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The effects of technology  
and offshoring on changes  
in employment and the  
task-content of occupations

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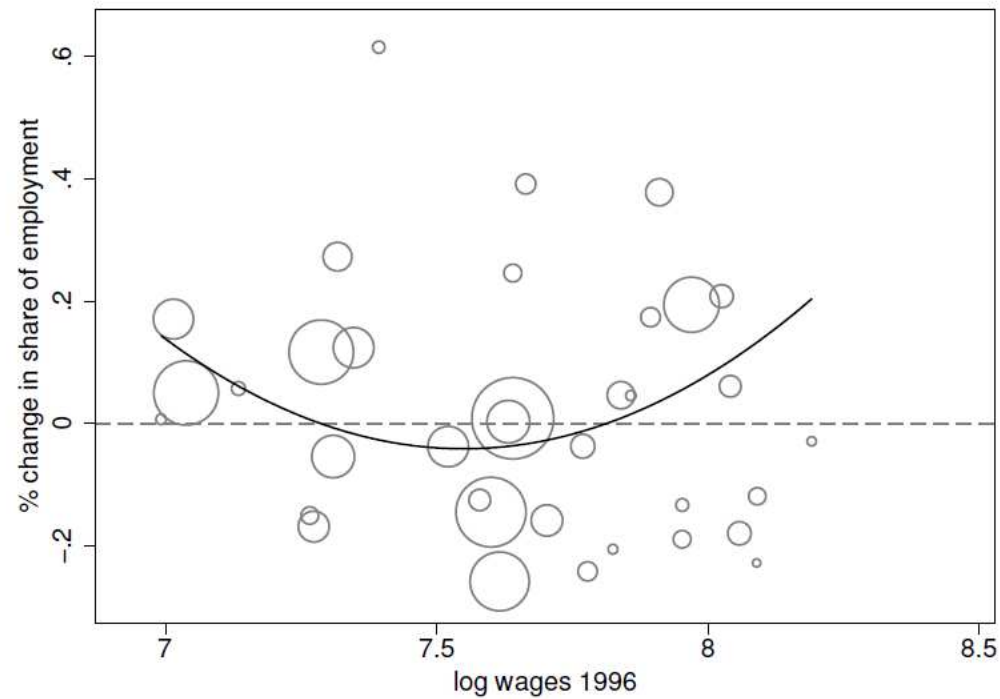


## Motivation

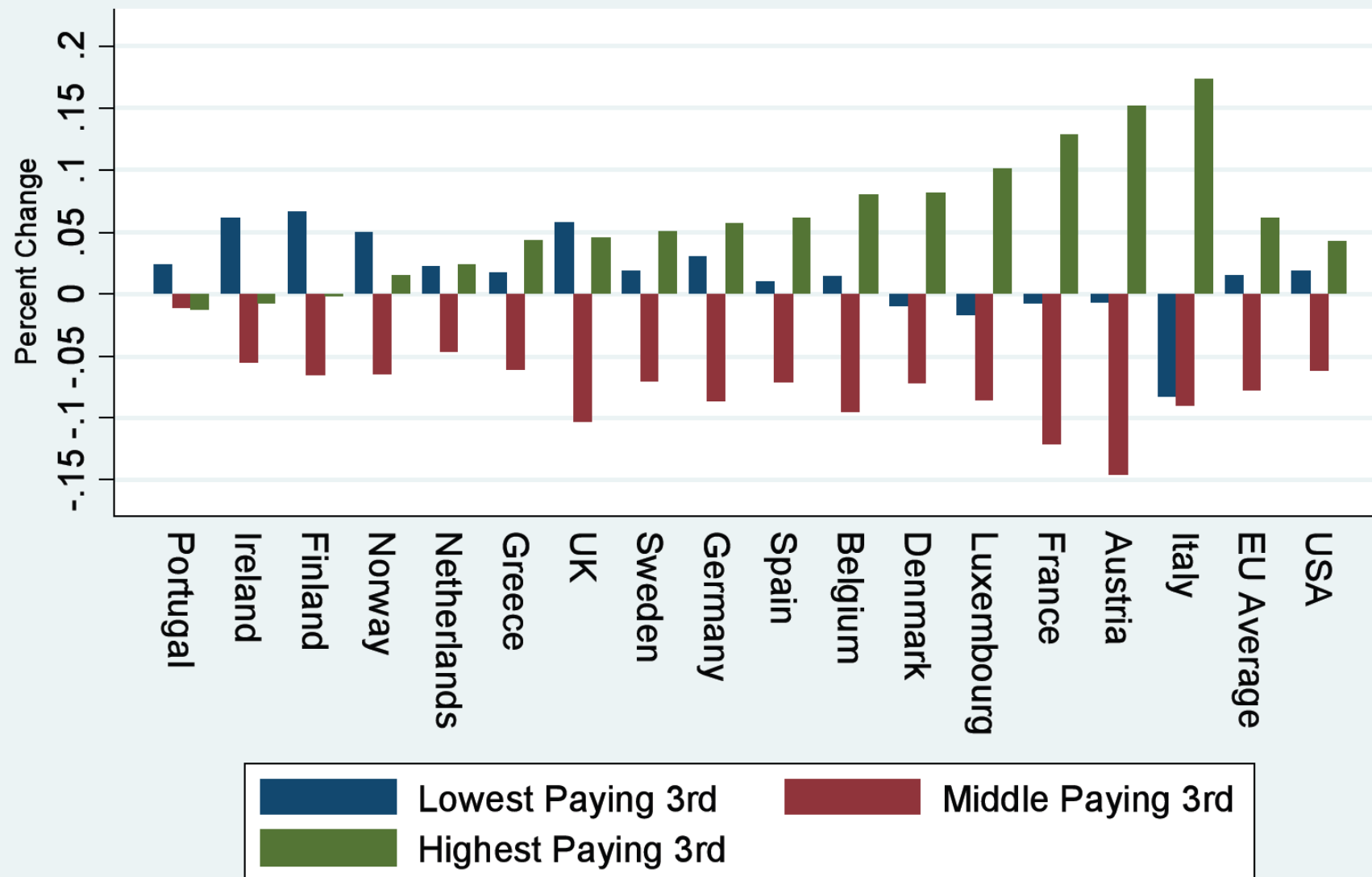
- ICT and globalization have changed the division of labour at different levels.
- In particular, recent studies have found widespread “job-polarization” for many OECD countries (Autor *et al.*, 2006; Goos and Manning, 2007; Acemoglu and Autor, 2010; Goos *et al.* 2011)
- There are two main explanations for these shifts in labour demand:
  - skill-biased technological change (SBTC)
  - globalization: trade and offshoring
- › But also SBTC can be endogenous (Acemoglu, 2002) and induced by trade (Bloom, Draca and Van Reenen, 2011).



