Conseil d'Orientation pour l'Emploi
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Automatisation, numérisation et emploi

AUTOMATION AND ITS IMPLICATIONS ON SKILLS USE AND TRAINING

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OCDE
DES POLITIQUES MEILLEURES POUR UNE VIE MEILLEURE

Automation, skills use and training

Digitalisation disrupts labour markets with its potential to automate tasks and change the way they are performed, leading to either job loss or new skill requirements in existing jobs (Autor, Levy, Murnane + Frey and Osborne + Arntz, Gregory and Zierhan)

The OECD is looking at this issues from several angles:

- A research paper based on PIAAC that:
  - sheds light on the number of jobs at risk of automation (and the people at risk);
  - looks at how different technologies affect that risk;
  - identifies the tasks/skills least likely to be automated;
- A composite measure of skill shortages and analysis that explores the link with digitalisation (and other mega trends);
- Country studies identifying policy directions for governments as well as mechanisms for employers and workers to adapt to changing skills requirements

The studies benefits from financial support of the European Commission and the JPMorgan Chase Foundation

Plan of the presentation

1. Measuring the risk of automation in PIAAC: brief summary
2. Labor augmenting and labor substituting technologies
3. What skills affect the risk of automation most?
4. Are shortages in these skills appearing already: France and Europe
5. Training and automation
6. Policies to address emerging shortages

MEASURING THE RISK OF AUTOMATION IN PIAAC: BRIEF SUMMARY

Methodology

We start from the method developed by Frey and Osborne:

- expert judgment on risk of automation in 70 occupations;
- identification of technological bottlenecks (perception and manipulation and creative and social intelligence);
- out-of-sample estimation for other occupations

We apply this method to PIAAC exploiting variation in tasks carried out in jobs belonging to the same occupation:

- identify the same occupations;
- identify similar bottlenecks;
- use Canadian PIAAC sample to exploit 4-digit ISCO;
- out-of-sample prediction for jobs in different countries

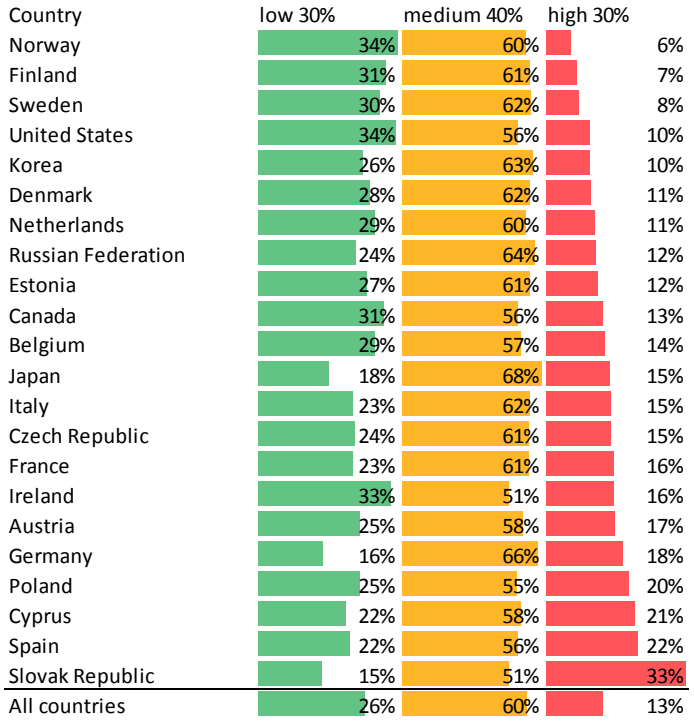
Cross-country results: please take note

Note regarding Cyprus
Note by Turkey
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union
The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Estimates confirm previous findings that individual variation is key in computing the risk of automation

Share of jobs that are less than 30%, 30-70% and more than 70% likely to be automated



Source: PIAAC, all countries, own calculations.

Accounting for individual variation reduces the estimated risk of automation;

Across all countries, 13% of workers have higher than 70% probability of being automated

Most jobs will change somewhat as a result of automation

Bottom line: estimates vary across studies, depending on the technique used, but tend to converge to a much smaller figure than FO when individual variation in skills use at work is accounted for

