Productivity slowdown and organisational structures

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Introduction

- Slowdown in productivity growth in many developed countries since the mid 2000s (eg Lafond et al., 2021);
- Growing productivity gap between frontier firms and the rest (eg Andrews, Criscuolo and Gal, 2019; Haldane, 2017).

But we might have expected digital tools increasingly used in production (data usage, cloud services, platform business models….) to increase firm-level and aggregate productivity.

Possible resolutions?

- Fewer new ideas or important innovations compared to previous periods of high productivity growth (Bloom et al., 2020; Gordon, 2017);
- ‘Productivity J-curve’: intangible aspects of digital adoption mean time is needed to achieve productivity gains (Tambe et al., 2020).

A few firms improve their productivity, but it takes time to spread gains to most firms.

How does digital use by UK firms relate to their productivity? How do firms use digital tools?

Previous paper: Are Digital-Using UK Firms More Productive?

Role of firms' expenditure on innovation and digital inputs:

- Economies where firms spend on innovation have higher social returns (Jones and Summers, 2020).
- High productivity firms are those with a high level of digital capital, highly concentrated among few firms (Tambe et al., 2020, for US, Cathles et al for EU).
- Strong link between firms' proprietary IT, rising industry concentration, and higher productivity among the leading firms (Bessen, 2020; Pelzman, 2020).
- Investment in organisational capital, apart from IT investments and purchases, to make the most of digital technology (Brynjolfsson and Hitt, 2020; Li and Hall, 2020).

Focus on UK firms and a large number of digital inputs.

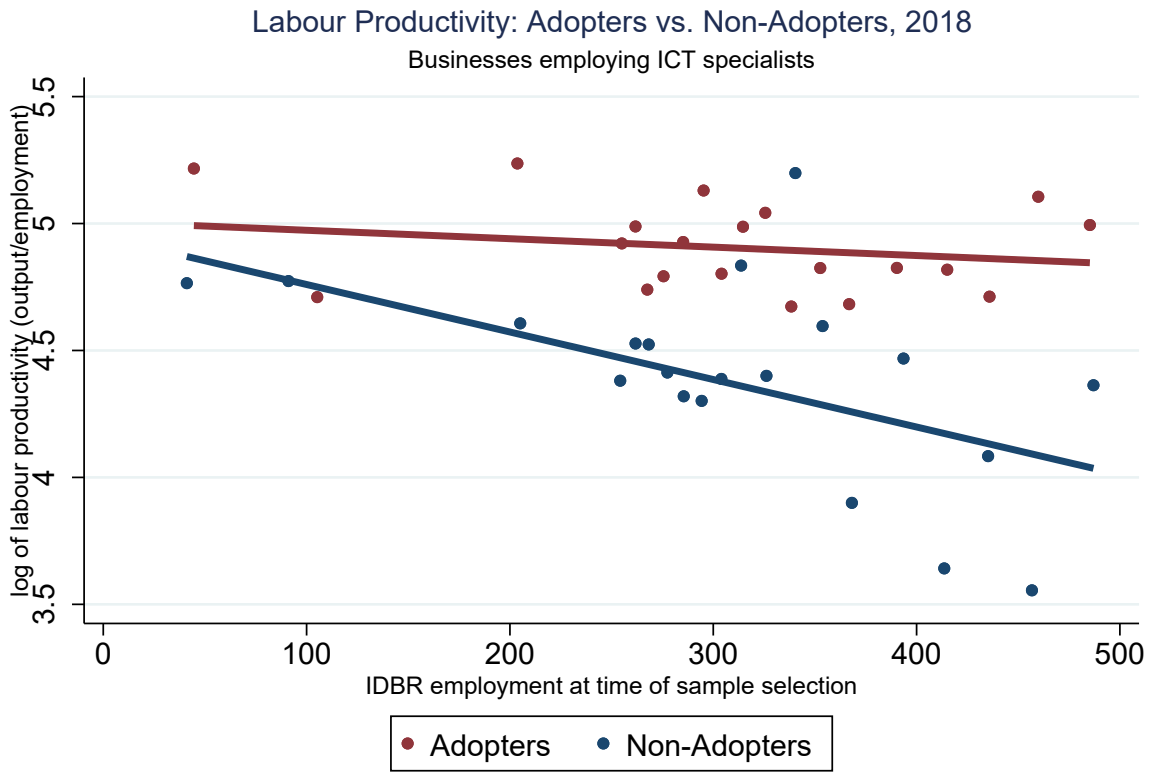
Production function estimation approach to the largest UK dataset to date, using TFP estimates based on physical and digital capital stocks.

