)	(0.0188)	(0.0149)	(0.0254)
R sq	0.699	0.747	0.501	0.554	0.498	0.574
F	45.73	47.11	24.83	18.40	20.36	22.84
N	665	665	665	665	665	665

OLS weighted (number of employees) regressions. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. SOC 2-digit dummies included.