Institut für Arbeitsmarkt- und Berufsforschung
Die Forschungseinrichtung der Bundesagentur für Arbeit

The greening of jobs in Germany: First evidence from a text mining based index and employment register data

The 2018 GGSD Forum & GGKP Annual Conference
Session A: Effects of Green Growth Policies on Labour Markets

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Markus Janser

Motivation

Societal	Research
Numerous initiatives to foster transitions towards a greener, less carbon-intensive economy	**Porter/Van der Linde (1995)** environmental regulations may promote innovation and thus improve competitiveness - as long as the regulations are designed well
Greening of jobs?	**Acemoglu et al. (2012, 2016)** a combination of environmental regulation and temporary research subsidies may lead to climate protection and sustainable long-run growth.
No measurement instruments	**e.g. Jaffe/Palmer (1997)** regulations inherently lead to a loss of competitiveness

Contribution: I measure, describe and examine the greening of occupations and its associations with employment and wage growth in Germany.

Research questions

(1) How can the greening of occupations best be measured?

(2) a) How green are occupations in Germany?
b) Is there a greening of jobs in Germany?

(3) Do occupations with larger greenness/greening show larger employment and wage growth?

Link
Literature Review

Literature review:
Identification approaches

- Output-based approach:
  Identification by goods and services
  e.g. Eurostat (2016), UN et al. (2016), Horbach/Janser (2016) , Blazejczak/Edler (2015), US BLS 2013),
  Proxy for number of green jobs: Turnover generated by green goods and services
- Mixture of output- & process-based approach:
  The process perspective „*identifies establishments that use environmentally friendly production processes and practices.” Sommers (2013:5), see also Deschênes (2013), ILO (2013, 2015)*
- Task-based approach: Identification by occupational tasks
  inspired by the literature on technological change and emplyoment polarization
  (e.g. Autor et al. 2003 Autor 2013, Autor/Dorn al 2013, Goos et al 2014, Autor 2015
  Consoli et al. (2016), Vona et al. (2016), Peters (2014), Bowen et al. (2018), Vona et al. (2018a/b)

“… the ‘greenness‘ of an occupation is defined based on job-specific characteristics—namely, **engagement with environmental tasks**—rather than being inferred from the portion of the workforce that is employed in the production of green goods or that uses particular green production processes.” Vona et al. (2016)

Literature review:
Employment & wage development

Germany

Edler/Blazejczak 2016

- 2.2 million people were working for environmental protection in Germany in 2012

Horbach/Janser (2016)

- Environmental establishments have slightly higher employment growth (+0.6 percentage points from 2009 to 2012
- Innovation and industry agglomeration foster employment growth in green firms. Non-green firms show a smaller increase in employment, even if they are also innovative.

Antoni et al. (2016)

- Renewable energy wage premium of more than ten percent in construction/installation activities and architectural/engineering services.

USA

Bureau of Labor Statistics (2012)

- 3.1 million jobs associated with green goods and services production

Peters (2014)

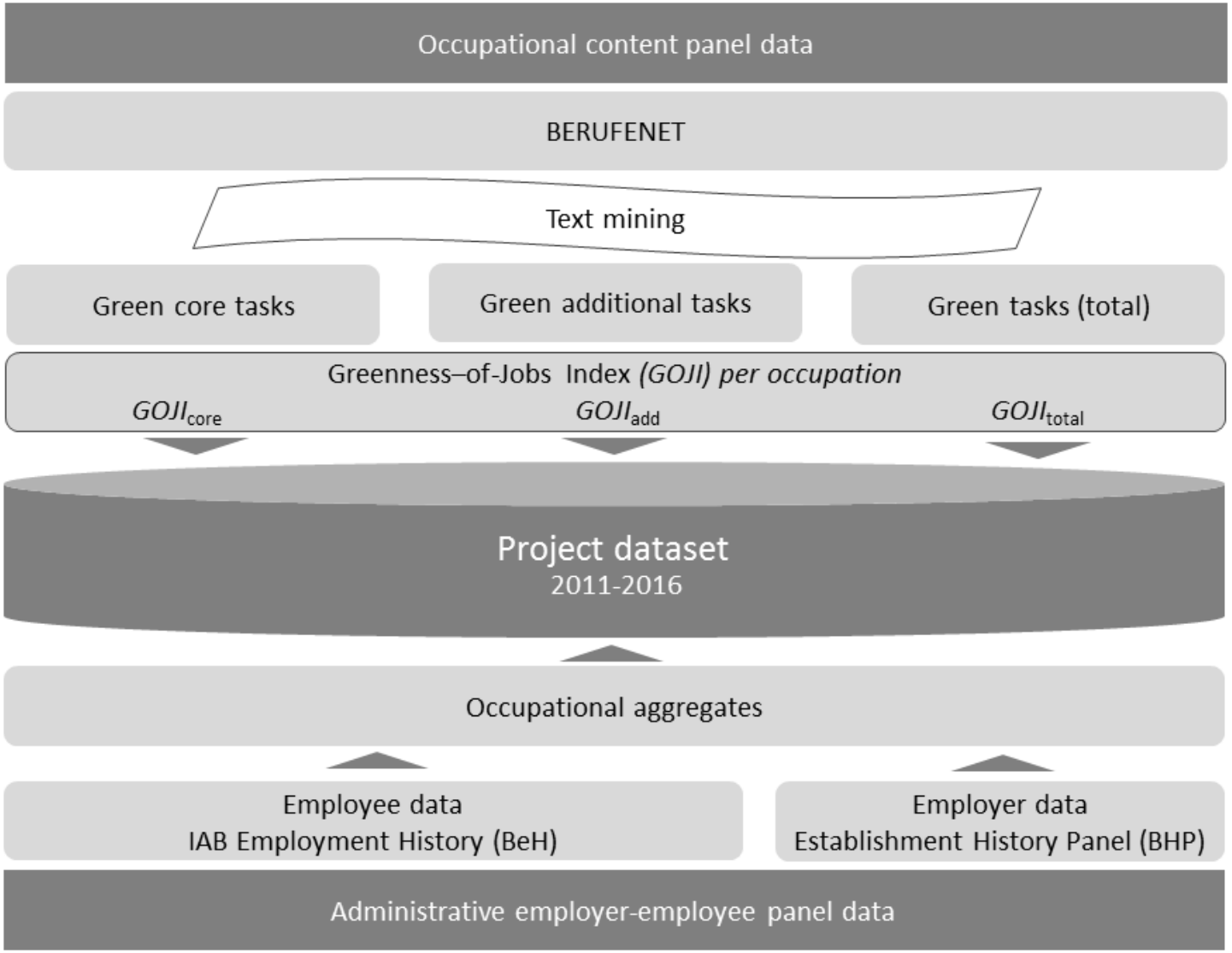
- Occupations with at least one green task: 176