Figure 2: Netherlands, changes in employment between 1996 and 2005 by occupations classified by wages, 2 digit SBC92 codes

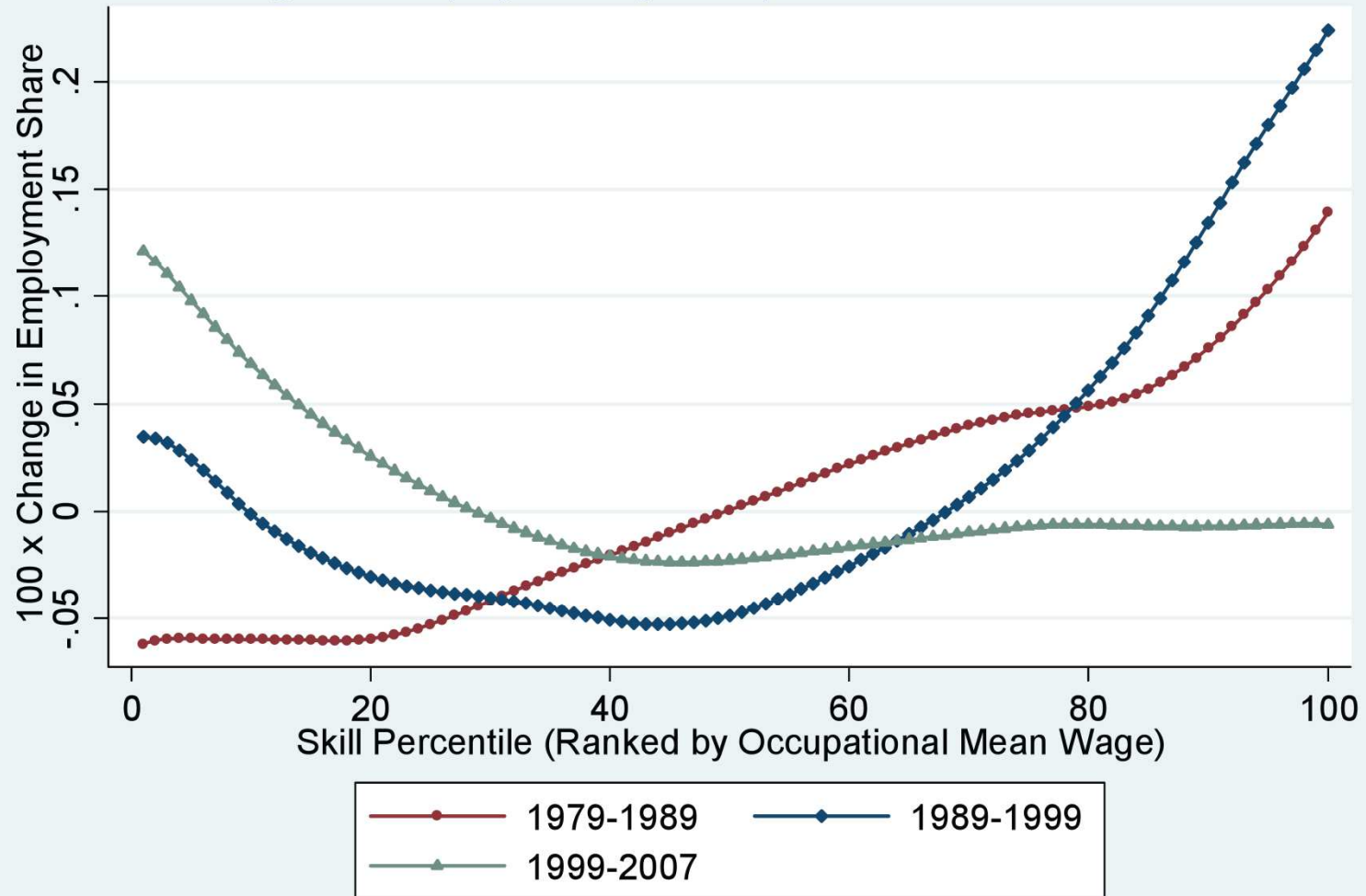


## Change in Employment Shares by Occupation 1993-2006 in 16 European Countries Occupations Grouped by Wage Tercile: Low, Middle, High





Smoothed Changes in Employment by Occupational Skill Percentile 1979-2007





## Literature

- Most studies have found that SBTC has been the main reason for increased job-polarization in the US and some OECD countries in the 80s and 90s, while offshoring had a significant but less important effect (Van Reenen, 2011 surveys the recent literature).
- However, the increase in offshoring levels since the 1990s has motivated further research and more studies are finding that offshoring has a sizeable effect, sometimes even larger than SBTC , for instance:
  - Firpo et al., 2011;
  - Goos et al., 2011



## Overview

- We look at employment changes at *both* the intensive margin (how the task-content is changing within occupations) and the extensive margin (how are employment levels changes by occupations).
- Until now, most papers focus only on the extensive margin.
- We use the British Skill Survey (BSS) for 1997, 2001 and 2006, linked with employment data from LFS and other data (i.e. wages, unionization) to look at *both* the changes in the extensive margin (employment) and intensive margin (task-content)
- Two main research questions:
  1. Has the task-content of occupations actually changed in the UK between 1997-2006?
  2. How has offshoring and SBTC affected both the extensive and intensive margins?



## Theoretical framework

- **Task-based framework:**

- Most papers are based on the task-based framework introduced by Autor, Levy & Murnane (QJE, 2003):
- They classify all tasks into two broad groups: routine and nonroutine tasks;
- Routinisation hypothesis: the significant fall in computer prices increased the demand for nonroutine tasks while reducing it for routine tasks:
  - Computers are strong substitutes to routine tasks groups;
  - Computers are complements to analytical and interactive (abstract) nonroutine tasks, and;
  - Computers have limited effects on manual nonroutine tasks.





