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UNITED KINGDOM · CHINA · MALAYSIA

ICT AND CAPITAL SAVING TECHNICAL CHANGE

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Motivation

- General purpose technologies (GPTs) have wide ranging economic effects
- Multi-factor productivity effects are realised through both labour and capital saving (David, 1990, 1991)
- We study the spatial distribution of production
- Historical precedent: 40 years after invention of the carbon filament incandescent lamp in 1879, electrification led a transformation from group to unit drive transmission within manufacturing.
- Electricity also meant firms no longer tethered to rivers as a source of power
- This in turn affected the efficiency with which the space in the factory was used and began to alter their design, increasing their footprint
- The technology of unit drive combined with organisational change that reduced capital acted to disperse economic activity



Motivation

- We explore whether a modern GPT – ICT (captured by broadband speeds) has also impacted the spatial distribution of production
- The technology allows information production, storage, analysis and application to de-couple
- In the opposite direction, David and Wright (2005) suggest ICT could “yield significant capital-savings in the reduced requirement for commercial office space”.
- Use new regional UK data on building capital (in addition micro data)
 - area of business properties (its metres²)
 - intensity capital is used - the average size and space (m²) per employee.
- We focus on three questions
 - Is ICT associated with changes in the use of building capital?
 - And, if so, how large is the effect?
 - Has ICT economic activity to be concentrated?



Motivation

- Identification from cross-time and cross-sectional variation in internet connection speeds - increasing from 256kbps to over 15mbps (range 4mbps to 24mbps)
- Broadband speeds not random and could be correlated with factors that explain commercial floorspace
- Use a long-difference approach (18-years) to remove fixed regional factors
- Unobservable region specific changes may still confound our results
 1. variation in desire for residential living
 2. UK has no national planning laws (Cheshire, 2018)
- To confront this we use a falsification test, micro data and an IV
- Data allow for types of space (office, retail, industrial)



Empirical Strategy

- $\Delta y_{it} = \alpha + \beta X_{it} + \gamma \Delta ICT_{it} + \varepsilon_{it}$

where Δy is our measure of business capital; ICT is the broadband connection speed within the region and X includes price of building capital and the level of output.

- Long-difference from 2000 to 2018 to remove time invariant regional characteristics
- In the base year all connections limited by copper cabling 256kbps
- When using micro data instrument for ICT using infrastructure of telephone network (DeStefano et al. 2018)



Data

- Valuation Office Agency (VOA) administrative database.
 - Numbers of hereditaments, total rateable values, total area of floorspace (thousands m²) and average rateable values per meter squared for local authorities in England and Wales from 2000 to 2018
 - retail properties, offices, factories and warehouses and miscellaneous group - halls, social clubs and garden centres
 - For years 2010 and 2017 we have data on individual hereditaments
- Business Structural Dataset (BSD), employment, sales.
- Broadband data from OFCOM at postcode level

Results

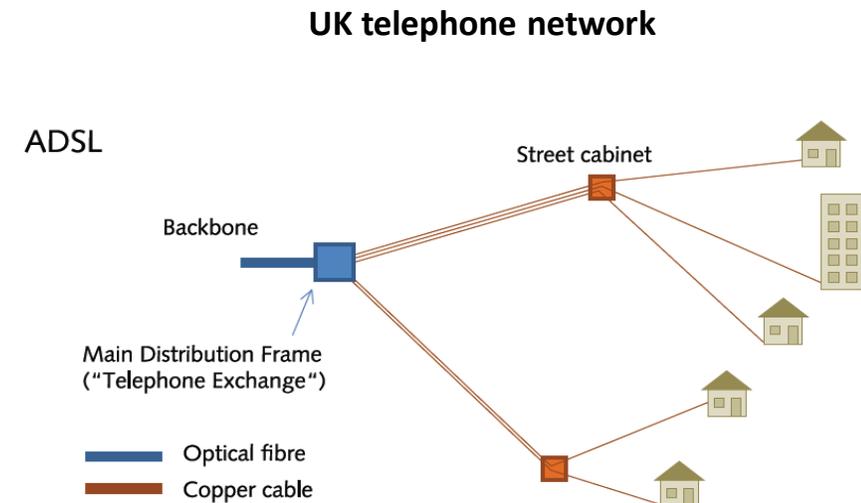


Dependent variable	Area (m ²)	Δarea (m ²)				
	2018	2000-2018	Office	Retail	Industrial	Houses & apartments
ΔBroadband speed	0.018***	-0.114***	-0.205***	-0.037*	-0.092***	0.018***
	(0.003)	(0.024)	(0.052)	(0.020)	(0.035)	(0.010)
R²	0.188	0.058	0.144	0.036	0.233	0.195
Observations	1038	1038	333	333	333	330



