

# Causal Relationship between Information Communication Technology and Firm Productivity



# Introduction

- Information is important
- The way in which firms use information impact their performance
- Intuitively ICT enhance firm's ability to process and manage information thereby increasing their productivity

- “computer paradox” Solow (1987)
- IT usage contributes to total output (Oliner and Sichel 2000)
- Growth in the IT sector and increased IT intensity in the IT using sector contributed to TFP and labour productivity growth (Jorgenson Ho and Stiroh 2002)
- Gap between U.S. and EU productivity can be attributed to a smaller European IT producing sector and less investment in IT (Van Ark et al 2008)
- US MNCs obtain higher productivity from IT capital usage than non-US MNCs (Bloom et al 2012)



## However the main question remains

- Does IT itself leads to efficiency gains or
  - better management
  - organizational structure
  - human capital
  - geographic location and so on?

*Does a causal relationship exists between ICT and firm productivity?*

- The Annual Respondent Database is a major source of firm level data in the UK
  - Census of larger businesses and a sample of smaller firms
  - Covers all sectors aside from finance after 1997
  - Firm performance variables
  - Same dataset used by Bloom et al (2012)
- ADSL Enablement Dataset
  - Roll-out of ADSL broadband across the UK

- Standard OLS Cobb-Douglas production function to estimate log TFP
- Use Lev Pet used to overcome the likely endogeneity of input decisions

$$tfp_{it} = \alpha_{it} + \beta_{ICT}ict_{it} + \beta_X X_{it} + \mu_{it}$$

- Given the potential for endogeneity between IT and productivity we employ IV estimation
  - Instruments: **First phase** of ADSL and ADSL\*Distance from the exchange
- Haller and Lyons (2012) and Bertchel et al (2013) investigate the effects of broadband and productivity but find no effect

# Instrument One: ADSL Enablement



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Broadband enablement is an appropriate instrument from a technical perspective:

- Broadband alone does not affect the productivity of a firm directly, but only through the employment of both hardware and software technologies
  - Not a suitable instrument for large firms

Roll-out exogenous to firm performance during the first roll-out:

- Regions enabled during the first stage urban, however exchange installation was staggered across the country
  - Limited supply of engineering technicians required at every installation site, both exchange and consumer location (BBC News 1999a, BBC News 1999b)