## Theoretical approaches

- The routinisation hypothesis was formalized in the task-assignment model by Acemoglu & Autor, 2010.
  - › Continuum of tasks that can be performed by any worker-type (Low, Middle, High)
  - › Structure of comparative advantages assures that workers specialize in certain tasks depending on their skill level.
  - › The equilibrium conditions of the model are given by two key variables: the equilibrium threshold tasks  $I_L$  and  $I_H$ .
- SBTC (computers) and offshoring remove tasks (or moves them to another country), and this changes the equilibrium thresholds  $I_L$  and  $I_H$
- Main insight: changes in demand for tasks, changes *both* the extensive margin (number of jobs) and the intensive margin (number of tasks by occupation)



Figure 23. Equilibrium Allocations of Skills to Tasks

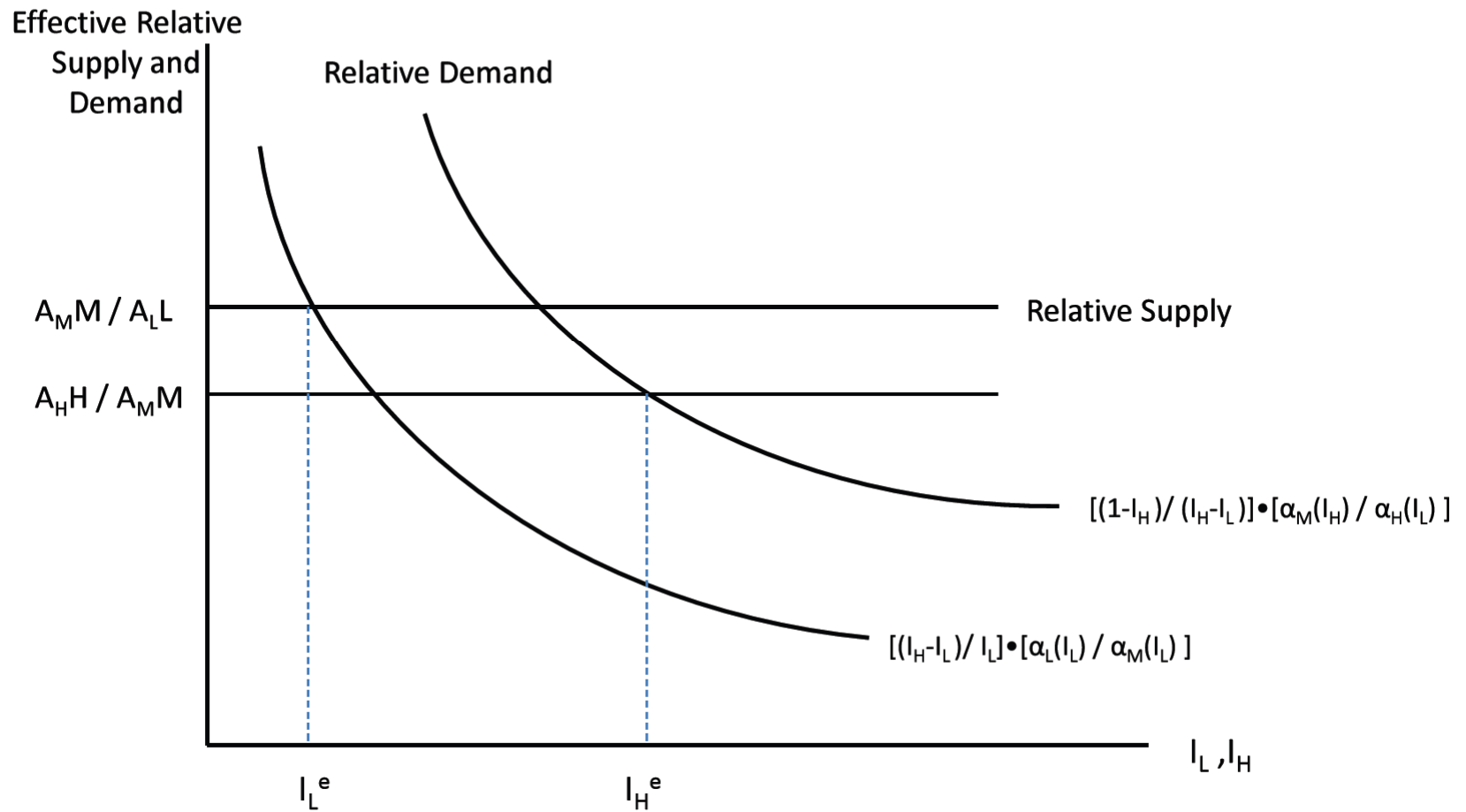
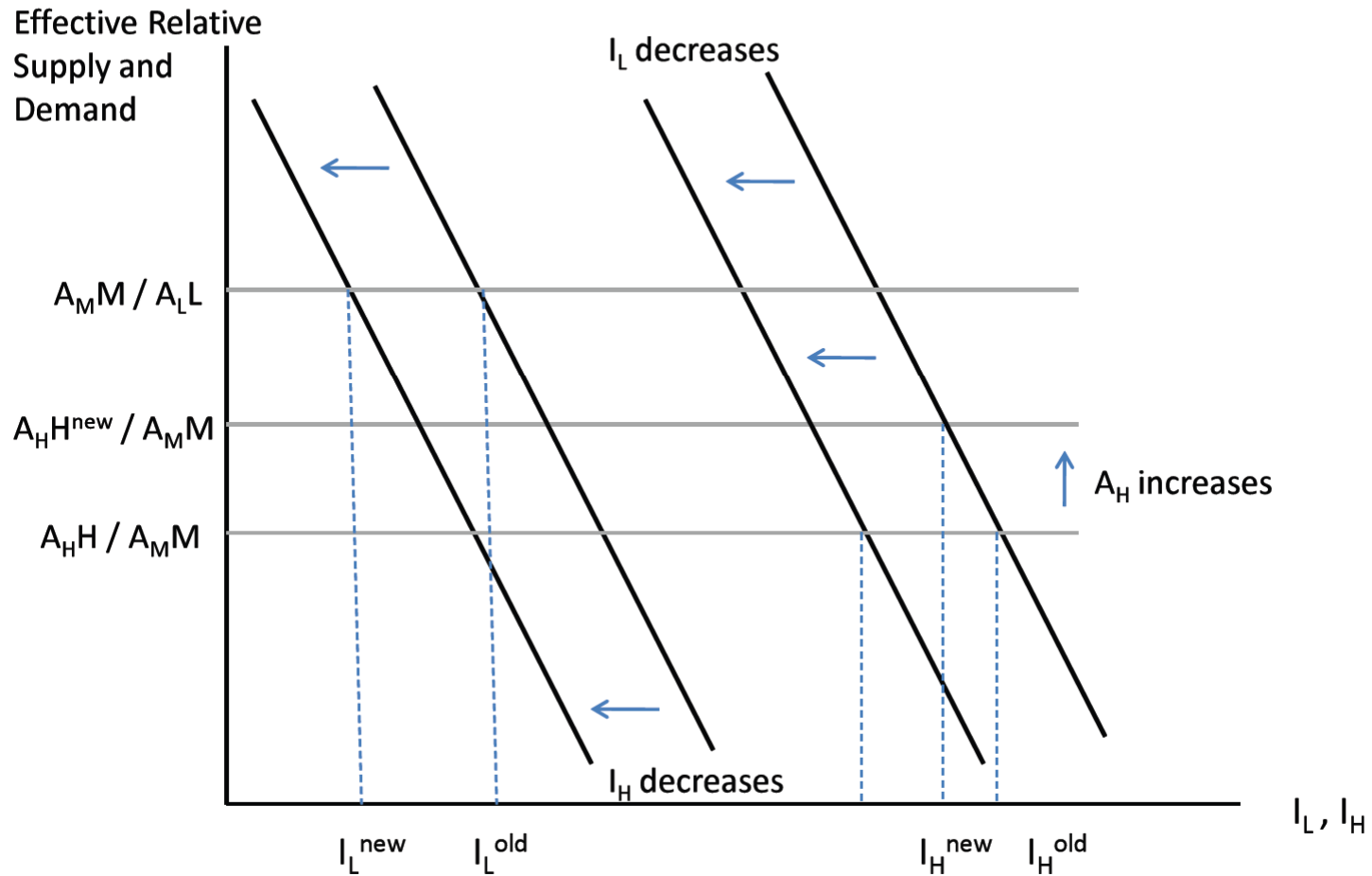