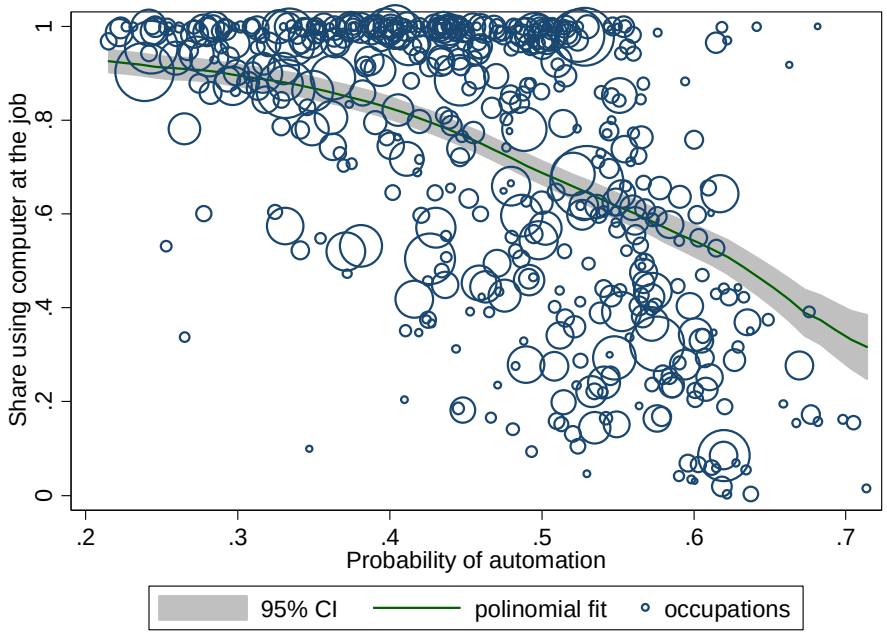
LABOR SUBSTITUTING AND LABOR AUGMENTING TECHNOLOGIES

Computer use and automatability

- Computer use declines with the level of job automatability.
- This suggests that computers, in the conventional meaning of the term* look more like labor augmenting, and not labor substituting technologies.
- This is consistent with the findings for Germany using the BIBB surveys (following slides).

*By this we mean the use of PCs and laptops in an office environment

Computer use declines with the level of job automatability



Source: PIAAC, all countries.
Note: Each observation is one occupation. There are 493 occupations in the chart. Only occupations with at least 10 observations are included . The size of the circles is proportional to the size of the occupation. The fitted polynomials are weighted by the final design weights.

BIBB-based results

Rule them or be ruled out by them?

- Those in automatable jobs are less likely to use computers or have knowledge in using them.
- This may suggest that computers (vs robots or other industrial machines) are the typical labor complements and not substitutes.

	Automatability (ALM)	Automatability (FO)
How often do you work with computers?		
Often	53%	52%
Sometimes	50%	46%
Never	63%	59%
What kind of computer user are you?		
Not a user	63%	59%
User	54%	52%
More than just a user	45%	45%
Level of your PC software knowledge		
No knowledge	60%	57%
Basic knowledge	52%	49%
Specialized knowledge	53%	52%
Has your company introduced new computer programs recently?		
No	56%	53%
Yes	53%	51%

Source: BIBB 2005/06 and 2011/12
Note: risk of automation of the median worker – share of workers at high risk of automation in Germany is 32% using BIBB vs 18% using PIAAC.

BIBB-based results

Can we tell labor-substituting and labor-augmenting technologies apart?

- We look at the correlations between automatability and the intensity of tool use at the job
- Jobs are ~350 occupations (KldB 1992, 3-digit);
- Intensity of tool use is the share of workers in each occupation reporting use of a certain tool in 1999;
- We call a tool/machine labor-substituting (labor-augmenting) if the correlation with automatability is at least 0.1 (negative 0.1 or less).
- Among potentially labor-substituting are construction machines, transport machines and manufacturing automated machines.
- Among potentially labor-augmenting are office machinery incl. PCs and laptops, software (word, spreadsheet, data analysis, communication), but also measuring instruments.