Vona et al. (2017)

- Share of green employment: 2-3%.
- Geographical concentration of green jobs (changes over time), top green areas are high-tech areas.
- Green wage premium: about four percent
- Green employment is pro-cyclical
- One additional green job is associated with 4.2 (2.2 in the crisis period) new local jobs in non-tradable non-green activities.

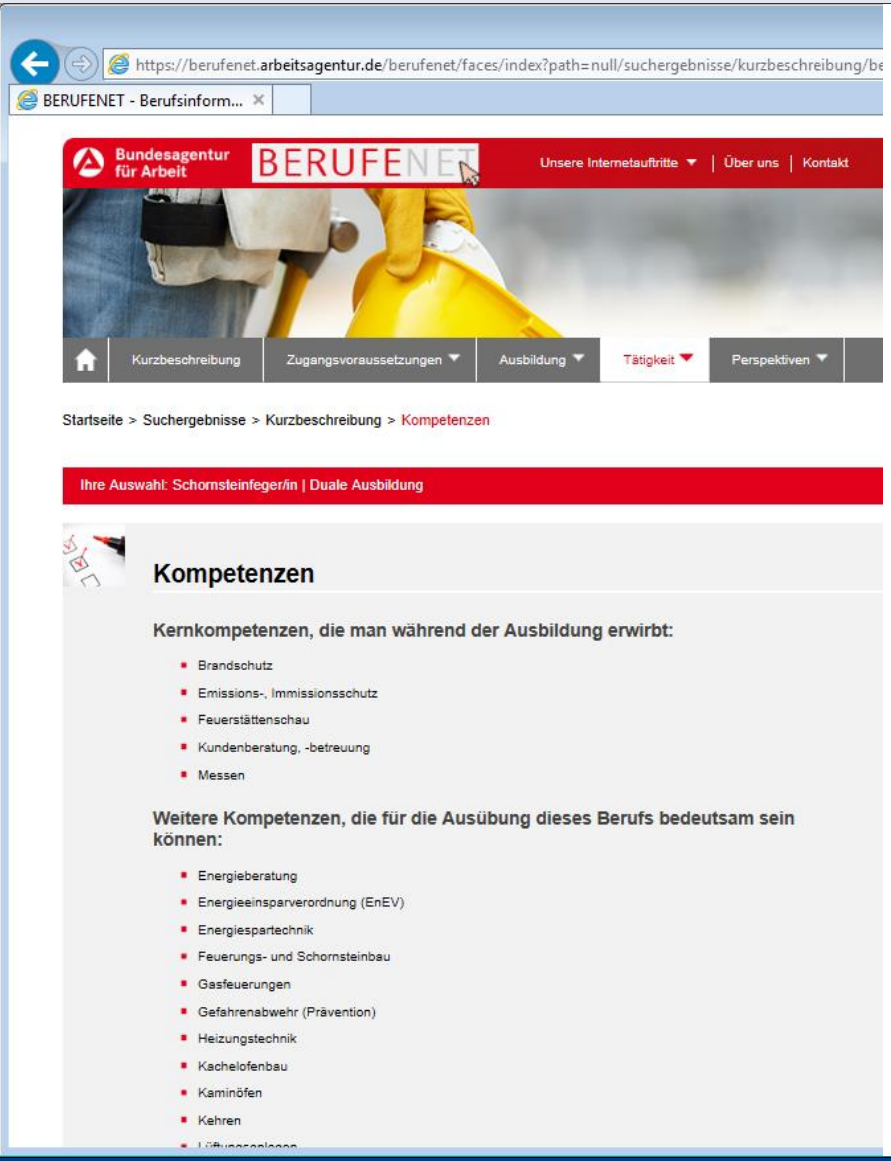
Employment impacts of environmental regulation> Backup

Data
Research objectives and the associated project dataset



Link
Research Data Center

Data
BERUFENET – the occupational expert database



Purposes of use

- for local employment agencies:
  information base for career guidance and job placement
- for the general public:
  information for vocational orientation

Content

- about 4,000 occupations
  about 8,000 requirements (Details)
- continuously edited and updated
- describes current occupations from A to Z
  - Job descriptions
  - Required qualifications and skills
  - Eearning potential, related occupations etc.
  - **But: No green tasks information**

Data: BERUFENET (Example)
Occupation ‘Chimney Sweep(er)’

Type	Requirement
Core requirements (N_{core} = 5)	Fire safety, Emission/Immission control, Fireplace inspection, Customer advisory service, Customer care, Measurement
Additional requirements (N_{add} = 16)	Energy consulting, Energy saving order (EnEV), Energy savings technology, Heating and chimney construction, Gas firings, … Environmental law, Environment protection, Environmental technology

Dictionary-based Content Analysis (Regular Expressions, R TM-Package)

Project-specific text corpus

Sources: international studies, scientific literature, newspapers
Content: characteristic elements of activities and tasks in the ‘green economy’

Definition of ‘Green Tasks’

Skills/Knowledge/Technologies/Practices required for a green economy which are known as being environmental friendly:

- low-carbon/carbon-reducing,
- energy efficient,
- (raw) material efficient,
- protecting biodiversity,
- usage of renewable resources, …

Data: Unweighted $GOJI_{core}$
Example: Occupation 'Chimney Sweeper'