Figure 26. Changes in Equilibrium Allocation





## Intensive and extensive margin changes

- A less noticed idea from Autor, Levy & Murnane (ALM) is that they are distinguish that the task-demand can change at two dimensions:
  - at the extensive margin (changes in the employment of occupations, each with a fixed task-content)
  - at the intensive margin (changes in the task-content of occupations, with fixed employment levels by occupation)
- ALM had task-data for two years: 1977 and 1991, which corresponded to the Fourth Edition and Revised Fourth Edition of the DOT dataset
- But the DOT was replaced by the ONET dataset, and ONET does not have changes in the task-content over time!
- Thus, recent papers (Firpo et al. 2011, Goos et al. 2011) use the ONET database and they cannot look at changes of the intensive margin



## First research question

- Thus, all the papers after ALM can only look at the extensive margin (employment changes using census or labour force surveys) and must assume that the intensive-margin (i.e. the task-content of occupations) is fixed.
1. Has the task-content of occupations actually changed in the UK between 1997-2006?



## Measuring changes in task-content

- We use three different approaches:
  1. Task-based approach: classifies occupations by their task-content characteristics:
    - Autor et. al: Use the “routinization hypothesis”
  - We use detailed task data at the individual level, but we want to move away from the routine/non-routine task classification used in Autor et al. (2003) and subsequent papers
    - › Their approach is well suited for a SBTC analysis (computerization), but not precisely for offshoring
  2. Factor-analysis to create 8 groups (out of 36 tasks in BSS)
  3. Summary indicators (e.g. task-occupation connectivity and task- rank correlations)



## Data

- The UK task data: British Skills Survey (BSS) by occupation and industry for 1997, 2001 and 2006
- In addition:
  - Employment data UK: British Labour Force Survey by occupation and industry (from 1997 to 2006)
  - Wage data UK Annual Survey of Hours and Earnings (ASHE) by occupation also from 1997 to 2006
  - All data is linked through Standard Occupational Classification (SOC\_2000)
- We have a very rich dataset combining:
  - Task-content / employment /wages at different levels (e.g. occupations, industries) for three different years



## BSS Task-data characteristics

- Tasks are defined as a broad set of “assignments/operations” performed across different occupations and industries.
  - E.g. using physical strength, using a computer, dealing with people
  - Thus, tasks are not equivalent to jobs!
  - In addition, they are not related to goods or intermediate inputs (as in the trade in tasks model of Grossman & Rossi-Hansberg, 2008)
- We still end up with 36 tasks, which are difficult to analyze jointly:
  - This is why routinisation classification is so popular
  - But it just uses one “dimension” of the task information and we expand on this by using other classifications





## Task examples:

code	task name	task description
1	detail	paying close attention to detail
2	people	dealing with people
3	teach	teaching people (individuals or groups)
4	speech	making speeches/ presentations
5	persuad	persuading or influencing others
6	selling	selling a product or service
7	caring	counselling, advising or caring for customers or clients
8	teamwk	Working with a team of people
9	listen	Listening carefully to colleagues
10	strength	physical strength (e.g., to carry, push or pull heavy objects)
11	stamina	physical stamina (e.g., to work for long periods on physical activities)
12	hands	skill or accuracy in using hands/fingers (e.g., to mend or repair, assemble etc.)
13	tools	knowledge of use or operation of tools/equipment machinery)
14	product	knowledge of particular products or services
15	special	specialist knowledge or understanding
16	orgwork	knowledge of how organisation works
17	usepc	Using a computer, 'PC', or other types of computerised equipment
18	faults	spotting problems or faults (in your own work or somebody else's work)
19	cause	working out cause of problems/ faults (in your own work or somebody else's work)
20	solutn	thinking of solutions to problems (in your own work or somebody else's work)



- For each worker surveyed we have task data and its importance:
- We can classify workers by occupation, industry and year

Individual level task data				
	importance	importance	importance	importance
person	task 1	task 2	.....	task n
1	0	3	.....	4
2	1	1	.....	4
3	3	4	.....	3
4	4	4	.....	2
5	4	2	.....	1
6	4	2	.....	2
7	3	1	.....	1
8	3	3	.....	2
9	2	3	.....	3
10	2	4	.....	4
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## Using BSS task data we obtain several indicators

- We can construct a Routine Task Intensity (RTI) index
  - And compare it with RTI from ONET
- Factor analysis to create 8 task-factor groups
- Three summary variables:
  1. Task-rank correlation
  2. Task-occupation correlation (TOC)
  3. Task-concentration



