Technological change and Job Satisfaction

Tim Hinks, Bristol Research Economics

University of the West of England, Bristol (UWE)

Workshop on Human-centred digital transitions: skill mismatches in European workplaces

CEDEFOP 11-12th December 2024 Thessalonika

Background

Interest in a historical perspective on what impact the "4th industrial revolution" of AI and Robotics will have on the economic landscape – can we learn anything from the past?

First question is "What are the characteristics of successful innovation?" – Historical-based answer from Mokyr (1992).

What are the previous consequences of industrial revolutions?

(i) Earnings increase

(ii) GDP per capita increases

(iii) Capital wealth increases and so too ***wealth inequality*** (Mokyr et al, 2015; Deaton, 2013)

(iv) Technological unemployment - "due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1933, p. 3).

The adoption and diffusion of new technologies and innovation is seen as being vitally important in raising productivity and growth levels amongst economists.

When did IR4.0 begin?

Background: When did IR4.0 begin?

“The transition period that follows the crash is what we are experiencing now (the last equivalent period was in the 1930s, after the crash of 1929). Our current revolution, which began roughly in 1971, the year Intel’s microprocessor was launched, is only half-way through its diffusion path. If history is a guide, it has twenty to thirty years of deployment ahead. In the past, those years have typically been a positive-sum game between business and society, thanks to government providing a common direction for convergent innovation and profitable investment, based on dynamic and sufficient demand.”

Perez and Leach (2018)

“A Smart Green ‘European Way of Life’: the Path for Growth, Jobs and Wellbeing”, Beyond the Technology Revolution WP 2018-01.

Many argue that current waves of new technologies such as co-bots, machine learning and artificial intelligence such as large language models are actually a 5th industrial Revolution.

Background

If focus on Intel microchip and what Perez calls IR4.0, then it is clear that during the 1980s and 1990s the introduction and then widespread diffusion of computers in the workplace resulted in a switch in demand towards more educated workers (Autor et al, 1998).

Results in a wage premium associated with using computers within jobs based on the "premise that computers increased cognitive skill requirements and complemented skilled and educated workers" (Freeman et al, 2020, p.394 taken from Handel, 2007) – skills-biased hypothesis. Evidence using LITS IV found that people with more digital skills also command a wage premium.

Raises the question "Do new technologies impact occupations differently?"

Goos and Manning (2007), Autor et al (2003, 2006), Goos et al (2009), Aksoy et al (2021) and Anton et al (2022) find the answer to be ***yes*** with the hollowing-out of middle-occupations, polarization of labour markets, greater pay inequality and greater gender pay inequality.

Theoretically

(1) New technologies can result in the creation of completely new occupations and new industries as well as destruction of current occupations and industries.

(2) New technologies can result in job displacement but through skills-biased can result in a wage premium.

(3) Countervailing re-instatement effects, whereby technologies create new tasks in which labour has a comparative advantage (Acemoglu and Restrepo 2019).

Background

Evidence of impact of new generation robots and of new digital technologies.

Acemoglu et al (2017), Acemoglu and Restropo (2016, 2017), Dauth et al (2018) use the International Federation of Robotics date series.

Findings are pessimistic in that employment has fallen, some evidence earnings have fallen and earnings inequality has risen – job displacement occurring in manufacturing sector.

Frey and Osbourne (2013, 2017) use O*NET definitions and analyse the impact artificial intelligent-type technologies will have on occupations – very large impact across many occupations but have subsequently been found to be something of outliers in the subsequent empirical literature, e.g. Arntz, Gregory, and Zierahn (2017), Nedelkoska and Quintini (2018), Pouliakas (2018), Vivarelli (2014) and Harrison et al. (2014).

Interesting methods being used to consider use of new technologies in occupations, e.g. use AI to scan job vacancies for key-words and form measures of occupations that maybe most at risk and predict impact on employment (ESCoE 2021 conference for examples).

Recent papers by DeStefano, Kneller and Timmis (2023, 2024) analyse the impact of broadband coverage and cloud-computing on the performance of UK firms.

Technological change and Job Satisfaction

One aspect of new technologies under-researched is the impact they have on current the work force.

Why important?

Technological Anxiety: (Mokyr et al, 2015; Robelski and Wischniewski (2018); Körner et al. (2019); Szalma and Taylor (2011) and Gihleb et al. (2022).).