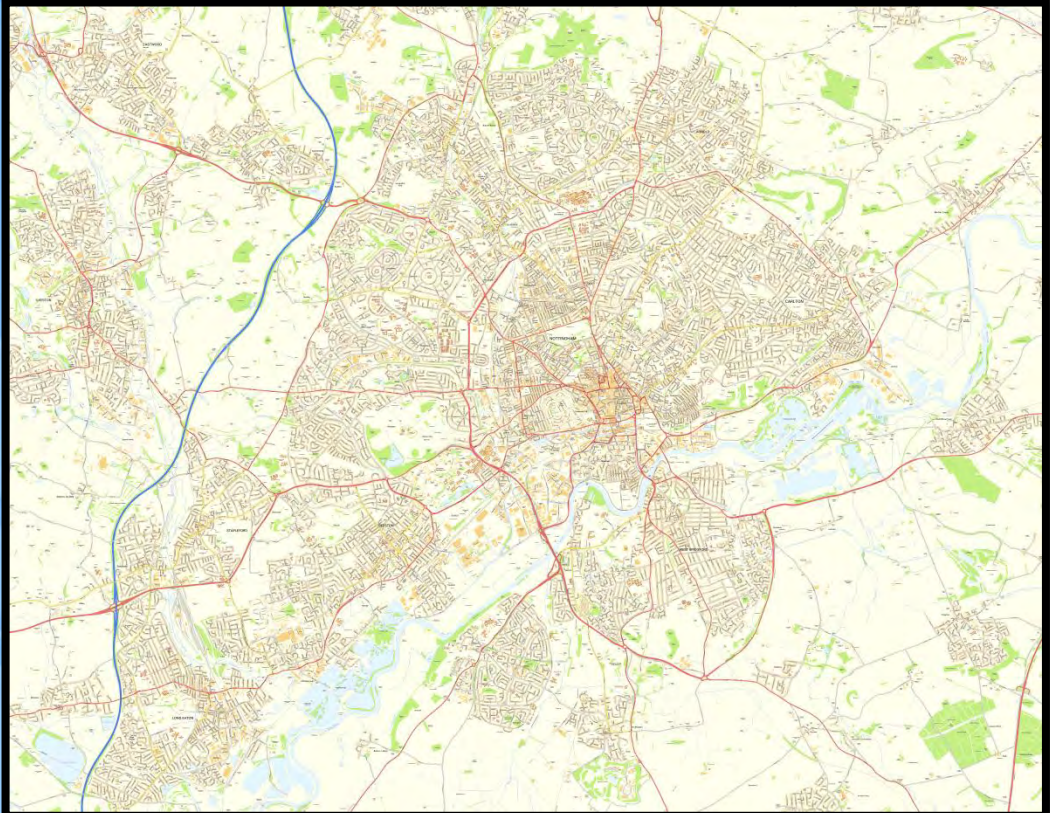


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