Labor-substituting tools & machines
$Corr(tool, \Pr(ALM)) \geq 0.1$

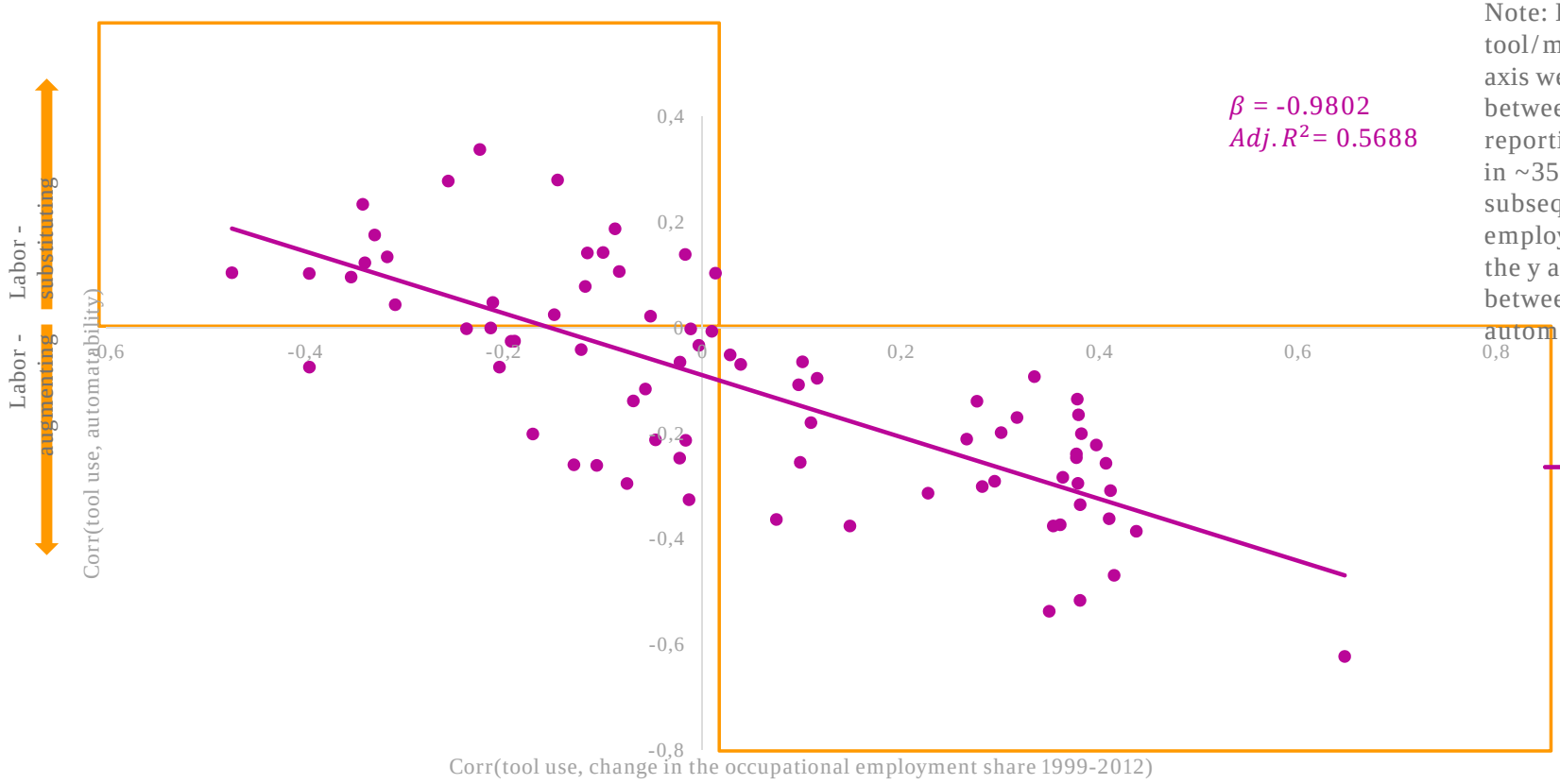
Labor-augmenting tools & machines
$Corr(tool, \Pr(ALM)) \leq -0.1$

Tools	Correlation with: Pr(ALM)	Pr(FO)
forklift_trucks	0.30	0.22
working_w_machines	0.19	0.18
automat_storagesystems	0.17	0.14
automatic_machines	0.17	0.17
manuf_machines	0.17	0.14
trucks	0.13	0.04
simple_transportmeans	0.13	0.05
vehicles_liftingmachines	0.13	0.02
simple_tool	0.12	0.07
scanner_cashier	0.12	0.10
crane_indoor	0.10	0.06
construction_machines	0.10	0.05
other_machines	0.10	0.03
lifting_aids_vehicles	(0.10)	(0.15)
fireextinguishers	(0.12)	(0.15)
terminal_internal_network	(0.12)	(0.02)
precision_tool	(0.12)	(0.10)
other_software	(0.13)	(0.05)
other_device	(0.13)	(0.19)
hardware_software_support	(0.14)	(0.08)
typewriter	(0.14)	(0.14)
mobilephone_radio	(0.16)	(0.17)
simple_measuring_instr	(0.17)	(0.19)
bus	(0.18)	(0.23)
calculator	(0.18)	(0.14)
elect_measuring_instr	(0.20)	(0.18)
microwave	(0.20)	(0.19)
databases	(0.21)	(0.11)
software_dev	(0.21)	(0.13)
laptop	(0.22)	(0.12)
measuring_instr	(0.22)	(0.22)
car_taxi	(0.22)	(0.21)
data_processing	(0.23)	(0.14)
isdn_phone	(0.23)	(0.11)
voicerecorder_microphone	(0.23)	(0.18)
terminal_internet_email	(0.24)	(0.13)
other_measuring_instr	(0.24)	(0.23)
spreadsheets	(0.24)	(0.14)
computer_diagnosis	(0.26)	(0.22)
fax_copier	(0.26)	(0.18)
scanner	(0.27)	(0.18)
graphics_programs	(0.29)	(0.19)
word_processing	(0.30)	(0.22)
simple_writing_tool	(0.31)	(0.27)
pc	(0.31)	(0.23)
scientific_programs	(0.31)	(0.23)
musical_instr	(0.32)	(0.35)
stationary_phone	(0.33)	(0.38)
answeringmachine	(0.34)	(0.32)
photocamera	(0.36)	(0.33)
projector	(0.47)	(0.44)
therapeutic_aids	(0.59)	(0.11)

Source: BIBB 1998/99
Note: The chart shows the all correlations between automatability and tools/machines that have a value of at least $|0.1|$. The complete list of reported tools and technologies is 78.