Those who perceive themselves most at risk from automation report higher job insecurity fears and lower job satisfaction (e.g. Gornay and Woodard, 2020; Schwabe and Castellacci, 2020; Dekker et al, 2017; Hinks, 2021, 2024a, 2024b; Ivanov et al, 2020; Guintella et al, 2023).

Implications for adoption of new technologies – or not if think this is inevitable and just a temporary issue based on previous technological revolutions.

Link between the Technology Acceptance Model (Perceived usefulness and Perceived ease of use) of Fred Davis (1985) and job satisfaction may be under-explored in relation to new technologies…..may be of no use!

Technological change and Job Satisfaction

Objective:

(1) To identify whether exposure to new technology has any relationship to job satisfaction.

(2) To identify if workers who experience changes in new technologies are more likely to think their job will be displaced and their skills out of date.

Hypotheses

1. Workers exposed to technological changes report higher job satisfaction.
2. Workers undertaking new tasks due to technological changes report higher job satisfaction - Those who are undertaking new tasks are expected to report higher job satisfaction consistent with the argument that new technologies replace humans in tasks they have an advantage in (e.g. repetitive or monotonous). .
3. Workers facing task displacement due to technological changes report lower job satisfaction - It is unclear whether those who report some tasks being displaced by the new technologies will report higher or lower job satisfaction. If these displaced tasks are repetitive then we would expect job satisfaction to rise. However, some displaced tasks may form an integral part of the identity of work for the employee which if not replaced will likely reduce job satisfaction..
4. Workers with increased productivity due to technological changes report higher job satisfaction - Those who observe they do tasks more quickly are seeing a productivity increase which we might expect to increase job satisfaction (e.g. because it removes some anxiety and stress in meeting output targets, can complete the same tasks in a shorter amount of time) – relate to the Technological Assessment Model (TAM) of *usefulness*.
5. Workers exposed to technological changes report a greater prospect of job displacement.
6. Workers exposed to technological changes report a greater need for new knowledge and skills.

Technological change and Job Satisfaction

Data

Data Source: 2nd European Skills and Jobs Survey (ESJS) 2021, covering 29 European countries.

Sample: Adults aged 25-64 in salaried employment.

Dependent Variables: Job satisfaction on a 0-10 scale, perceptions of job displacement, and need for new skills.

Independent Variables: Exposure to new technologies, task changes, productivity changes, and various job characteristics.

Technological change and Job Satisfaction

- **Model Specification**
- **Equation**:
- $Job\ Satisfaction_{i,c} = \beta_1 \text{New Technology}_{i,c} + \beta_2 \text{Task Discretion}_{i,c} + \beta_3 \text{Cognitive Interpresonal}_{i,c} + \beta_4 \text{Cognitive Maths}_{i,c} + \beta_5 \text{Physical}_{i,c} + \beta_6 \text{Repetitive}_{i,c} + \beta_7 \text{Fixed Methods}_{i,c} \sum_{k=1}^{n} \beta_k X_{k,i,c} + \varepsilon_{i,c}$ (1)

When estimating a multi-level, intercept-only model we found that the country group effects were not statistically significant with the intraclass correlation (ICC) being 0.024 which is less than the critical value of 0.05 as suggested by Hayes (2006) – inappropriate method.

Structural equation Modelling following Minardi et al (2023) - analyse the relationships between technological change, job tasks, job discretion and job satisfaction. However, the goodness of fit statistics meant we rejected this methodology, i.e.

Comparative fit index = 0.33 when a minimum of 0.9-0.95 is considered acceptable.

Root mean square error of approximation (RMSEA) of 0.063 is above the suggested 0.05 critical value.

Only the standardized root mean square residual (SRMR) of 0.029 was below the suggested 0.05 critical value.

Technological change and Job Satisfaction

Dependent Variables:

1. Job satisfaction, 0-10 scale where 0 is completely dissatisfied, 5 moderately satisfied and 10 is completely satisfied. Mean of 7.17.

2. Workers' perceptions and expectations of the impact of new digital technologies on their job is captured in the question "*To what extent do you think new digital or computer technologies in your company or organisation can or will do part or all of your main job*". Four responses 1=not at all, 2= a small extent, 3= a moderate extent and 4= a great extent.