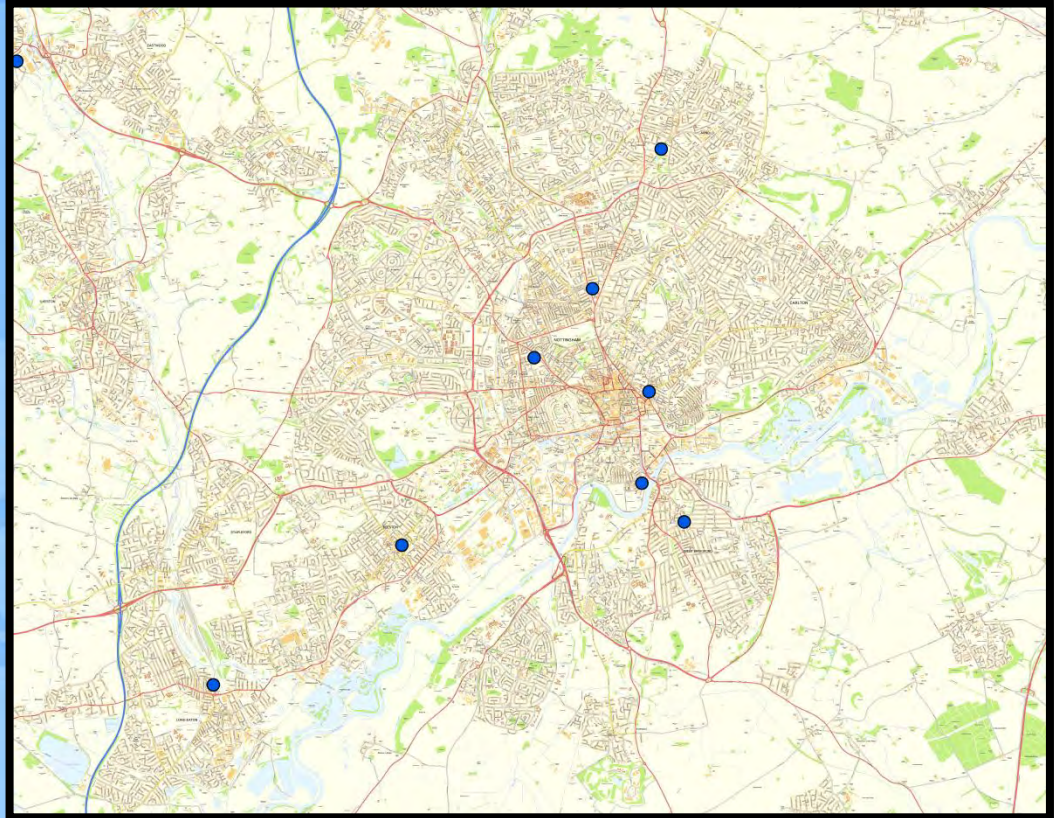
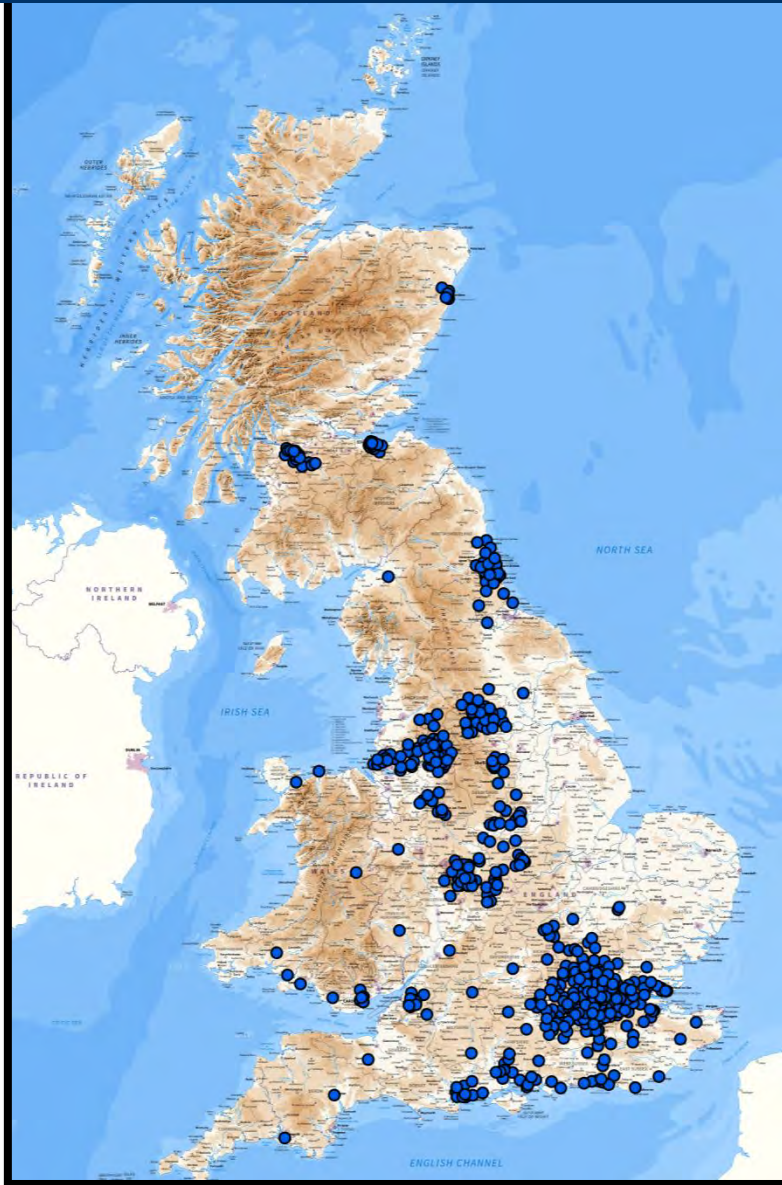