Type	Requirements	Greenness-Index (gi) Elements	
		gr_core_{2014}	r_core_{2014}
Core requirements (N_{core}=5)	Fire safety	0	1
	Emission/Immiss. control	**1**	1
	Fireplace inspection	0	1
	Customer advisory service	0	1
	Measurement	0	1
	$\sum$	**1**	5

$$GOJI_{core} = \frac{\sum gr\_core_{occ,t}}{\sum r\_core_{occ,t}} \qquad GOJI_{core} = \frac{1}{5} = 0.200$$

Data: Unweighted $GOJI_{add}$
Example: Occupation 'Chimney Sweeper'


Type	Requirements	Greenness-Index (gi) Elements	
		gr_add_{2014}	r_add_{2014}
Additional requirements (N_{add}=16)	Energy consulting	**1**	1
	Energy saving order (EnEV)	**1**	1
	Energy savings technology	**1**	1
	Heating and chimney construction	0	1
	Gas firings	0	1
	Danger defense (prevention)	0	1
	…	…	…
	Oil heatings	0	1
	Pellet heating systems	**1**	1
	Environmental law	**1**	1
	$\sum$	**8**	16

$$GOJI_{add} = \frac{\sum gr\_add_{occ,t}}{\sum r\_add_{occ,t}} \qquad GOJI_{add} = \frac{8}{16} = 0.500$$

Data: Unweighted $GOJI_{total}$
Example: Occupation 'Chimney Sweeper'

Type	Requirements	Greenness-Index Elements	
		gr_core_{2014}	r_core_{2014}
Core requirements (N=5)	Fire safety	0	1
	Emission/Immiss. control	**1**	1
	Fireplace inspection	0	1
	Customer advisory service	0	1
	Measurement	0	1
	$\sum$	**1**	5

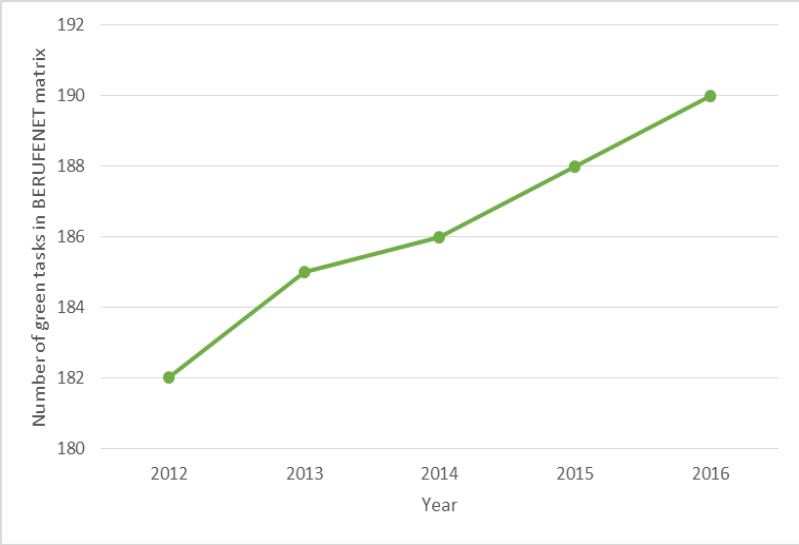
Type	Requirements	Greenness-Index Elements	
		gr_add_{2014}	r_add_{2014}
Additional requirements (N=16)	Energy consulting	**1**	1
	Energy saving order (EnEV)	**1**	1
	Energy savings technology	**1**	1
	Heating and chimney construction	0	1
	Gas firings	0	1
	Danger defense (prevention)	0	1
	…	…	…
	Oil heatings	0	1
	Pellet heating systems	**1**	1
	Environmental law	**1**	1
	$\sum$	**8**	16

$$GOJI_{total_{occ8d,t}} = \frac{\sum gr\_core_{occ8d,t} + \sum gr\_add_{occ8d,t}}{\sum r\_core_{occ8d,t} + \sum r\_add_{occ8d,t}}$$

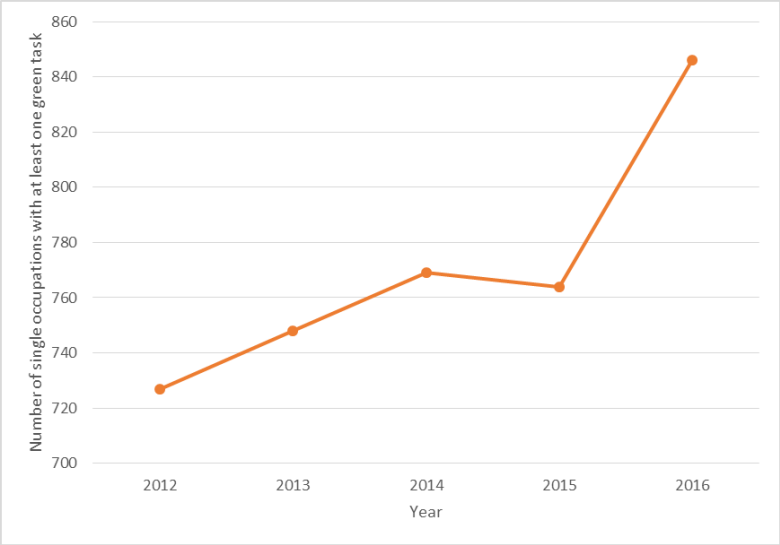
$$= \frac{1+8}{5+16} = \frac{9}{21} = 0.429$$

Descriptives - Individual occ. level (8-digit level, KldB 2010)
Number of hits after matching keywords with green tasks