BIBB-based results

Employment declined in occupations that employ tools/machines which are positively correlated with automatability (labor-substituting tools/machines). It grew in occupations that employ technologies which are negatively correlated with automatability (labor-augmenting technologies)



Source: BIBB 1998/99 and 2011/12
Note: Each observation is a tool/machine (78 in total). On the x axis we show the correlations between the share of workers reporting tool/machine use in 1999 in ~350 occupations and the subsequent occupational employment growth 1999-2012. On the y axis we show the correlations between the tool/machine use and automatability.

BIBB-based results

Income declined in occupations that employ tools/machines which are positively correlated with automatability (labor-substituting tools/machines).
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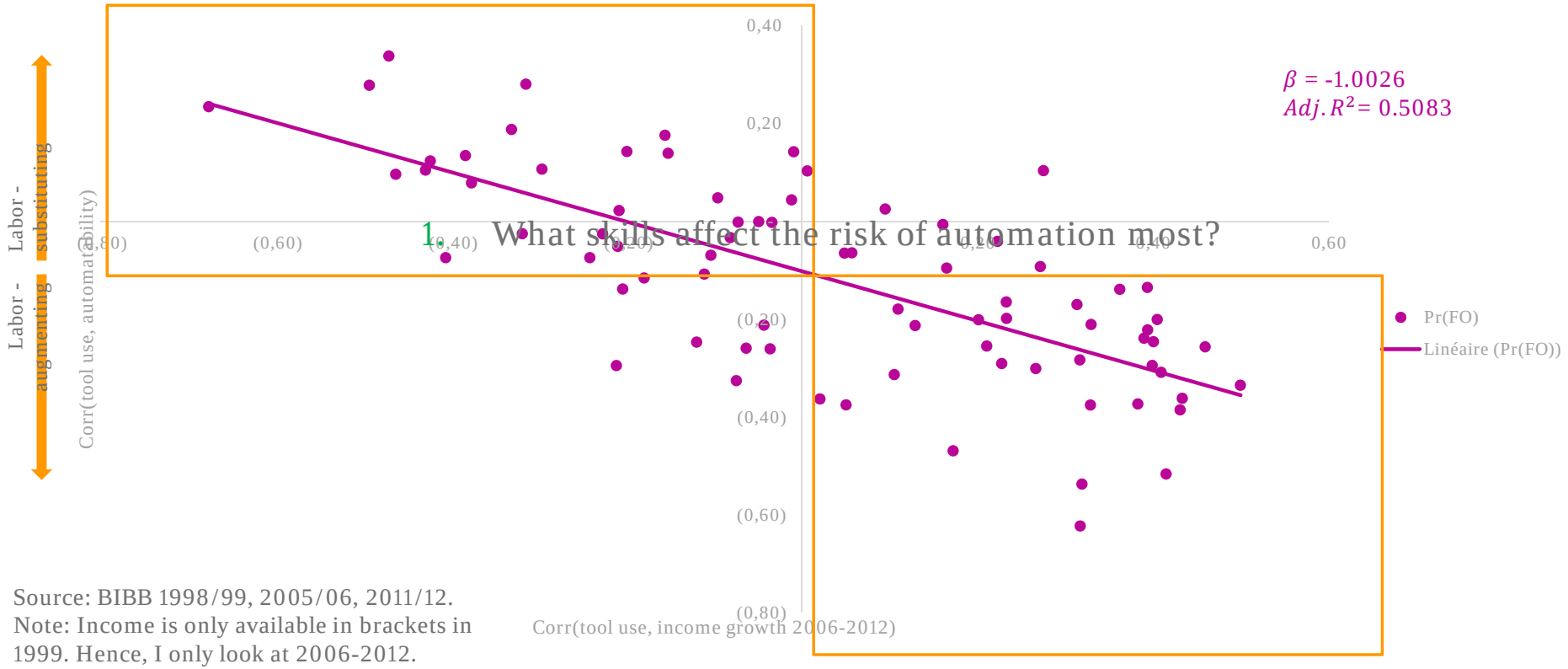


1. What skills affect the risk of automation most?

Source: BIBB 1998/99, 2005/06, 2011/12.
Note: Income is only available in brackets in 1999. Hence, I only look at 2006-2012. Income is self-reported gross monthly income.

WHAT SKILLS AFFECT THE RISK OF AUTOMATION MOST?