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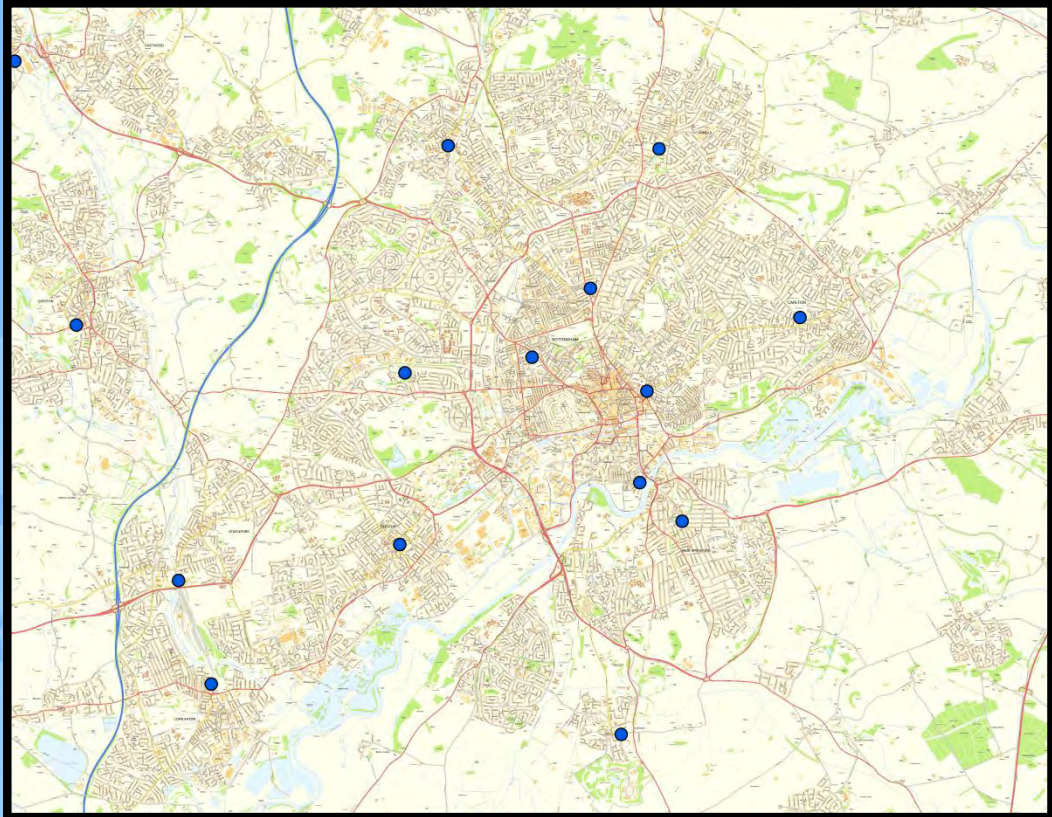
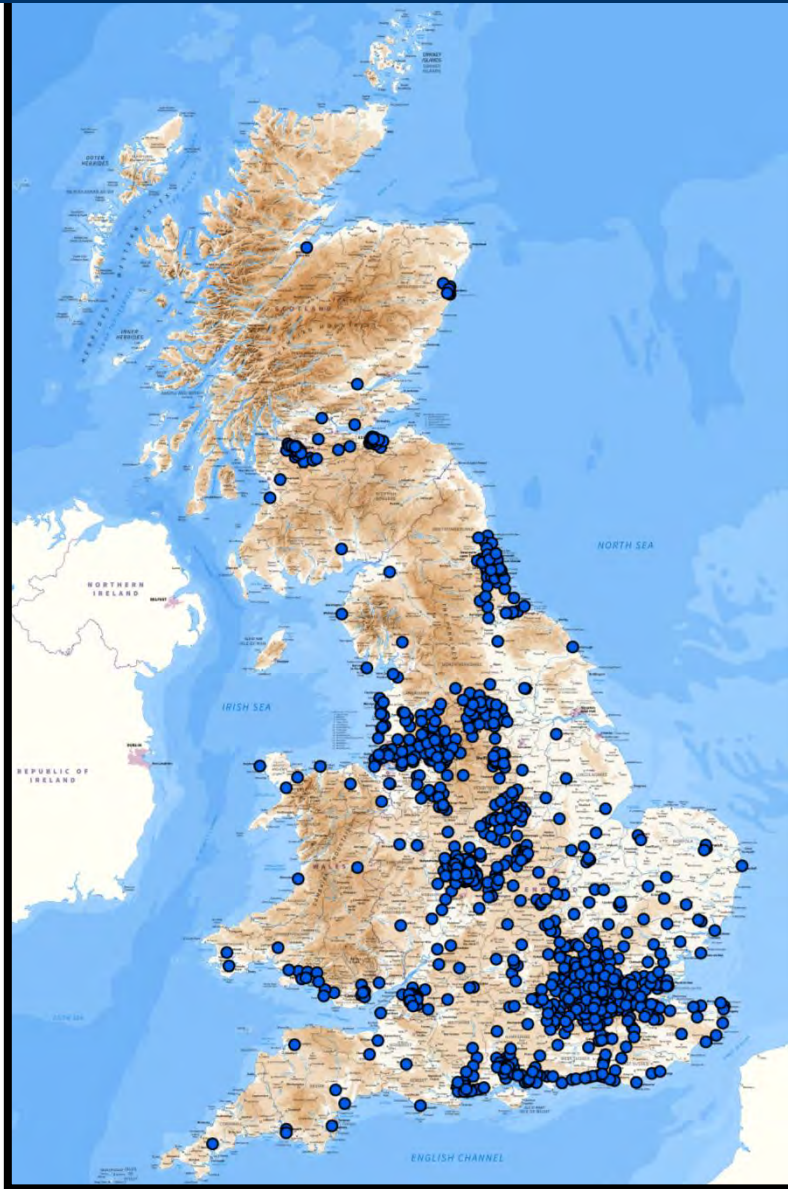