Displace Job	Frequency	Percent
Not at all	14,420	33.63
A small extent	12,912	30.11
A moderate extent	11,241	26.22
A great extent	4,306	10.04

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Dependent Variables cont…

3. Workers' perceptions of whether they need new knowledge and skills to work with new technologies is taken form the question "*To what extent do you think new digital or computer technologies in your company or organisation* need or will need new knowledge and skills you currently do not have". Four responses as before.|

Skills do not have	Frequency	Percent
Not at all	7,901	18.53
A small extent	15,146	35.52
A moderate extent	14,888	34.91
A great extent	4,713	11.05

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Independent Variables used for changing technologies in the workplace

A derived binary variable "*change in technology in the job*", is used to capture whether workers have experienced using new computer technologies (i.e. new computer programs or software or computerised machinery) or not.

This derived variable forms the basis for three follow-up *nested* binary-response questions as to what impact these new technologies have had on job tasks. These variables are whether the new technologies mean you (i) now do some different or new tasks, (yes=1, no=0) (ii) now do some of your tasks at a faster pace than before, (yes=1, no=0) and (iii) now do not do some tasks you did before, (yes=1, no=0).

Is also information on whether workers use AI to help them code – do not include here.

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Independent Variables –

To check the robustness of our findings we also control for whether workers' have seen changes in aspects of their jobs not related specifically to the use of new technologies. We use responses to the questions "*In your main job, do you now spend more time, about the same time or less time on…"* (i) choosing the methods or tools of your work (ii) doing short repetitive movements or tasks (iii) learning new things compared to 12 months ago or when you started your current job?. The three responses are recoded so that less time=1, about same time=2 and more time=3.

To capture changes in how the organisation works or is structured in the last 12 months we include variables that capture whether there were new working methods (i.e. changes in how the work is done) and whether there were new digital technologies implemented at the organisation-level. This level of change would likely impact on the individual worker experience and could capture a relative measure of change that could mitigate the more individual-level changes a worker experiences in their job.

Technological change and Job Satisfaction

Independent Variables related to Job Satisfaction from the Industrial relations literature, e.g. Minardi et al (2023).

Job Discretion

Use principal components analysis to capture the degree of discretion of the job.

Comprises employees who often or always choose the methods or tools of their work, plan their work activities and work on varying assignments, react to situations that could not be anticipated and learnt new things.

The Kaiser-Meyer-Olkin (KMO) is 0.706.

We expect that workers who have more control over their work will report higher levels of job satisfaction.

Interpersonal skills

Use PCA based on seven related questions including whether workers provide advice to people, give oral presentations, deal with people outside of the company teach or train people and work in a team to achieve shared objectives.

The Kaiser-Meyer-Olkin (KMO) is 0.836.

We expect that workers whose work involves more interaction with people will report higher levels of job satisfaction.

Technological change and Job Satisfaction

Independent Variables related to Job Satisfaction from the Industrial relations literature, e.g. Minardi et al (2023).

Cognition used in Job

Group of dummy variables capturing level of maths used in job.

While our cognitive proxy is restricted compared to variables used by Minardi that focussed on problem solving skills, there is likely to be a correlation with problem solving and maths skills. As a result, we would expect those who use more advanced mathematics in their job to report higher job satisfaction.

Physical exertion

Captured by the yes/no question as to whether the person lifts or carries heavy objects or loads or people, without the help of a machine. The a priori is that physical jobs are negatively associated with job satisfaction.

Repetitive and Fixed Procedures

We control for whether the work is repetitive and whether work is based on fixed procedures, both of which are expected to lower job satisfaction.

Initial Results Technological change and Job Satisfaction

VARIABLES	JOBSAT 1	JOBSAT 2	JOBSAT 3	JOBSAT 4	JOBSAT 5	JOBSAT 6
Change in technology in the job	0.318***	0.145***				0.081**
Task Discretion		0.205***	0.202***	0.187***	0.185***	0.188***
Cognitive interpersonal		0.087***	0.081***	0.070***	0.069***	0.074***
No maths		-0.071	-0.063	-0.057	-0.056	-0.065
Basic maths		0.001	0.007	0.008	0.011	0.005
Medium maths		*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
Advanced maths		0.165***	0.147***	0.143***	0.139***	0.153***
Whether job has a physical aspect to it		-0.403***	-0.398***	-0.381***	-0.374***	-0.378***
Repetitive		-0.129***	-0.134***	-0.099***	-0.096***	-0.092***
Fixed Procedures		-0.081**	-0.085**	-0.079**	-0.079**	-0.076*
Change in technology resulted in new tasks			-0.046	-0.073**	-0.078**	
Change in technology resulted in increased productivity			0.367***	0.354***	0.337***	
Change in technology resulted in displacing some tasks			-0.050	-0.056*	-0.062*	