Number of green tasks



Occupations with at least one green task

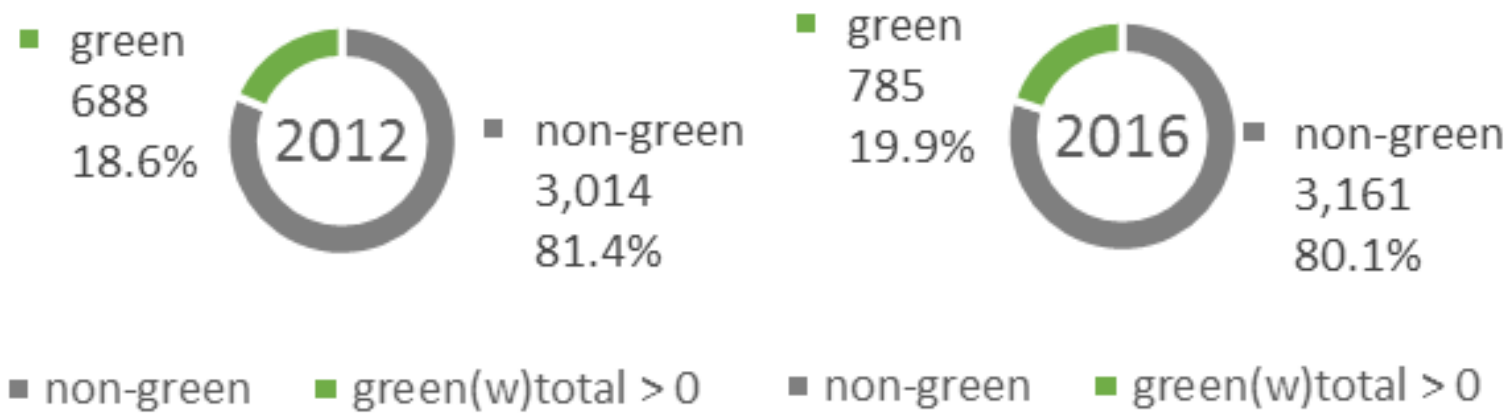


Descriptives: *Goji* ranking of individual occupations: Top-4/Medium-4/Last-4 *GOJI* values in 2016 (Kldb2010, 8-digit)

Pos.	Occupational title (English translation)	$GOJI_{total}$	$GOJI_{core}$	$GOJI_{add}$
	Top 4			
1	Specialist - Environmental protection	**0.889**	0.900	0.875
2	Environmental advisor	**0.850**	0.833	0.857
3	Recycling specialist	**0.769**	0.750	0.778
4	Environmental auditor	**0.765**	0.750	0.769
…	**Medium 4 (Median $GOJI_{total}$: 0.083)**			
389	Woodworking mechanic - Sawmill industry	**0.083**	0.250	0.050
390	Standardization expert	**0.083**	0.250	0.000
391	Master of hydraulic engineering	**0.083**	0.182	0.000
392	Technician - Machine technology (process engineering)	**0.083**	0.167	0.000
…	**Last 4**			
782	Motor mechanic	**0.024**	0.125	0.000
783	Engineer - Air-conditioning system technology	**0.024**	0.043	0.000
784	Engineer - Refrigeration system technology	**0.024**	0.037	0.000
785	Traffic construction engineer	**0.024**	0.000	0.043

Descriptives - Individual occ. level (8-digit level, KldB 2010)