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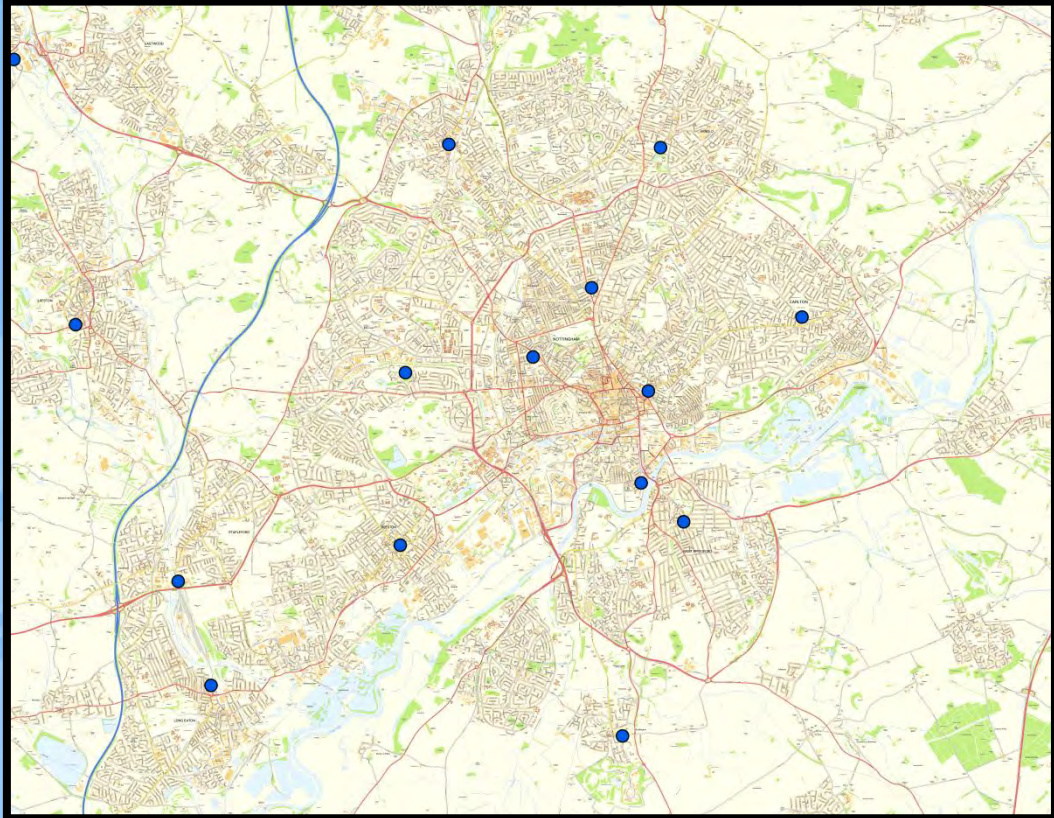
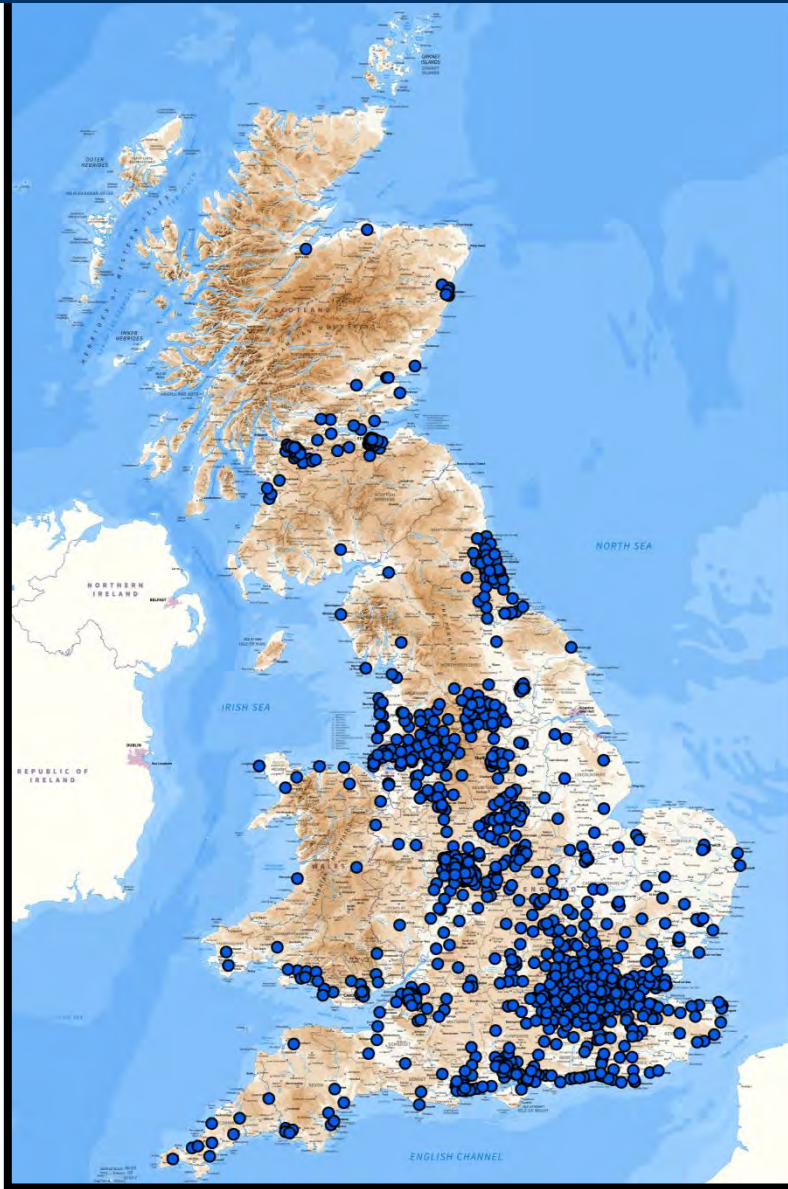