Instrumental Variable

- Instruments based on telephone network infrastructure
- 5,630 Telephone exchange in UK
- ADSL 8mbps versus 64kbps for narrowband
- Connection speeds deteriorate for cable-distances $>2\text{km}$. Max 3.5km
- Fibre has faster speeds but also decays with distance
- Telephone quality okay up to 16km.



Instrumental Variable



Estimation Method	OLS	IV First Stage	IV Second Stage
Dependent variable	Δ area (m ²) Micro Data	Broadband Speed	Δ area (m ²)
Hereditament Type	All		All
ΔBroadband speed	-0.006*** (0.001)		-0.013*** (0.004)
ΔFibre Availability		0.388*** (0.052)	
ΔFibre Availability * Local Loop Length		-0.057*** (0.008)	
F-stat on excluded instruments		2,781.54	
Observations	133,487	96,996	96,996



Relocation versus agglomeration

- Our results imply that economic activity has become more agglomerated
- Is this just relocation of existing activity?
- Redding and Turner (2015) discuss this point in relation to infrastructure
 - Treated regions – benefit from infrastructure and displacement
 - Untreated regions – near treated regions & suffer displacement
 - Residual – neither benefit from treatment or suffer displacement
- Estimate economic geography type of model

Relocation versus agglomeration



Dependent variable	Δ area (m ²)	Δ Number of firms	Δ Employment	Δ Output
Hereditament Type	All	All	All	All
Δ Broadband speed	-0.007*** (0.002)	0.015 (0.022)	-0.108*** (0.021)	-0.128*** (0.048)
Δ Broadband speed in neighbouring LAs	0.001 (0.002)			
Δ Space (m ²) per employee		-0.147*** (0.015)	-0.938*** (0.012)	-0.814*** (0.030)
R ²	0.186	0.124	0.884	0.531
Observations	930	999	999	999



Conclusion

- ICT is like past GPTs, it is capital saving
 - But by squeezing space
 - Acts to increase agglomeration
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- **This work was based on data from the Office for National Statistics (ONS) and supplied by the Secure Data Service at the UK Data Archive. The data are Crown Copyright and reproduced with the permission of the controller of HMSO and Queen's Printer for Scotland. The use of the data in this work does not imply the endorsement of ONS or the Secure Data Service at the UK Data Archive in relation to the interpretation or analysis of the data. This work uses research datasets which may not exactly reproduce National Statistics aggregates. In addition this research used data from them ICT Capital Stock Dataset provided by the VML.**



Literature

- Growth theory
 - K-biased technical change only a small feature of growth models (Acemoglu, 2003)
 - Barkai (2016) and Barkai & Benzell (2018) K-share of income also falling, Benzall & Brynjolffson (2019) model this
 - Empirical literature includes Sato (1970) and Berman (2000)
- ICT and firms
 - Broadly accepted that ICT use can lead to productivity growth, Brynjolffson and Hitt (1996, 2003), with Bloom et al. (2005, 2014) suggesting causal impacts.
 - Strong positive bias towards higher skill workers and away from lower skilled workers (Akerman et al., 2015)
 - Hubbard (2003) finds evidence that the use of on board computers affected capacity utilisation in the trucking industry
 - Cramer and Kreuger (2016) study the capacity utilisation of UberX drivers versus those employed by traditional taxi cab firms.
- Organisation and ICT
 - Garricano and Heaton (2010), Bloom et al (2012) - effects of ICT are realised when made alongside organisation and managerial changes or retraining
 - Bloom et al. (2014) study managerial hierarchies.
- Economic geography & ICT
 - Kolko (2012) finds a positive relationship between broadband expansion and economic growth in cities
 - Ioannides et al. (2007) find that ICT leads to a less concentrated distribution of city sizes, suggesting that it acts to disperse economic activity across geography.



Outline

- Motivation
- Literature
- Data and Empirical Strategy
- Results
 - Regional data on squeezing space
 - Falsification test – residential properties
 - Micro data & instrumental variable
 - Relocation versus Agglomeration
- Conclusions