Share of occupations with $GOJI_{total}$ > 0 in 2012 and 2016

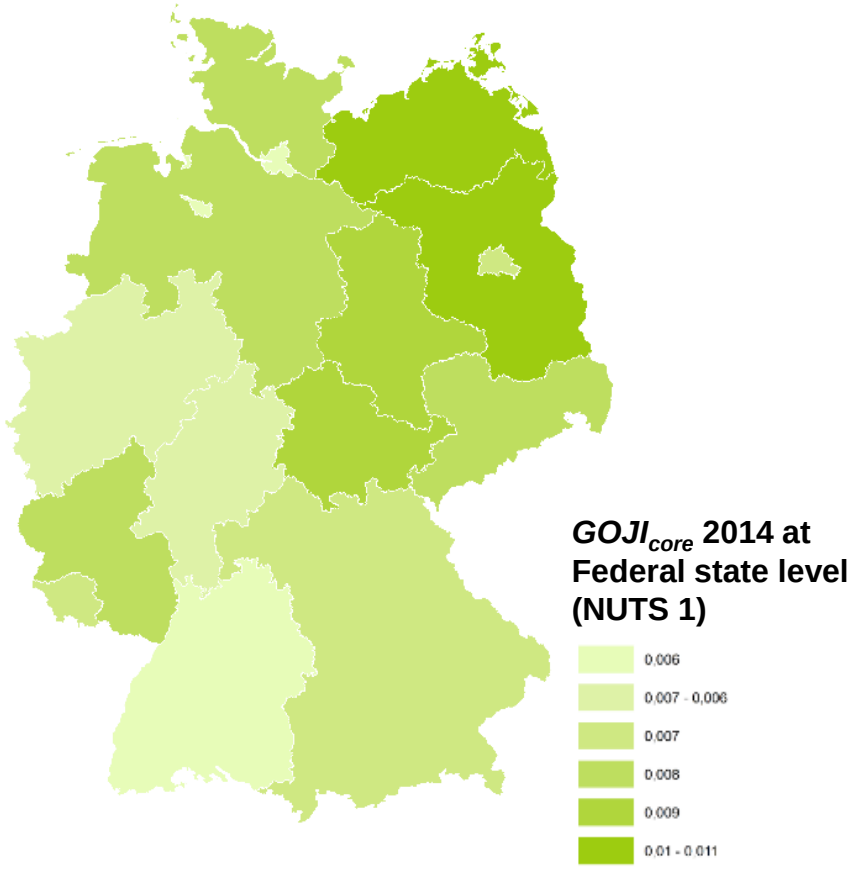


Occupational areas and their greenness of jobs

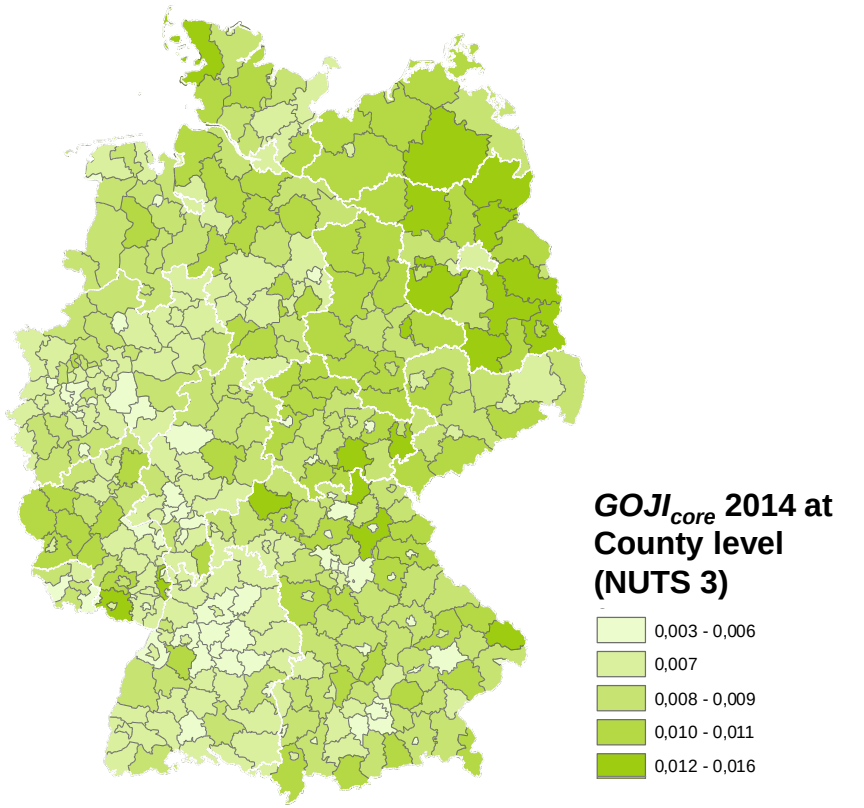
Classification title (KldB2010) Occupations in …	$GOJI_{core}$	$GOJI_{add}$	$GOJI_{total}$
A. Agriculture, forestry, farming & gardening	0.042	0.063	0.056
B. Production of raw materials and goods & manufacturing	0.003	0.017	0.012
C. Construction, architecture, surveying & tech. build. serv.	0.046	0.058	0.063
D. Natural sciences, geography & informatics	0.008	0.023	0.018
E. Traffic, logistics, safety & security	0.020	0.020	0.020
F. Commercial services, trading, sales, hotel business & tourism	0.000	0.001	0.001
G. Business organization, accounting, law, administration	0.000	0.000	0.000
H. Health care, social sector, teaching & education	0.001	0.002	0.001
I. Philology, literature, media, art, culture, design, humanities, soc. sciences & economics	0.000	0.001	0.000

Descriptives
The regional distribution of the GOJI

$GOJI_{core}$ at federal state level (NUTS 1), weighted by employment



$GOJI_{core}$ at county level (NUTS 3), weighted by employment



> Employment-weighted aggregation of *GOJI*

Greening of jobs: ranking of individual occupations by $GOJI_{total}$ Top-4/Medium-4/Last-4 *GOJI* values in 2016 (Kldb2010, 8-digit)

Pos.	Occupational title (English translation)	$GOJI_{total}$ Δ abs.	2012	2016
	Top 4			
1	Technician—Environ. protection technician (landscape ecol.)	**0.220**	0.300	0.520
2	Technician—Waste technology	**0.212**	0.407	0.619
3	Extension specialist (heat, cold and sound insulation work)	**0.199**	0.176	0.375
4	Wood preservation expert	**0.144**	0.056	0.200
…	**Medium 4**			
71	Dietary cook	**0.035**	0.080	0.115
72	Specialist agricultural farmer—Agricultural technology	**0.035**	0.056	0.091
73	Electronics techn.—Energy & building services engineering	**0.035**	0.042	0.077
74	Master chimney sweep	**0.035**	0.238	0.273
…	**Last 4**			
134	Helpers—Wood, wickerwork	**0.002**	0.048	0.050
135	Engineer—Interior design	**0.002**	0.040	0.042
136	Technician—Construction engineering	**0.002**	0.038	0.040
137	Agricultural laboratory technician	**0.001**	0.037	0.038

GOJI and employment growth: Estimation results

Dependent variables:	GREENNESS 2012 (level) OLS Full-time equivalents (pp, delta 2012-2016)		GREENING 2012-2016 (growth) FE Full-time equivalents (log, yearly panel 2012-2016)	
	(1)	(2)	(3)	(4)
$GOJI_{total}$ Green tasks total	0.238***		-0.230	
	(2.60)		(-1.58)	
$GOJI_{core}$ Green core tasks		-0.005		-0.058
		(-0.06)		(-1.31)
$GOJI_{add}$ Green additional tasks		0.246***		-0.102
		(2.72)		(-1.05)
Constant	0.430	0.429	13.24***	13.25***
	(1.63)	(1.60)	(22.60)	(22.59)
Control variables of occupational characteristics are included (employee, employer, employment, tasks, tools, (lagged) wage, regional, and sectoral characteristics). FE regression incl. time dummies for 2013-2016.				
N	1146	1146	5699	5699
R^2	0.491	0.492	0.613	0.613

If the $GOJI_{total}$ or $GOJI_{add}$ is higher by one pp, the employment growth is related with an increase of 0.238 or 0.246 pp respectively

The change of *GOJI*-values from 2012 to 2016 has no statistical significant correlation with employment growth.

Model > Backup

GOJI and wage growth: Estimation results

Dependent variables:	GREENNESS 2012 (level) OLS Daily Wage (pp, delta 2012-2016)		GREENING 2012-2016 (growth) FE Daily Wage (log, yearly panel 2012-2016)	
	(1)	(2)	(3)	(4)
$GOJI_{total}$ Green tasks total	-0.009		0.098**	
	(-0.17)		(2.01)	
$GOJI_{core}$ Green core tasks		0.069**		0.001
		(2.03)		(0.01)
$GOJI_{add}$ Green additional tasks		-0.083*		0.062
		(-1.93)		(1.35)
Constant	0.018	0.014	5.747***	5.733***
	(0.11)	(0.09)	(11.38)	(11.28)
Control variables of occupational characteristics are included (employee, employer, employment, tasks, tools, regional, and sectoral characteristics). The FE regression also contains time dummies for the years 2013-2016.				
N	1137	1137	5702	5702
R^2	0.452	0.456	0.694	0.694

A $GOJI_{core}$ larger by 1 pp is associated with an increase of wage growth by 0.069 pp, whereas a $GOJI_{add}$ larger by 1 pp is related with a decrease of wage growth by 0.083 pp.

A growth of $GOJI_{total}$ by 1 pp between 2012 and 2016 is associated with an increase of wage growth by 0.098 pp.