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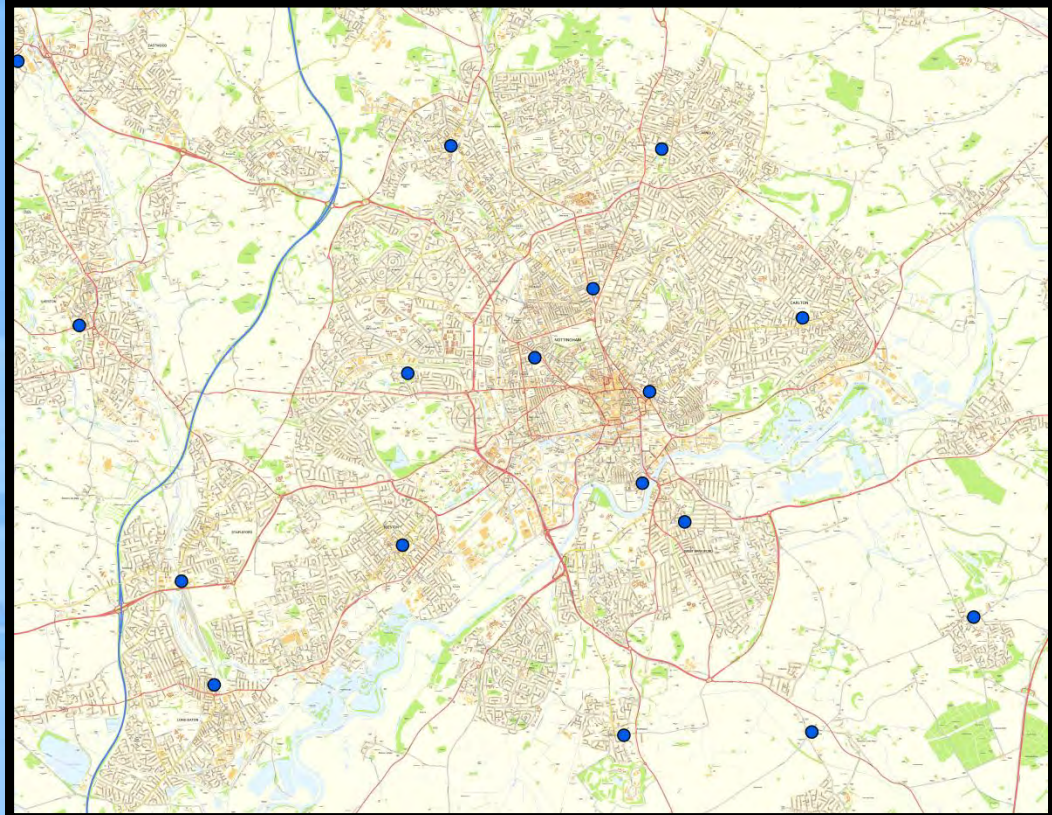
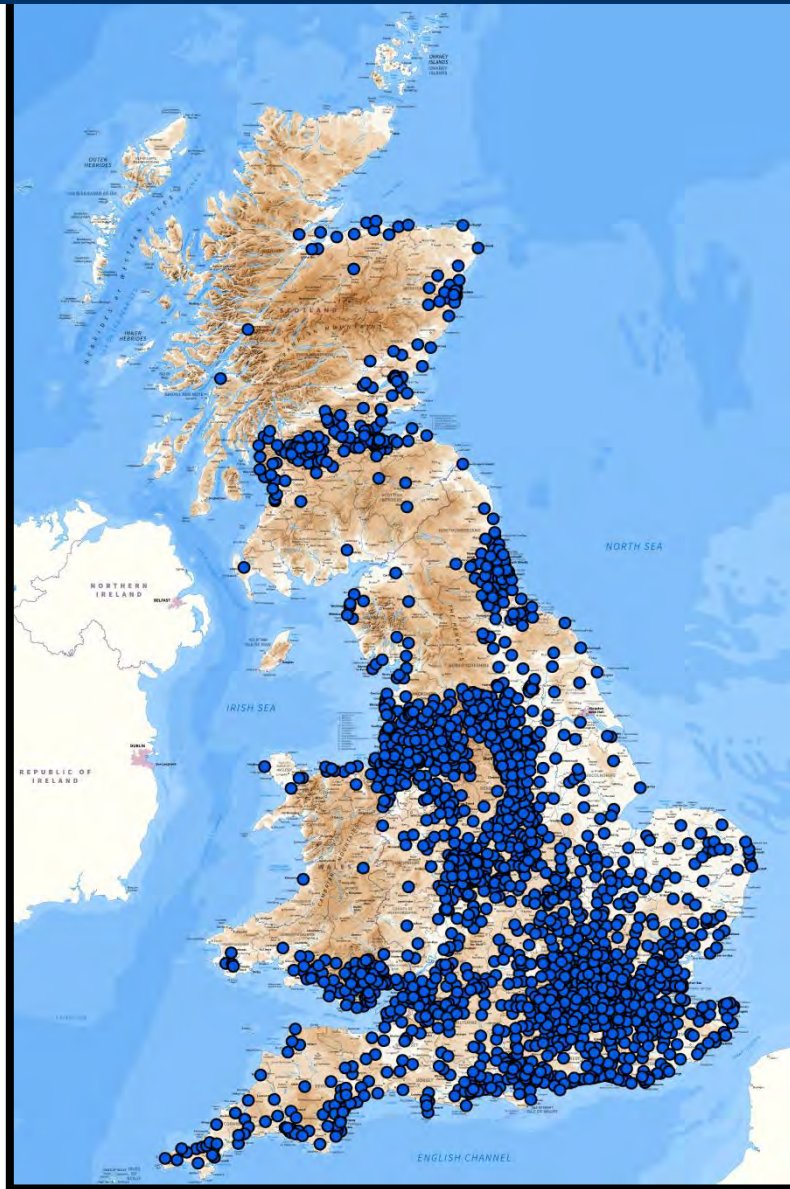