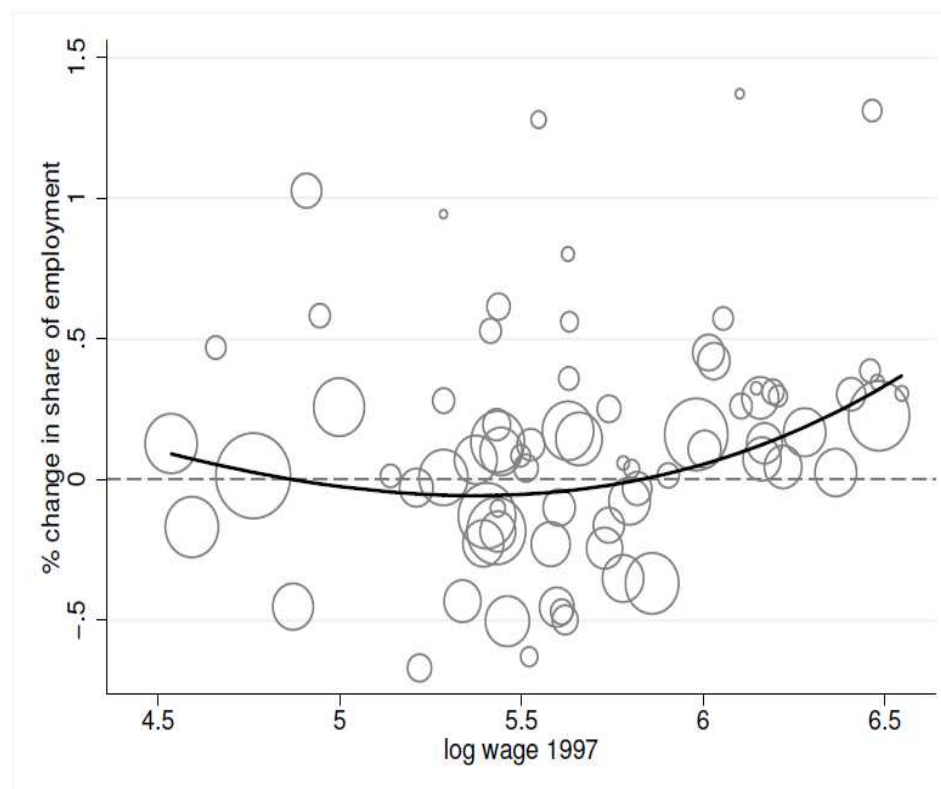
## Empirical results:

1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)



## Job polarization (from LFS data)

Figure 1: United Kingdom, changes in employment between 1997 and 2006 by occupations classified by wages per hour, 3-digit SOC00 occupational codes





## Empirical results:

1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)
2. Routinisation (RTI) is changing in both at the extensive *and* intensive margin



Table 2: Tasks shifts, intensive and extensive margin

	Routine	Non-routine	
		Service	Abstract
Importance 1997	34.21	40.30	25.49
Importance 2006	33.14	40.90	25.95
Change	-1.07	0.61	0.46
Extensive margin	-0.65	0.24	0.41
Intensive margin	-0.42	0.37	0.06



## Empirical results for first paper:

1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)
2. RTI is changing in both at the extensive *and* intensive margin
3. When using factor-groups, also changes at *both* margins





Table 2: Shifts in task-content using eight factor-groups and changes at the extensive and intensive margins

All occupations								
	literacy	problem solving	checking	planning	number	physical	interactive	PC use
task1997	3.80	5.68	7.67	5.28	2.15	3.60	4.50	3.33
task2006	3.80	5.07	7.56	5.35	1.92	3.11	4.32	4.87
change	0.00	-0.60	-0.11	0.08	-0.23	-0.49	-0.18	1.54
extensive margin	0.10	-0.06	-0.03	0.09	-0.02	-0.22	0.07	0.08
intensive margin	-0.10	-0.54	-0.08	-0.02	-0.21	-0.27	-0.25	1.47



## Empirical results for first paper:

1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)
2. RTI is changing in both at the extensive *and* intensive margin
3. When using factor-groups, also changes at *both* margins
4. Summary indicators:
  - > Rank-correlation is also changing, specially for high-skill occupations



- Task-rank correlation: measures the changes in relative importance of tasks, by comparing the correlation between the rank of the tasks within the occupation in 1997 and 2006 (a lower correlation indicates more changes in the importance of tasks within the occupation)





## Empirical results for first paper:

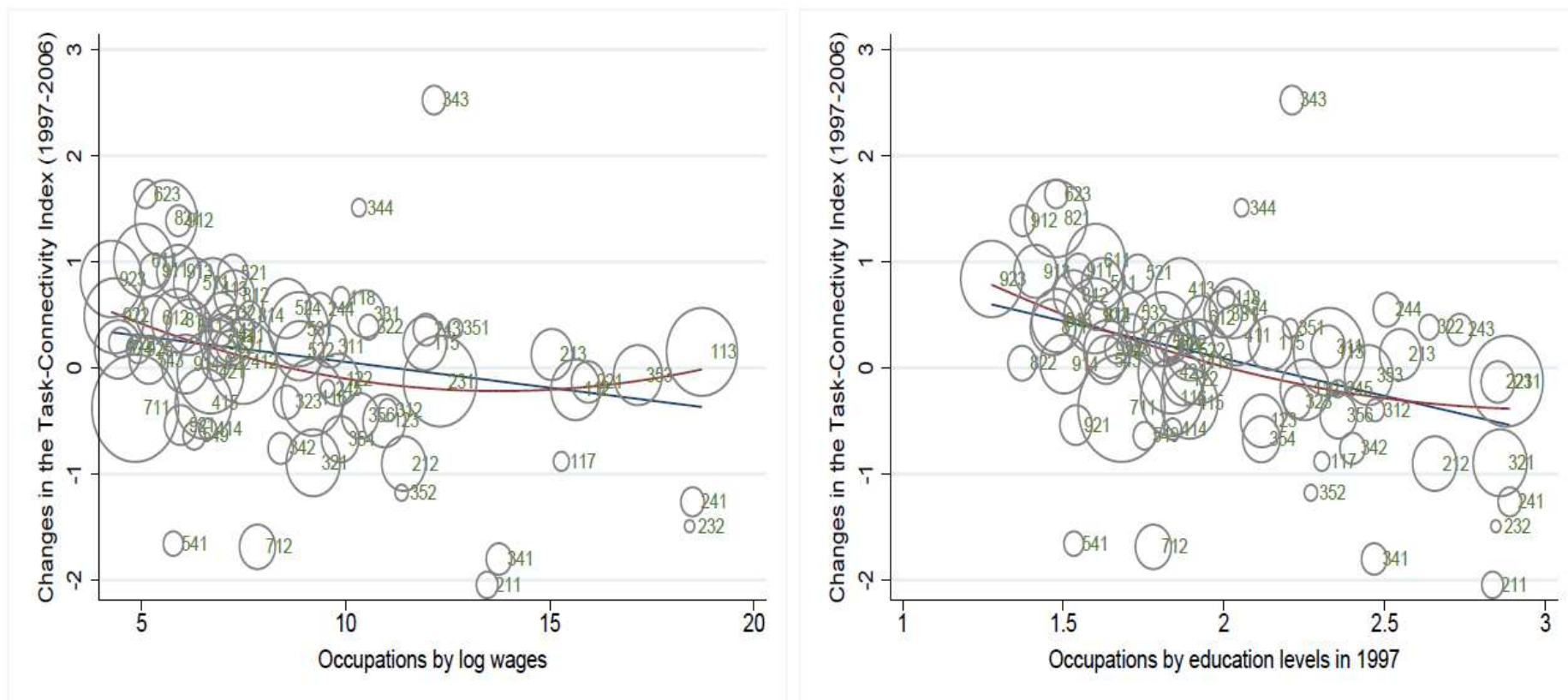
1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)
2. RTI is changing in both at the extensive *and* intensive margin
3. When using factor-groups, also changes at *both* margins
4. Summary indicators:
  - > Rank-correlation is also changing, specially for high-skill occupations
  - > TOC also changing: decreasing for low-skill and increasing for high skill