Model > Backup

Conclusions

(1) The BERUFENET based Greenness-of-Jobs Index (*GOJI*) facilitates tackling descriptive and analytical research questions at occupational, sectoral and regional level.

(2) The paper shows a moderate greening of occupations and employment in Germany for 2012-2016.

(3) GOJI and employment growth
Measured by the $GOJI_{total}$ in 2012, the greenness of jobs is associated with a slight increase of employment growth. This is mainly drive by the level of $GOJI_{add.}$

(4) GOJI and wage growth
Measured by the $GOJI_{core}$ in 2012, the greenness of jobs is associated with a slight increase of wage growth. Contrary, the greenness of jobs is correlated with a lower wage growth if I use $GOJI_{add}$ for measuring the greenness of jobs.
The greening of jobs (change of $GOJI_{total}$ between 2012 and 2016) is associated with an slight increase of wage growth.

Policy Implications (1/2)

(1) Using occupational content data and administrative employment data, it is possible to identify the greenness and greening of jobs without expensive surveys and new data sources.

(2) The descriptive analysis of the GOJI distribution reveals a large heterogeneity between occupational aggregated, industries and regions.

Keep this variety in mind before policy implications are drawn:
If the promotion of green jobs is a policy target, it is more advisable to promote the transformation of existing occupations rather than to design new occupations.

Policy Implications (2/2)

(3) The economic significance of the results is relatively small in the short time period observed. However, this is not bad news at all, because the overall results of this presentation show that green transitions and labor market outcomes can even positively interrelate with each other.

(4) There is still a need to prevent threats of individuals to lose their employability through these transitions.

The most important objective for labor markets policy:
Support the green adaptation of occupations, employees, and employers to the changing needs of the labor market, e.g.
- continuous reforms of occupational contents and institutions, and
- the use of existing active labor market policy instruments
  (e.g. promotion of further training, retraining and life-long learning).

Thank you very much for your attention!

Markus Janser
markus.janser@iab.de

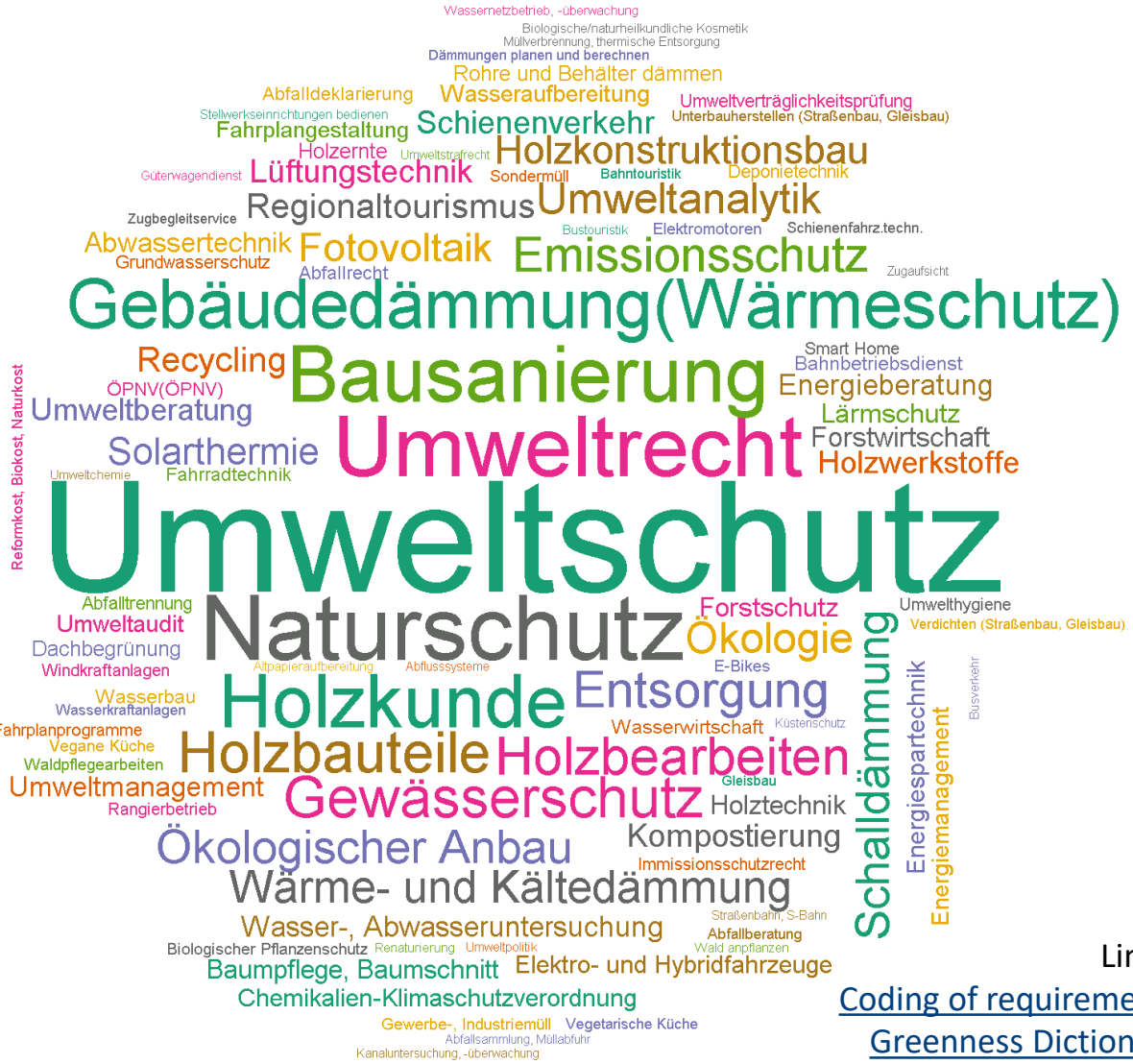
Backup

Data

Employment-weighted *GOJI* aggregates

Data
TEXTMINING - Word cloud

Frequency of green tasks dictionary keywords weighted by their appearance in BERUFENET requirements



Links:

Coding of requirements

Greenness Dictionary

Data: Goji on aggregated occupational levels
Aggregation from 8-digit level to 5-digit level

$$goji_{core,add,total_{occ5d,t}} = \frac{\sum goji_{core,add,total_{occ8d \in 5d,t}}}{N_{occ8d \in 5d\,,t}}$$

Example of 'Occupations in renewable energy technology - complex tasks' 2014

KldB 2010 8-digit	KldB 2010 5-digit	Occupational title 2014 (8-digit)	Occupational types 2014 (5-digit)	Emp 5_2014	Emp 8_2014 (estim.)	goji$_{core}$ 8_2014	goji$_{core}$ 5_2014 (aggreg.)
26243-100	26243	Solar technician	Occupations in renewable energy tech-nology-complex tasks	2,671	890.33	0.200	0.211
26243-101		Wind Energy Technician			890.33	0.100	
26243-108		Specialist solar technology			890.33	0.333	

Equal distribution assumption

Source: BERUFENET 2014, own calculations.