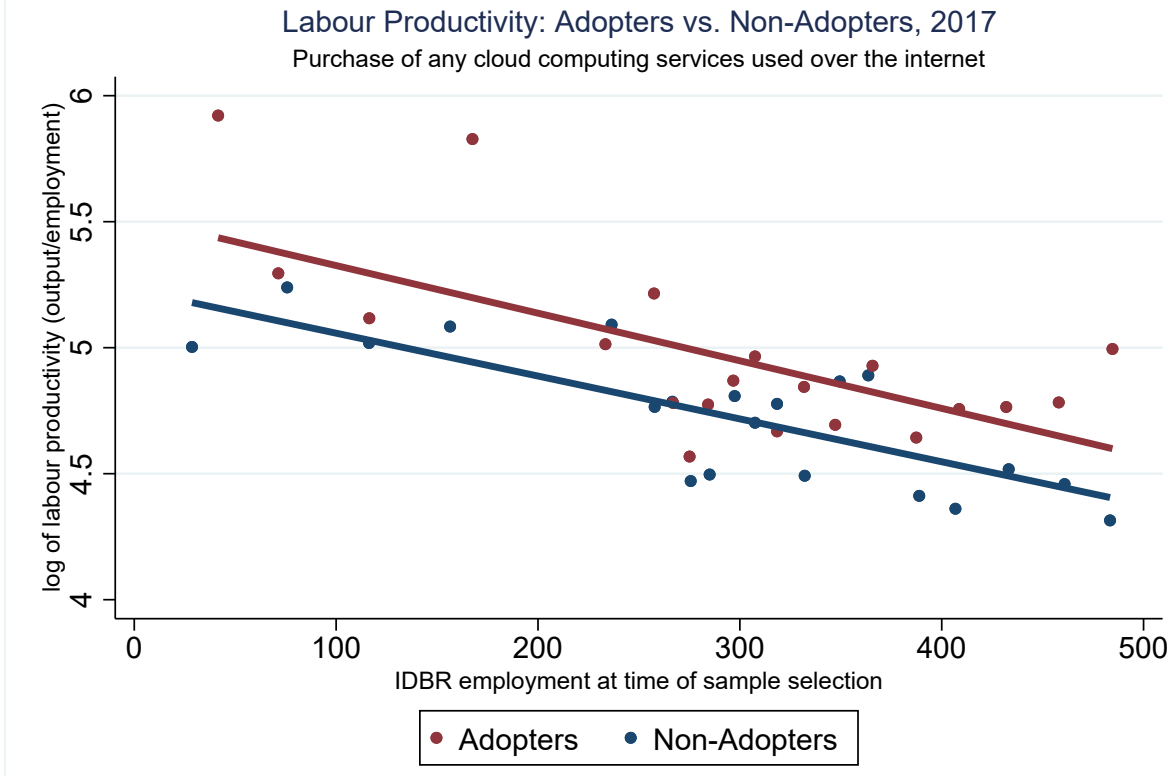
Data & estimation

- Create stocks of physical and intangible capital flow variables per firm and year.
- Perpetual Inventory Method (PIM) by ONS until 2014 from ABS: land, vehicles, machinery.
- Carried them forward for 2015-2018 using firms' annual expenditure on "land and existing buildings", "vehicles" and "other fixed capital", using EUKLEMS depreciation rates by industry.
- Similar method for capital stock using APS expenditures on R&D, programming, information, telecommunication, education and training services, with EUKLEMS depreciation rates, assuming 5 years average life.
- Baseline TFP, regressing GVA against ABS capital stock, employment and production costs
- Alternative TFP measure controlling additionally for APS capital stock variables.
- Several standard approaches: Olley and Pakes (1996), Levihnson and Petrin (2003), Wooldridge (2009) w/ and w/o GMM.
- Preferred approach: Wooldridge (2009) with GMM, 3rd degree (IV approach with lagged values as instruments)

Descriptive Results

Correlation between labour productivity and firm size: digital adopters vs. non-adopters