- Task-occupation correlation (TOC): measures how different tasks within an occupation are correlated to most important core-tasks for that occupation.



Figure 4: United Kingdom, changes in task-occupation connectivity (TOC) indicator between 1997 and 2006 by occupations classified by wages per hour (left) and education levels (right), 3-digit SOC-2000 occupational codes





## Empirical results for first paper:

1. Using only employment data, we also find job polarization pattern, as Goos et al. (2011)
2. RTI is changing in both at the extensive *and* intensive margin
3. When using factor-groups, also changes at *both* margins
4. Summary indicators:
  - > Rank-correlation is also changing, specially for high-skill occupations
  - > TOC also changing: decreasing for low-skill and increasing for high skill
  - > Concentration (Gini coefficient for task importance) also changing (moving to more multi-tasking and less task-specialization)

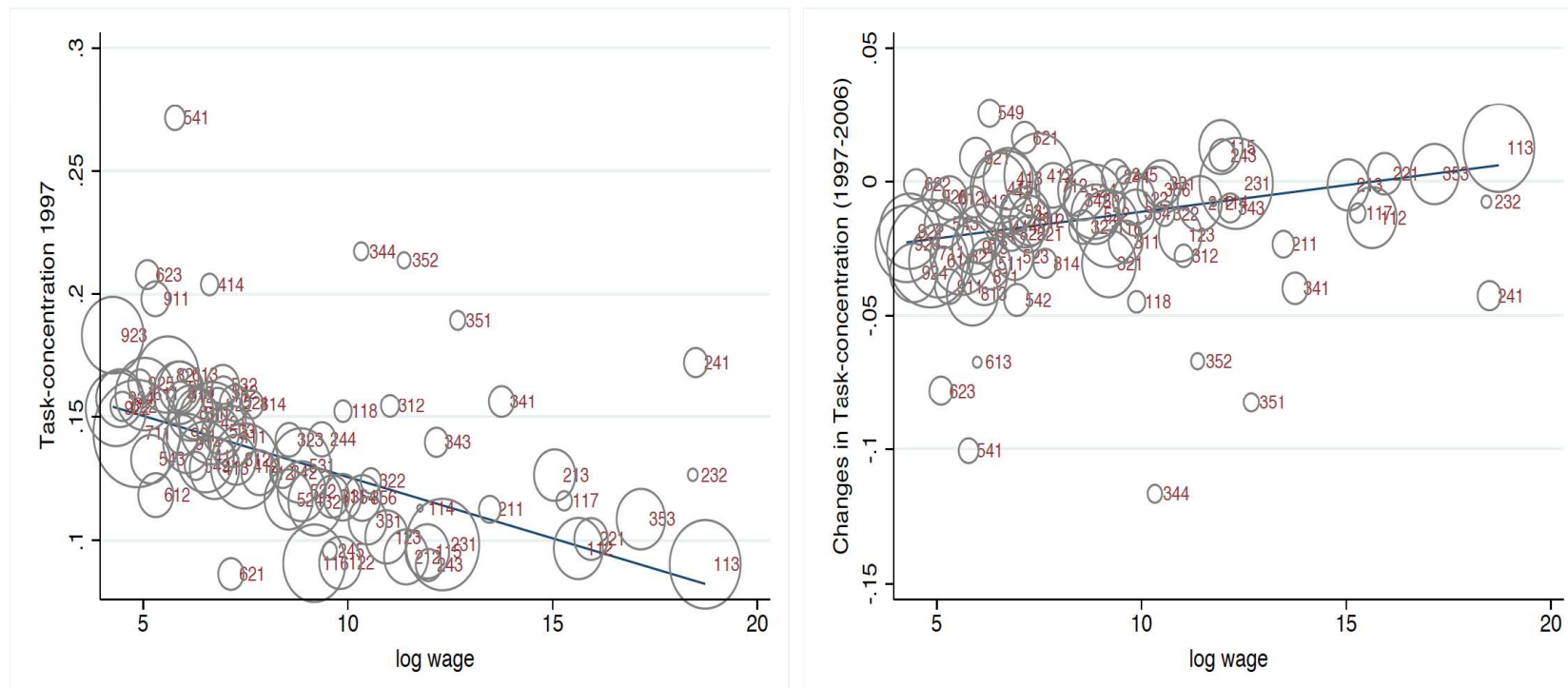




- Task-concentration: using the Gini coefficient we measure how the importance of tasks is concentrated and how it changes within the occupation between 1997 and 2006
- A lower Gini coefficient indicates more task “generalization” or multi-tasking, while higher coefficients indicate more “specialization”.