> Data

Data: Employment-weighted *GOJI*
Aggregation from 5-digit level to higher aggregated levels

Aggregation at occupational level

$$goji_{d\,t} = \sum_{o \in d}^{d} goji_{occ\,t} * w_{occ,t}$$

weight w is based on the relation between number of employees within single occupation *occ* and total number of employees working in the specific KldB 2010 classification level *d*

Aggregation at sectoral and regional level

$$goji_{d\,t} = \sum_{o \in d}^{d} goji_{sec\,t} * w_{sec,t}$$

$$goji_{d\,t} = \sum_{o \in d}^{d} goji_{reg\,t} * w_{reg,t}$$

weight w is based on the relation between number of employees within single sector *sec* / *region reg* and total number of employees working in the specific WZ / NUTS classification level *d*

> Data

Next steps

Further econometric examples

→ Dependent variable: wage growth

Spatial analysis / Aggregation of greenness indizes on NUTS-4 level

Aggregation from single-occupation-level to occupational (main) groups

Extending database for a long-term perspective of the greening of jobs

Prepare and import additional data from 2006 and 2016

Data
TEXTMINING - Coding of requirements

Categories of 'green tasks'	'Green tasks' code	Matches (requirements)	
		2011	2014
01 Sust. energy production & storage	gt01_EPES	12	12
02 Energy efficiency (incl. building)	gt02_EEFF	15	15
03 Air Pollution management	gt03_APM	7	7
04 Mobility	gt04_M	19	22
05 (Raw) material efficiency	gt05_RME	2	2
06 Recycling / waste management	gt06_RWM	19	19
07 Water / waste water management	gt07_WWM	14	14
08 Sust. Farming, forestry, food, cons. goods	gt08_SFFFC	17	18
09 Environm./Climate protection (general)	gt09_ECP	30	31
Total		**135**	**140**

Link Greenness Dictionary
Back

Empirical example
Employment development - Econometric model (Fixed effects)

$$emp_{occ\,t} = \beta_0 + \beta_1 goji_{occ\,t} + \beta_2 pers_{occ\,t} + \beta_3 firm_{occ\,t} + \beta_4 sect_{occ\,t} + \beta_5 regio_{occ\,t} + \varepsilon_{occ\,t}$$

Response variable

$emp_{occ\,t}$ employment growth rate of occupation occ in time t (here: 2012-2014)

Regressors

$goji_{occ\,t}$ greenness-of-jobs indicator

$_{core}$ based on core requirements,

$_{light}$ based on additional req.,

$_{mix}$ based on both core and add. req.

$pers_{occ\,t}$: personal characteristics;

$firm_{occ\,t}$: firm characteristics;

$regio_{occ\,t}$: firm location (NUTS 1);

$sector_{occ\,t}$: sector dummies

Empirical example
Wage development - Econometric model (Fixed effects)

$$wage_{occ\,t} = \beta_0 + \beta_1 goji_{occ\,t} + \beta_2 pers_{occ\,t} + \beta_3 firm_{occ\,t} + \beta_4 sect_{occ\,t} + \beta_5 regio_{occ\,t} + \varepsilon_{occ\,t}$$

Response variable

$wage_{occ\,t}$ wage of occupation occ in time t (here: 2012-2014)

Regressors

$goji_{occ\,t}$ greenness-of-jobs indicator

$_{core}$ based on core requirements,

$_{light}$ based on additional req.,

$_{mix}$ based on both core and add. req.

$pers_{occ\,t}$: personal characteristics;

$firm_{occ\,t}$: firm characteristics;

$regio_{occ\,t}$: firm location (NUTS 1);

$sector_{occ\,t}$: sector dummies

TEXTMINING
Next steps / Possible issues for discussion

Text crawling using R

Building a corpus including HTML-data from CD-ROM (2004)

- Parsing offline HTML-pages
- Different content representation / Need for a new analysis system
- Selection of the appropriate scope of text sources (requirements list only?)

Creating the keyword catalog in R

Generation of a new ‘keyword catalog’ by Text mining methods (ML?)

Calculation of the Greenness index

Tackling the bias problem due to different levels of tasks complexity

Applying a text mining approach to calculate the weights

Econometric Application

Running test regressions with different gi-schemes
(y: employment growth within occupational segments)

Side Note: Potential for regional labor market research
Example from Vona et al. (2016)

Vona, F., G. Marin, D. Consoli, (2016), *'Measures, Drivers and Effects of Green Employment: Evidence from US Local Labor Markets, 2006-2014*', Nota di Lavoro 48.2016, Milan, Italy: Fondazione Eni Enrico Mattei

Spatial issues covered:

- Spatial dynamics
  → Geographical concentration of green jobs (changes over time),
- Profiling fast-growing and top (green) areas
  → Top green areas are high-tech areas
- Green job local multiplier
  → one additional green job yields the creation of 4.2 new jobs in non-tradable activities

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Profiling Tables > Backup
Local Multiplier Tables > Backup

Literature review:
Employment impacts / social costs of environmental regulation

- (Moderate) positive impact

  Vona et al. (2016)

  PorterIvan der Linde (1995) → env. regulation triggers env. innovation > comparative advantage
- No impact