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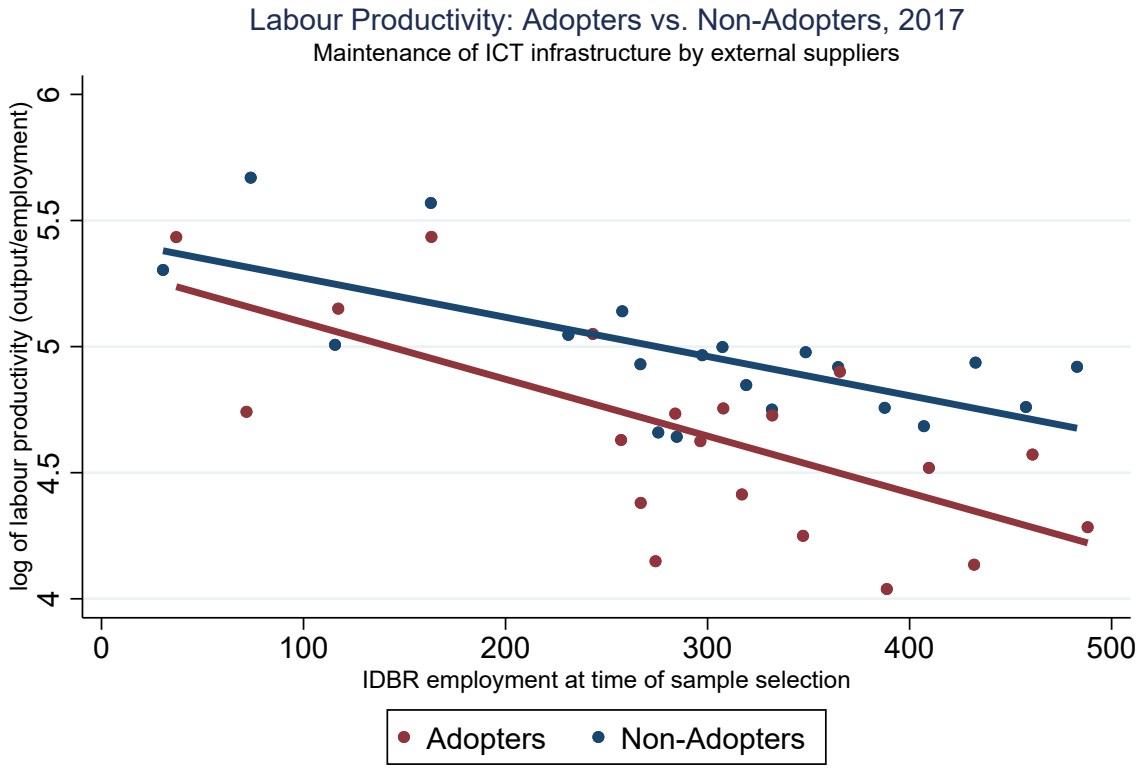
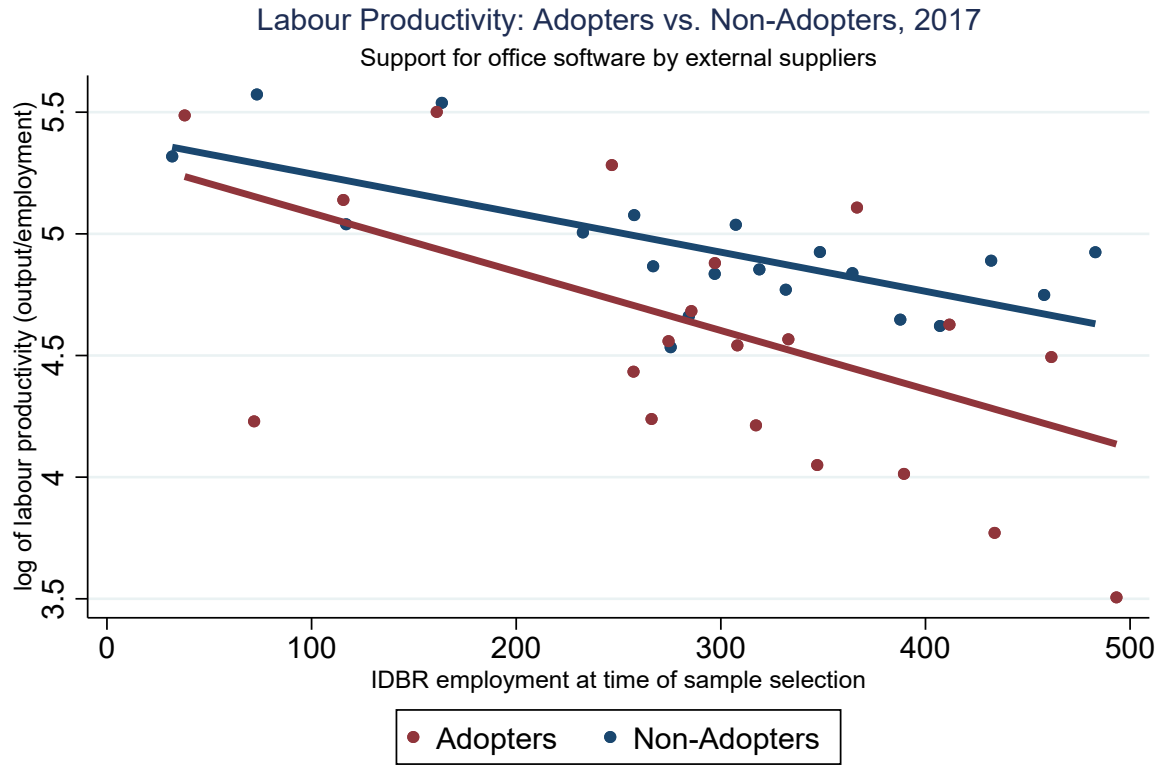