Key bottlenecks to the risk of automation

1. Engineering Bottlenecks	O*NET	O*NET description	PIAAC		
	Variable	Definition	Short description	Variable	Definition
Perception and manipulation	**Finger dexterity**	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.	**no match**		
	Manual Dextrity	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.	**Fingers, hands**	F_Q06C	How often - Using hands or fingers
	Cramped work space, awkward positions	How often does this job require working in cramped work spaces that requires getting into awkward positions?	**no match**		
Creative intelligence	**Originality**	The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.	**Problem-solving**	F_Q05A	Problem solving - Simple problems
			Problem-solving	F_Q05B	Problem solving - Complex problems
	Fine arts	Knowledge of theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama, and sculpture.	**no match**		
Social intelligence	**Social perceptiveness**	Being aware of others' reactions and understanding why they react as they do.	**Teaching**	F_Q02B	How often - Teaching people
			Advise	F_Q02E	How often - Advising people
			Plan for others	F_Q03B	How often - Planning others activities
			Communication	F_Q02A	How often - Sharing work-related info
	Negotiation	Bringing others together and trying to reconcile differences.	**Negotiate**	F_Q04B	How often - Negotiating with people
	Persuasion	Persuading others to change their minds or behavior.	**Influence**	F_Q04A	How often - Influencing people
			Sell	F_Q02D	How often - Selling
	Assisting and caring for others	Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients.	**no match**		

Explaining the variance in the risk of automation

ANOVA of the predictors of 0/1 automatability

- Variables that have to do with social intelligence (planning the work of others, sales, influencing and advising) explain most of the variance in the 0/1 indicator of automatability.

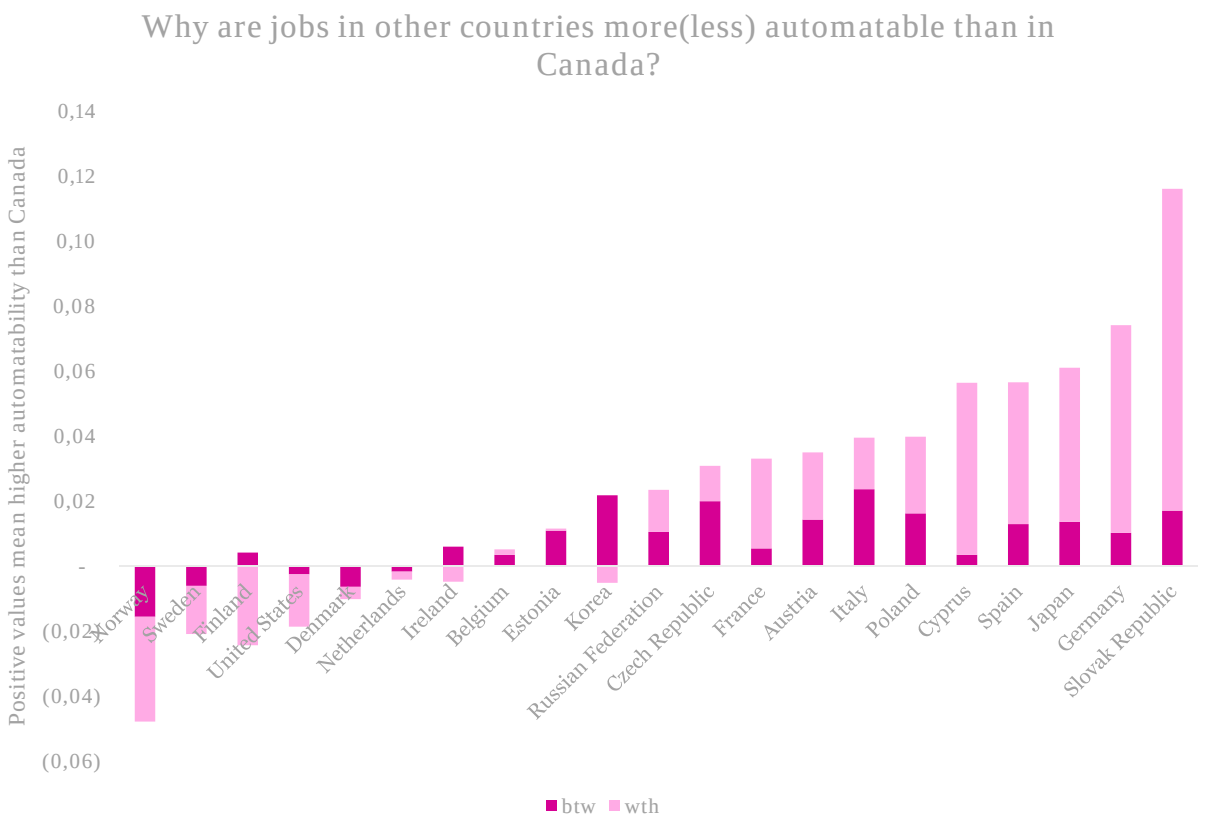
Number of obs = 4,656 R-squared = 0.1969
Root MSE = .448138 Adj R-squared = 0.1900

	Partial SS	df	MS	F	Prob<F
Model	227.25	40	5.68	28.29	-
planother~o	33.85	4	8.46	42.14	-
sell_fo	18.07	4	4.52	22.49	-
influence~o	17.74	4	4.44	22.09	-
communic_fo	14.50	4	3.63	18.05	-
advise_fo	12.41	4	3.10	15.45	-
dextrity_fo	10.93	4	2.73	13.60	-
teach_fo	4.10	4	1.03	5.10	0.00
negotiate~o	1.60	4	0.40	1.99	0.09
psolve1_fo	1.50	4	0.38	1.87	0.11
psolve2_fo	1.06	4	0.27	1.32	0.26
Residual	926.82	4,615	0.20		

Source: PIAAC, individual-level data for Canada, for the 71 occupations corresponding to the 70 Frey & Osborne (2017) occupations in the training data.