  Berman/Bui (2001), Morgenstern (2002), Cole/Elliott (2007), Martin et al. (2014) , Gerster (2015)
- (Moderate) negative impact

  Greenstone (2002); Walker (2011); Abrell et al. (2011), Curtis (2014), Kahn and Mansur (2014)

- Social/Transitional costs

  Walker (2013) , Bartik (2015)

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Occupation-Requirement matrices

Year	Number of occupations (8-digit-level)	Number of requirements
2011	3,894	6,561
2012	3,911	6,670
2013	3,937	6,709
2014	3,946	6,745
2015	3,938	6,819
2016	4,236	7,325

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Descriptives:
Top-10 green occupational types by $GOJI_{total,2-digit}$ 2014

	Occupational type (en)	Occupational type (de)	$goji_{total,2d}$ 2014
34	Occup. in building services engineering and technical building services	Gebäude- und versorgungstechnische Berufe	.13
52	Drivers and operators of vehicles and transport equipment	Führer/innen von Fahrzeug- und Transportgeräten	.06
11	Occup. in agriculture, forestry, and farming	Land-, Tier- und Forstwirtschaftsberufe	.05
12	Occup. in gardening and floristry	Gartenbau- und Floristikberufe	.04
33	Occupations in interior construction	(Innen-)Ausbauberufe	.04
25	Technical occup. in machine-building and automotive industry	Maschinenbau- und Fahrzeugtechnikberufe	.03
41	Occup. in mathematics, biology, chemistry and physics	Mathematik-, Biologie-, Chemie- und Physikberufe	.02
32	Occup. in building construction above and below ground	Hoch- und Tiefbauberufe	.02
53	Occup. in safety and health protection, security and surveillance	Schutz-, Sicherheits- und Überwachungsberufe	.02
22	Occup. in plastic-making and -processing, and wood-working and -processing	Kunststoffherstellungs- und -verarbeitungs-, Holzbe- und -verarbeitungsberufe	.012

Descriptives: Greenness of occupations

Top green occupations (8-digit) by $GOJI_{add\ 2014}$

Occupational title (English)	Occupational title (German)	$GOJI_{add\ 2014}$
Head of office of experts for environmental issues	Leiter/in - Sachverständigenbüro für Umweltfragen	0.78
Environmental management officer	Umweltmanagementbeauftragte/r	0.78
Recycling specialist	Recycling-Fachkraft	0.67
Environmental expert	Umweltgutachter/in	0.67
Environmental auditor	Umwelt-Auditor/in	0.64
Waste advisors	Abfallberater/in	0.62
Technical assistant for environmental protection	Umweltschutztechnische/r Assistent/in	0.55
Specialist in environmental protection	Fachwirt/in - Umweltschutz	0.55
Specialist in recycling and waste management	Fachkraft - Kreislauf- und Abfallwirtschaft	0.54
Waste manager	Abfallbeauftragte/r	0.50

Data:
Greenness-of-jobs Indices on aggregated occupational level

$$\boldsymbol{goji_{core,add,total_{occXd,t}}} = \sum_{\boldsymbol{occ5d \in Xd=1}}^{\boldsymbol{n}} \boldsymbol{w_{occ5dtoXd,t}} * \boldsymbol{goji_{core,add,(w)total_{occ5d,t}}}$$

$$\boldsymbol{w_{occ5dtoXd,t}} = \frac{\boldsymbol{emp_{occ5d \in d,t}}}{\sum \boldsymbol{emp_{occ5d \in Xd,t}}}$$

where

$\boldsymbol{goji_{occXd,t}}$ *Greenness-of-Jobs Index (0…1)* on aggregated occupational digit-level occ*Xd* in year *t.*

$\boldsymbol{w_{occ5dtoXd,t}}$ *Weight*, based on the relation between number of employees within occupation on 5-digit level ($\boldsymbol{emp_{occ5d \in d,t}}$) and the total number of employees working in the higher occupational aggregate ($\boldsymbol{emp_{occ5d \in Xd,t}}$) in year *t*.

$\boldsymbol{goji_{occ\ 5d,t}}$ Greenness-of-Jobs Index *(0…1)* of single occupation on 5-digit-level in year *t.*

Indices

$\boldsymbol{d}$	digit-level of occupational classification KldB2010
$\boldsymbol{occ5d}$	single occupation on 5-digit-level of KldB2010 (basic level)
$\boldsymbol{t}$	year t

Data: The Greenness Dictionary, List of keyword categories

	Category of Keywords	Category Code	Number of keywords
1	Energy production & storage	EN	19
2	Mobility & tourism	MOB	34
3	Building	BUILD	21
4	Farming, forestry, food, consumer goods	FFFC	19
5	Energy efficiency & further climate protection	CP	10
6	Emission protection (air, water, soil, noise)	EP	27
7	Circular economy, (raw) material efficiency & waste management	CE	13
8	Environmental protection (general)	EPGEN	10
	Total number of green tasks keywords	GT	153

Link
Overview Greenness Dictionary

Data: The Greenness-of-Jobs Index (here: different weights for core and additional requirements)

$$gi_{ot} = w_{r\_core} \frac{\sum gr\_core_{o,t}}{\sum r\_core_{o,t}} + w_{r\_add} \frac{\sum gr\_add_{o,t}}{\sum r\_add_{o,t}}$$

where

gi_{ot}	'greenness index' *(0…1)* of occupation o in year t
w_{r_core} ; w_{r_add}	weights for the specific requirements types (*r_core*: core requirements, *r_add*: additional requirements) In the following example: w_{r_core} : 2/3 , w_{r_add} : 1/3
$\sum gr\_core_{o,t}$	green core requirements of occupation o in year t
$\sum r\_core_{o,t}$	all core requirements of occupation o in year t
$\sum gr\_add_{o,t}$	green additional requirements of occupation o in year t
$\sum r\_add_{o,t}$	all additional requirements of occupation o in year t

Indices

o	single occupation o (8-digit-level of KldB2010)
t	year t

Motivation

Greening the economy will affect skills needs in three ways:

- new occupations and new skills qualification and training frameworks
- many existing occupations and industries will experience greening changes to tasks within their jobs
- increased demand for some occupations and decreases for others

European Centre for the Development of Vocational Training, 2012