Sources: ABS, APS and E-COM Survey



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Estimation Results

Productivity vs. Digitalisation 2017. IV estimation

Dependent Variable	TFP - Wooldridge (2009) using system GMM 3rd degree											
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
% internet access	0.892***											
	(0.0666)											
% orders via website		0.367***										
		(0.0428)										
have a website			-1.563									
			(3.602)									
ICT especialists				3.427***								
				(0.309)								
use of CRM					2.064***							
					(0.282)							
cloud computing						5.280***						
						(0.893)						
ICT maintenance (external)							-2.610***					
							(0.571)					
office software support (external)								-3.055***				
								(0.785)				
management software (external)									-0.413			
									(0.271)			
web solutions (external)										-0.667		
										(0.441)		
security data protection (external)											-5.894***	
											(1.181)	
3D printing												0.876***
												(0.160)
constant	-0.0713	3.130***	4.923	0.615**	2.258***	-0.296	4.290***	4.046***	3.642***	3.802***	5.799***	3.291***
	(0.262)	(0.0370)	(3.502)	(0.261)	(0.172)	(0.631)	(0.192)	(0.161)	(0.157)	(0.262)	(0.482)	(0.0294)
Firm Size, Sector and Region FE	No	No	No	No	No	No	No	No	No	No	No	No
N	2203	2203	2203	2203	1180	2203	2203	2203	2203	2203	2203	2203
idstat	247.8	206.2	2.514	122.2	77.49	36.00	27.84	19.75	46.06	15.33	25.42	91.08
idp	7.65e-56	9.42e-47	0.113	2.14e-28	1.33e-18	1.97e-09	0.000000132	0.00000883	1.15e-11	0.0000904	0.000000462	1.38e-21
widstat	285.4	223.5	2.396	149.7	81.86	33.63	28.02	19.28	50.08	15.62	24.27	138.4

Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01

Some initial conclusions

- Unique UK firm-level dataset, enabling us to explore links between a large set of digital inputs and investments and productivity.
- Large firms are more digital intensive than small ones.
- Digital adopters have higher productivity than non-adopters.
- Use of multiple in-house digital technologies strongly positively related to TFP.
- Some digital variables are positively related to TFP, and others negatively related. Difference driven by the use of in-house as opposed to bought-in capabilities.

Further research

- Role of digital technology taking account of organisational capabilities.
- Firms crossing from non-digital to digital threshold. Do organisational capital / available skills need to change first?

Next steps

- Digital tools are a means of using/implementing ideas and data
- New ideas/insights are combinations of old ones (Weitzman 1998): combinatorial growth is so fast that the limit is the ability to process & use ideas
- If there are N ideas, all equally useful so there are 2^N combinations, and new ideas arrive with some standard distribution, productivity growth at the frontier is exponential (Jones 2021)
- Are new ideas getting harder to use? (Bloom et al AER DATE but Bessen 2022): frontier firms can figure it out, others lag further behind
- Some barriers may be external to the firm eg barriers to entry & concentration, regulation, finance
- What about the internal dynamics?

Not all (combinations of) ideas are good ones…

Janelle Shane
https://www.aiweirdness.com/,
AI Weirdness:

A model: Jones 2021

C is the number of current ideas (in a universe K); z_C is the value of recipe c and F(x) is the CDF for each z_c

Define Z_K as the highest value idea for all C in K; Pr [Z ≥ x] = 1 - F(x)

As K increases towards infinity, probability the next draw exceeds the current highest value goes to zero - unless there is a combinatorial element – in which case there is an exponential distribution of values

The theorem applies to any strictly decreasing and continuous function 1-F(x)

Suppose 1-F(x)= $e^{-\theta x}$; then (frontier) productivity growth with combinatorial increase in K, and exponential increase in processing K, is exponential

One parameterisation: with R_t researchers, the flow of new ideas that get used is:

$$N_{t+1} = \alpha R_t^{\lambda} N_t^{\phi}$$

Where λ <1 could reflect eg duplication, declining researcher productivity and ϕ > 0 if evaluation and use gets easier with familiarity/learning by doing/tacit knowledge/organisational know-how

Conclusions/next steps

- If we accept that ideas are combinatorial, productivity can be exponential – there is nothing inevitable about ideas getting harder to find
- But they can get harder to use , depending on firm-specific characteristics as well as features of the market/environment
- What can we say about λ and ϕ IRL?
- Large literature on advance of scientific knowledge – broad conclusion: maybe, but disputed, and AI is automating some parts of knowledge discovery, will make researchers much more productive
- *Do we know much about speed of R&D inside firms?*
- Key to firm performance likely to be ϕ
- *Complex software and processes (Bessen 2022)*
- *Trust & hierarchy within the firm – giving autonomy to employees*
- *Accumulated internal know-how/culture*
- All likely to cause virtuous circle for those firms that can use digital