Why are jobs in other countries more(less) automatable than in Canada? A shift share analysis of industries

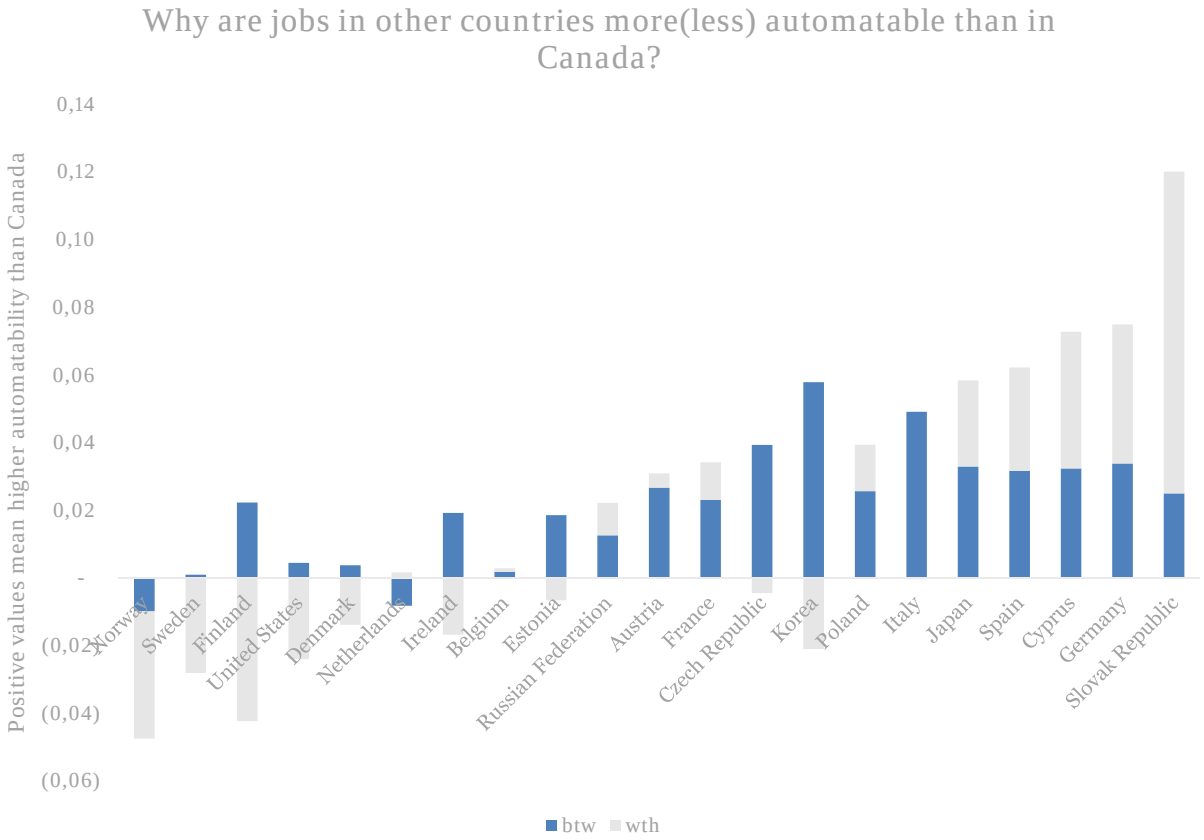
- Risk of automation may differ across countries either because the structure of economic activities (industries) differs (between variance), or because the way these industries organize the jobs differs (within variance).
- Surprisingly, most of the cross-country variance in automatability is explained by within-industry variation in tasks (70%) and less by differences in the industrial structure (30%).
- The findings vary a lot by country: between Canada and USA, we don't find significant differences in the industry structure, but the US jobs within same industries have more engineering bottlenecks than Canadian jobs. Between Korea and Canada, on the other hand, Korea's industry structure is biased towards industries with more automatable tasks.



Source: PIAAC, all countries, own calculations.

Why are jobs in other countries more(less) automatable than in Canada? A shift share analysis of occupations

- Countries differ in their level of automatability both because of differences in the structure of their occupations (50% of total variation) and because of the differences in the composition of tasks within occupations (50% of total variation)
- Between Canada and Sweden, for instance, differences in task composition within occupation almost fully explain why jobs in Sweden are more difficult to automate. In Korea, on the other hand, the within-occupational task differences make Korean jobs more difficult to automate, but the occupational structure is bias towards more automatable jobs.