Figure 4: United Kingdom: Task-concentration (Gini coefficient) in 1997 (left) and changes between 1997 and 2006 (right) by occupations classified by wages per hour, 3-digit SOC00 occupational codes





## Main results for FIRST research question:

1. Task-content *is* changing and at different dimension:
  - > by Routine (RTI) index
  - > by factor-groups
  - > by task-correlation, task-occupation connectivity (TOC) and by task-concentration
2. This fits with the theoretical model by Acemoglu and Autor (2010) where the task-content of occupations is key to understand changes in labour demand
3. It also makes it difficult to maintain the assumption (implied by recent empirical papers using the ONET database) that the task-content is constant over time

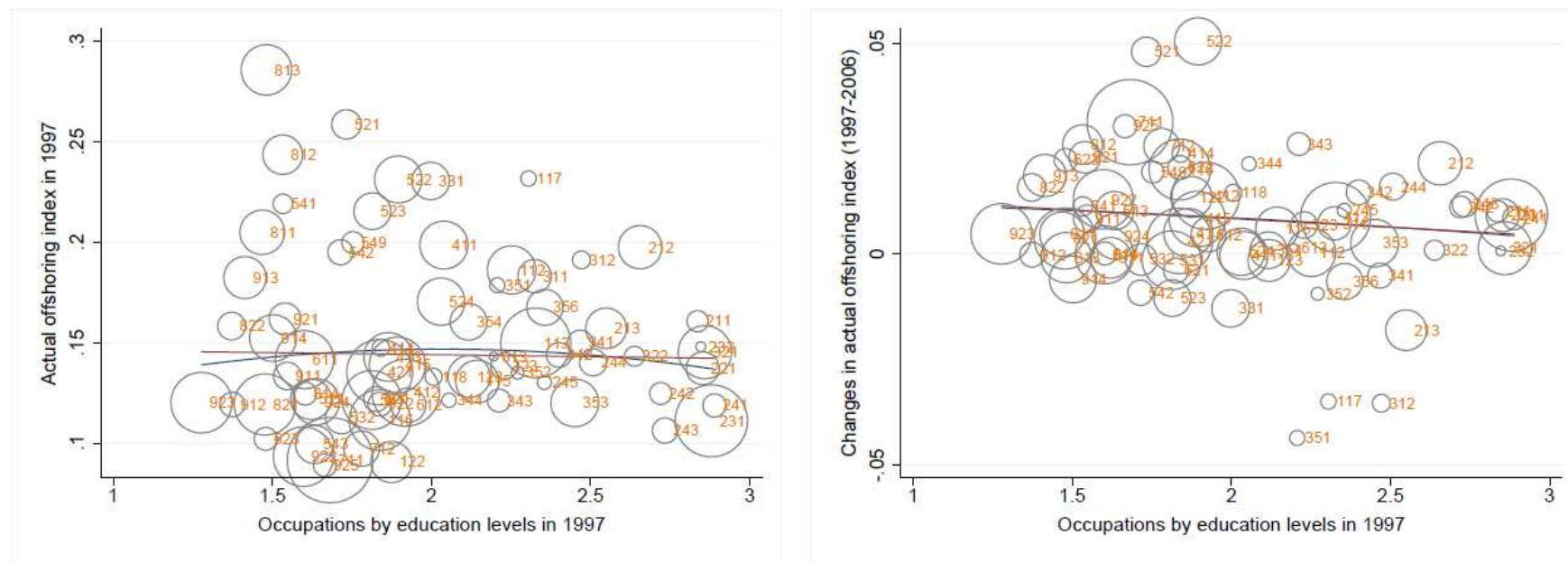


## Second research question

- How has offshoring and SBTC affected both the extensive and intensive margins?
- First, we need to obtain indicators for offshoring:
  - › Actual offshoring index (AOI): using IO tables (WIOD) and following Feenstra and Hanson (1996)
  - › Spatial separability index (SSI): based on the idea that tasks are offshorable depending if they can be spatially separated (Blinder, 2006, 2009)
- ... and Indicators for SBTC:
  - › RTI from ONET data following Acemoglu and Autor, 2010; and mapping at the BSS occupational level
  - › From BSS: RTI and Computer-use index (CUI)



Figure 7: United Kingdom, actual-offshoring index (AOI) for 1997 (left graph) and changes in AOI between 1997 and 2006 (right graph), by occupations classified by education levels in 1997, 3-digit SOC-2000 occupational codes, with linear and quadratic fit (weighted by 1997 employment levels)

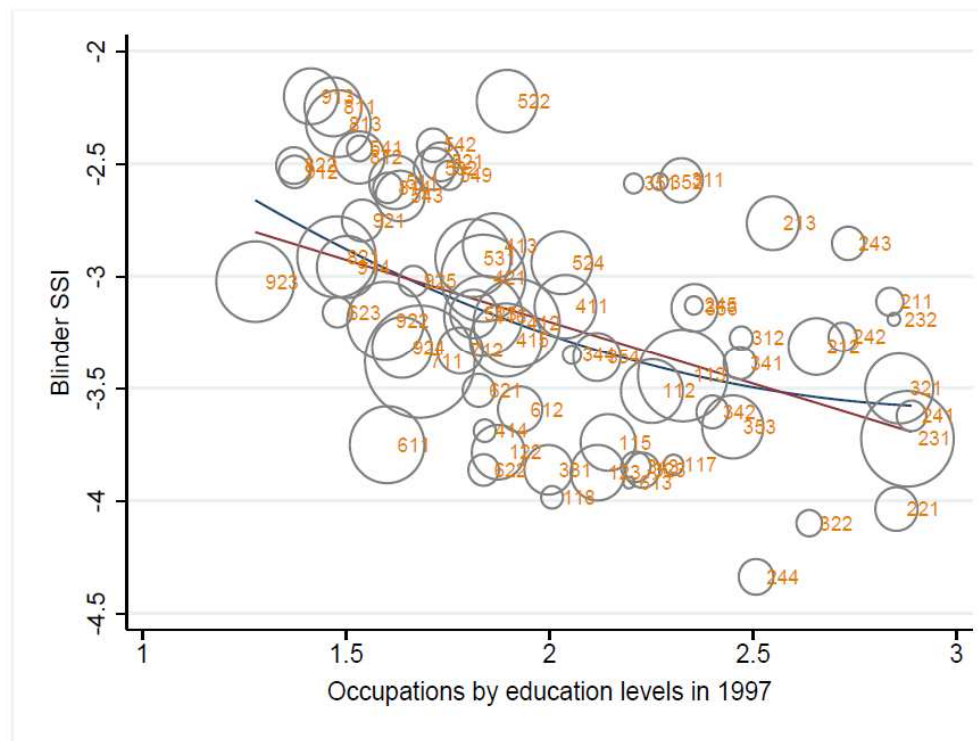


Source: Own estimations using WIOD, BSS and ASHE data.



## Note: Correlation RTI with SSI is only about 0.4!

Figure 8: United Kingdom, Blinder spatial-separability index (SSI), when occupations are classified by education levels in 1997, 3-digit SOC-2000 occupational codes



Source: Own estimations using ONET and UK LFS data.