Initial Results Technological change and Job Satisfaction

VARIABLES	JOBSAT	JOBSAT	JOBSAT	JOBSAT	JOBSAT	JOBSAT
	1	2	3	4	5	6
Cont…….						
More repetitive tasks in last year				-0.191***	-0.189***	-0.193***
More autonomy in last year				0.094***	0.094***	0.094***
More to learn in last year				0.178***	0.174***	0.179***
Change in how work in organisation					-0.148***	-0.145***
Organisational change in technology					0.187***	0.204***
Country Fixed Effects	yes	yes	yes	yes	yes	yes
Industrial Sector	no	yes	yes	yes	yes	yes
Observations	41,788	41,788	41,788	41,788	41,788	41,788
R-squared	0.030	0.065	0.068	0.072	0.074	0.071

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Issue

Causality – people who are more satisfied with their job maybe more open to technological change and indeed welcome it and so select into jobs that if more likely to offer this opportunity.

Possible instruments - what is spent on new technologies by the firm or what is spent on training of workers that use new technologies in the firm.

The rationale for this is that if someone has been trained in computer and IT skills needed for the job, then this makes it more likely for them to experience some change in computerised technology assuming the training is worthwhile and is useful when using the new technologies. It is unclear how this training would directly impact job satisfaction unless through workers experiencing changes in technologies in the job.

Table 2
Job Satisfaction Equations and Experienced Changes in Technology in the job, 2SLS

	Model 1		Model 2	
	1st Stage	2nd Stage	1st Stage	2nd Stage
Experienced changes in computer technology in the job		**1.143*** **		**0.392*** **
Undertaken training in computer/IT skills for job	**0.240*** **			
Undertaken training to learn to use new computerised technologies for job – (asked online only)			**0.659*** **	
Constant	0.360***	8.096***	0.256***	8.048***
Durban-Wu-Hausman	120.719		64.053	
Cragg-Donald Wald F-Statistic	2357.73		13,226.41	
Observations	41,750		29,147	

Initial Results Experience of new technologies and perceptions of job displacement

VARIABLES	(1) Displace Job by new technologies	(2) Displace Job by new technologies	(3) Displace Job by new technologies
Change in technology resulted in new tasks	0.060***	0.051***	
Change in technology resulted in increased productivity	0.052***	0.043***	
Change in technology resulted in displacing some tasks	0.107***	0.100***	
Change in technology in the job			0.087***
Change in how work in organisation		0.014**	0.023***
Organisational change in technology		0.047***	0.052***

Initial Results Experience of new technologies and perceptions of the need for new skills

VARIABLES	(1) New Skills for new technologies	(2) New Skills for new technologies	(3) New Skills for new technologies
Change in technology resulted in new tasks		0.170***	
Change in technology resulted in increased productivity		0.159***	
Change in technology resulted in displacing some tasks		0.136***	
Change in technology in the job	0.293***		0.266***
Change in how work in organisation	0.105***	0.094***	0.098***
Organisational change in technology	0.198***	0.201***	0.173***

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Very Cautious Conclusions

Need to be aware of different mechanisms at play between changes in technologies and job satisfaction.

Find here that new digital technologies that improve productivity are correlated with higher job satisfaction.

Possible evidence that new digital technologies that mean new tasks or displace old tasks adversely effect job satisfaction.

Issues

Selectivity problems with sample of just workers – but nothing to be done about this with the ESJS.

Omitted variable bias - e.g. if someone reports new tech lead to increased productivity then this could actually be more to do with the person having a positive view towards new technology in the first place. Also Personality Traits (conscientiousness, openness, extroversion, agreeableness, and neuroticism) can significantly affect job satisfaction and could all impact people’s views in whether they think their experiences of new tech has had any impact on productivity, or new tasks or displacing tasks.

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Any Questions?