Source: PIAAC, all countries, own calculations.

Differences in tasks: zooming in on Canada, Germany and the United States

- On average, workers in Germany report less frequent use than Canadian workers of almost all job tasks associated with engineering bottlenecks, except for communicating; In particular, the reporting of teaching tasks is about ½ S.D. less than in Canada.
- The opposite is the case of the USA; American workers report more instances of engineering bottlenecks in almost all dimensions, except for communicating.
- Workers in Norway report far less frequent use of manual (finger and hand) tasks than Canadian workers, but somewhat higher use of communicating and advising;
- Finally, workers in Slovakia report significantly less frequent use of tasks requiring social intelligence , and in particular, teaching (~1/2 S.D less), influencing (~1/2 S.D. less), and advising (~1/2 S.D. less)

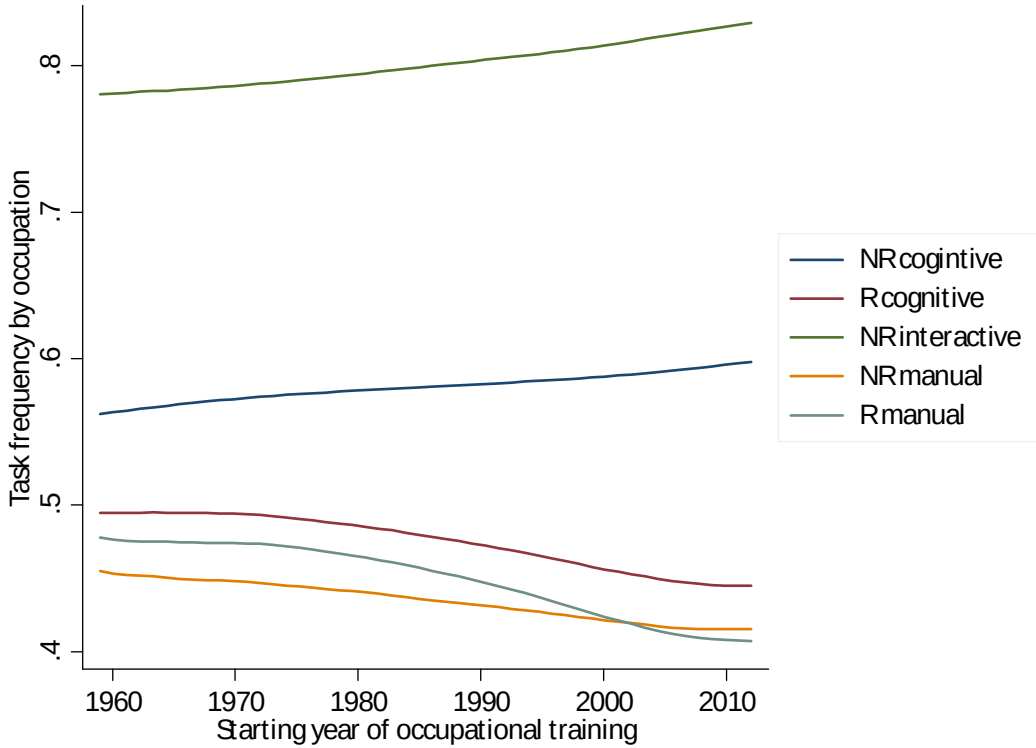
		Difference between average task scores in selected countries and average task scores in Canada (expressed in standard deviations)			
Job task	Mean task score in Canada	Germany	USA	Norway	Slovakia
dextrity_fo	4.11	(0.09)	0.20	(0.67)	0.02
psolve1_fo	4.04	(0.15)	0.09	0.00	(0.02)
psolve2_fo	2.85	(0.11)	0.16	(0.04)	0.03
teach_fo	2.80	(0.49)	0.20	0.01	(0.47)
planothers~o	2.55	(0.36)	0.12	0.06	(0.26)
influence_fo	3.26	(0.03)	0.04	0.02	(0.50)
negotiate_fo	2.81	(0.22)	0.10	(0.16)	(0.26)
sell_fo	2.26	(0.02)	0.03	0.02	(0.12)
advise_fo	3.55	(0.30)	0.11	0.20	(0.63)
communic_fo	4.21	0.06	(0.05)	0.14	(0.02)

Source: PIAAC, selected countries, own calculations.

TRAINING CONTENT AND THE RISK OF AUTOMATION

Risk of automation and training 1960-2012

- We have data on the occupations for which working Germans have received training (Ausbildungsberuf) in the dual system of education, the polytechnic and university education.
- Each person can list up to 5 such trainings chronologically
- We know the years in which the training started and ended
- Over time, Germans train more frequently in occupations that require high level of interactive and non-routine cognitive tasks;
- They train less frequently in occupations that require routine cognitive and routine manual tasks and non-routine manual tasks;
- These are between, not within-occupational changes. Task frequency is kept at 2006 levels.