## Regressions by occupations

$$X_i = \alpha_0 + \alpha_1 O_i + \alpha_3 S_i + \alpha_2 C_i + \epsilon_i$$

- Dependent variables (X):
  - Employment changes (extensive margin)
  - Task-rank correlation (intensive margin)
- Independent variables:
  - O=Offshoring: AOI, or Spatial separability index from Blinder (2010) at occupation level).
  - S=SBTC (RTI for both BSS and ONET, or computer-use index (CUI)
  - C=Control variables: initial employment, unionization, initial education or wages (since both all highly correlated)





Table 3: OLS estimates for the changes in employment between 1997 and 2006, United Kingdom, 3-digit occupational level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log employment	-0.400*** [0.104]	-0.367*** [0.098]	-0.376*** [0.096]	-0.374*** [0.102]	-0.367*** [0.098]	-0.386*** [0.104]	-0.395*** [0.098]	-0.375*** [0.099]
Offshoring (AOI)	-0.178*** [0.045]		-0.109** [0.042]				-0.195*** [0.044]	
Blinder index (SSI)				-0.225*** [0.050]	-0.114 [0.094]			-0.213*** [0.058]
RTI-ONET		-0.234*** [0.055]	-0.189*** [0.054]		-0.149 [0.099]			
Computer Use (CUI)						0.113 [0.077]	0.122* [0.072]	0.043 [0.084]
Union	0.648 [0.435]	0.644 [0.426]	0.617 [0.419]	0.667 [0.403]	0.656 [0.406]	0.670 [0.468]	0.623 [0.436]	0.658 [0.407]
Constant	0.321*** [0.083]	0.330*** [0.081]	0.329*** [0.080]	0.332*** [0.081]	0.331*** [0.080]	0.328*** [0.089]	0.329*** [0.084]	0.336*** [0.082]
Observations	74	73	73	73	73	73	73	72
R-squared	0.368	0.423	0.446	0.414	0.436	0.328	0.413	0.422

Notes: Dependent variable is the change in employment (1997-2006). All independent variables are for 1997 except Union, which measures the change in percentage of workers who are associated to a trade union between 1997-2006. All regressions are at the 3-digit SOC-2000 occupational level. Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$





## EXTENSIVE margin econometric results:

- For the UK our results show that both SBTC and offshoring are important factors explaining changes in employment in British jobs
- The effect of SBTC is somewhat larger than offshoring:
  - if offshoring increases with one standard deviation this results in a decrease in employment change of about 15 to 20%.
  - If the RTI increases with one standard deviation employment change decreases with about 20 to 25%.



Table 5: OLS estimates for the changes in the task-rank correlation indicator between 1997 and 2006, United Kingdom, 3-digit occupational level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log employment	0.068*** [0.013]	0.066*** [0.013]	0.066*** [0.013]	0.066*** [0.012]	0.066*** [0.013]	0.067*** [0.013]	0.068*** [0.014]	0.066*** [0.012]
Offshoring (AOI)	0.003 [0.008]		-0.004 [0.008]				0.005 [0.008]	
Blinder Index (SSI)				0.018* [0.010]	0.015 [0.018]			0.017 [0.011]
RTI-ONET		0.016** [0.007]	0.017** [0.008]		0.005 [0.014]			
Computer Use (CUI)						-0.011 [0.011]	-0.011 [0.011]	-0.005 [0.012]
Union	0.198** [0.084]	0.201** [0.084]	0.200** [0.086]	0.199** [0.080]	0.200** [0.080]	0.200** [0.084]	0.201** [0.085]	0.201** [0.080]
Constant	0.893*** [0.010]	0.892*** [0.010]	0.892*** [0.010]	0.892*** [0.010]	0.892*** [0.010]	0.892*** [0.010]	0.892*** [0.010]	0.891*** [0.010]
Observations	74	73	73	73	73	73	73	72
R-squared	0.542	0.560	0.561	0.566	0.566	0.553	0.554	0.571

Notes: Dependent variable is task-rank correlation 1997-2006. All independent variables are for 1997 except Union, which measures the change in percentage of workers who are associated to a trade union between 1997-2006. All regressions are at the 3-digit SOC-2000 occupational level. Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$



## INTENSIVE margin econometric results:

- The offshoring indicators are usually not significant
- But the effect of our SBTC indicators is significant:
  - If the RTI increases with one standard deviation the task-rank correlation index decreases with about 20 to 25%.
- Moreover, changes in the task-rank correlation are strongly associated with higher degrees of unionisation.
  - The union indicator has positive, significant and robust coefficients



Table 6: OLS estimates for the changes in the task-occupation connectivity (TOC) index between 1997 and 2006, United Kingdom, 3-digit occupational level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log employment	0.124 [0.117]	0.096 [0.106]	0.084 [0.106]	0.113 [0.111]	0.096 [0.107]	0.118 [0.105]	0.119 [0.107]	0.115 [0.103]
Offshoring (AOI)	-0.027 [0.083]		-0.145* [0.086]				0.018 [0.073]	
Blinder Index (SSI)				0.135 [0.093]	-0.136 [0.167]			0.081 [0.096]
RTI-ONET		0.264*** [0.066]	0.323*** [0.078]		0.365** [0.138]			
Computer Use (CUI)						-0.250*** [0.091]	-0.251*** [0.093]	-0.204** [0.094]
Union	2.142*** [0.710]	2.229*** [0.715]	2.193*** [0.720]	2.216*** [0.674]	2.243*** [0.755]	2.201*** [0.710]	2.205*** [0.717]	2.255*** [0.696]
Constant	0.162 [0.103]	0.149 [0.097]	0.148 [0.096]	0.148 [0.103]	0.150 [0.097]	0.139 [0.097]	0.139 [0.097]	0.127 [0.097]
Observations	74	73	73	73	73	73	73	72
R-squared	0.291	0.378	0.395	0.328	0.386	0.382	0.382	0.397

Notes: Dependent variable is changes in TOC (1997-2006). All independent variables are for 1997 except Union, which measures the change in percentage of workers who are associated to a trade union between 1997-2006. All regressions are at the 3-digit SOC-2000 occupational level. Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$



## Main results SECOND research question:

- Offshoring significantly affects changes in employment levels (extensive margin) but not at the intensive margin (task-rank correlation nor TOC)
- SBTC affect strongly changes in both the extensive *and* intensive margin.
- For changes in employment levels, the SBTC effects are still larger than the offshoring effect, but offshoring has become more important (as in Firpo *et al.*, 2011; and Goos *et al.*, 2011)
- These last effects, are also confirmed when using Dutch employment changes data