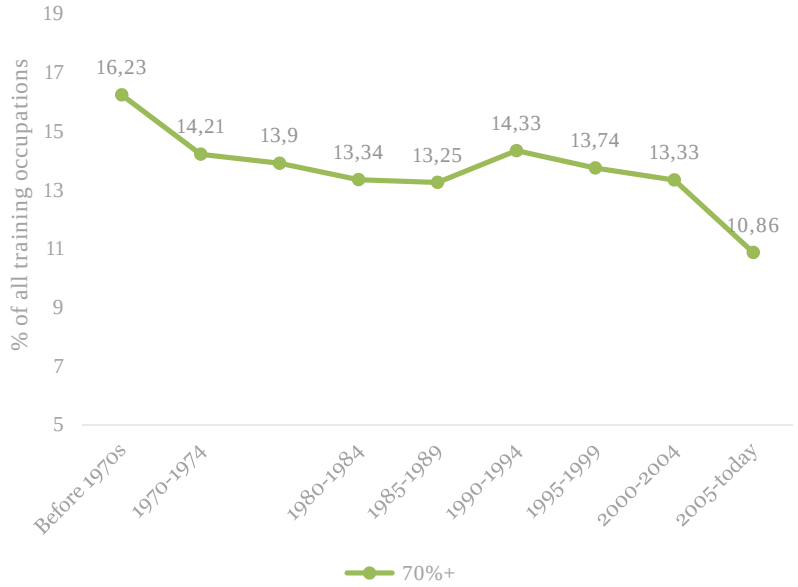


The graph plots the polynomial of ALM tasks (as measured in 2006) of the occupations for which training was obtained in the year indicated on the axis.
Source: BIBB 2011/2012.

Risk of automation and training: 1960-2012

- Today, only 11% receive training in occupations that have more than 70% chance of being automated;
- This was the case with 16% of those who were in training before the 1970s;
- What makes up for the difference between the automatability of actual jobs (23-24%) and the automatability of the training occupations? Jobs that do not require occupational training (e.g., elementary jobs).
- Why does this matter? It matters for the substitution of human capital. To an extent, technology substitutes jobs that where investment in HC is low.

Share of people undergoing training in occupations with more than 70% chance of being automated



Source: BIBB 2011/2012. ALM Automatability

Reskilling

When individuals reskills – i.e. they acquire a second qualification/certificate in a different occupation – does the second training have a lower risk of automation than the first one?

- Yes, the probability of automation in the second training is significantly lower than the one in the first training
- The second qualification is more intense on NR cognitive and NR interactive tasks
- The second qualification is less intense on R cognitive, NR manual and R manual tasks

	Mean (1st training)	Mean (2nd training)	t-stat	p-value	Obs.
Pr_ALM	0.55	0.51	19.52	0.00	6,968
Pr_FO	0.53	0.50	17.05	0.00	6,968
NR_cognitive	0.52	0.64	(43.51)	-	6,968
R_cognitive	0.51	0.45	22.28	0.00	6,968
NR_interac~e	0.76	0.83	(35.76)	0.00	6,968
NR_manual	0.47	0.39	19.39	0.00	6,968
R_manual	0.50	0.41	34.00	0.00	6,968

POLICIES TO ADDRESS EMERGING SHORTAGES

Policy lessons: some answers and a few questions

Initial education: can we teach creativity and social skills

- Learning to learn to be ready for ever changing skill needs: Estonia and Finland good examples
- Basic skills (literacy and numeracy) are often in shortage and are essential to further learning
- Can we teach creativity and social skills?

The rising importance of adult learning to fostering adaptability

- Ensuring portability (CPF)
- Engage the low-skilled: *Union Learning Fund* in the UK actively recruits low-skilled workers in training activities
- Link training for the unemployed to labour market needs
- Recognise informal and non-formal learning

Assess skill needs

- Invest in high-quality skill anticipation and assessment exercises and ensure use of skill needs data in policy;
- Ensure all relevant stakeholders are involved in the production of skill needs information.
- Strengthen co-ordination mechanisms between stakeholders in the assessment and use of skill needs information

Shape change

- Stimulate demand for higher-level skills: public investment in new technology infrastructure; education programmes to boost ICT skills in schools and in the workplace

CONCLUSIONS AND FUTURE WORK

Conclusions

Importance of:

- Tasks rather than Occupations
- Skills rather than Qualifications (scratch the surface)
- Look at what the labour market needs through the use of signals (wages, employment dynamics)

Policies can adapt to these changes when they are based on solid evidence

OECD keeps working in that direction with the forthcoming Skills for Jobs Database

Future research

1. Attaching a timeframe to the risk of automation
2. Looking at future skill shortages
3. Assessing the readiness of adult learning systems in the face of rapidly changing skill needs

Launch of the OECD Skills for Jobs Database

Conference
Paris, 10 July 2017

- ✓ 100+ participants
- ✓ Representatives from all OECD countries
- ✓ International organizations (ILO, WEF, EU Commission…)
- ✓ Business, social partners and academia, …

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Thank you

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