# Exchanges Enabled by the end of 2003



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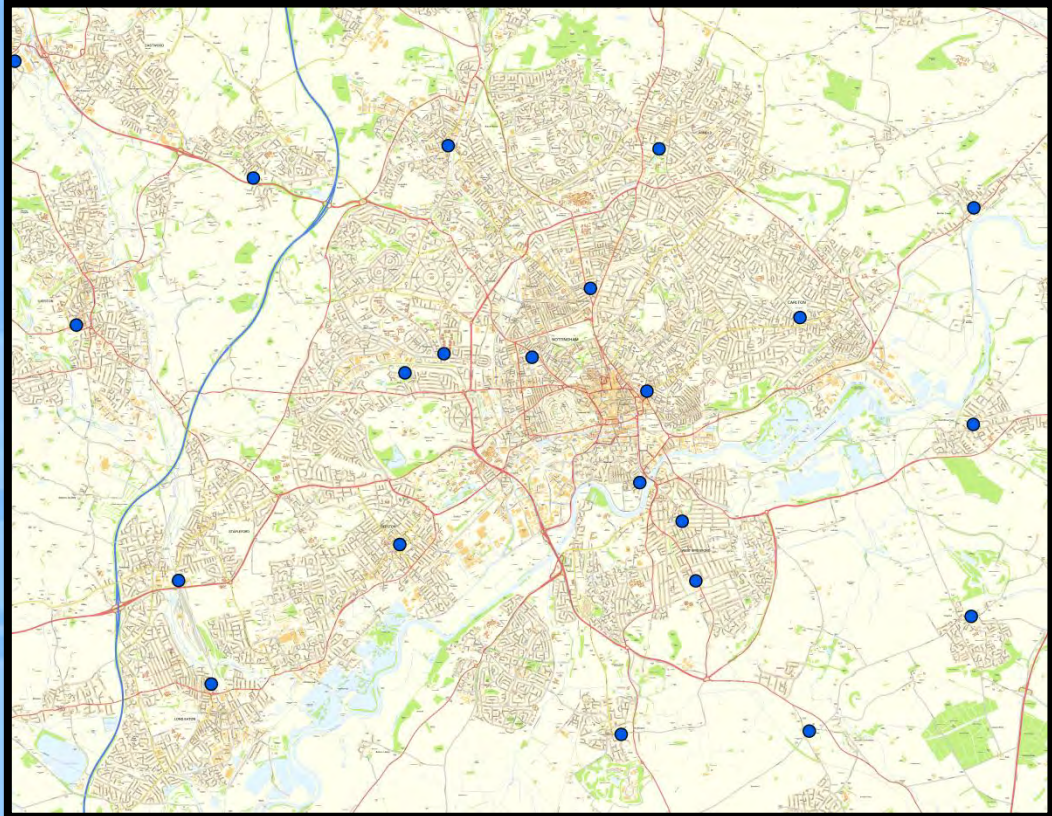
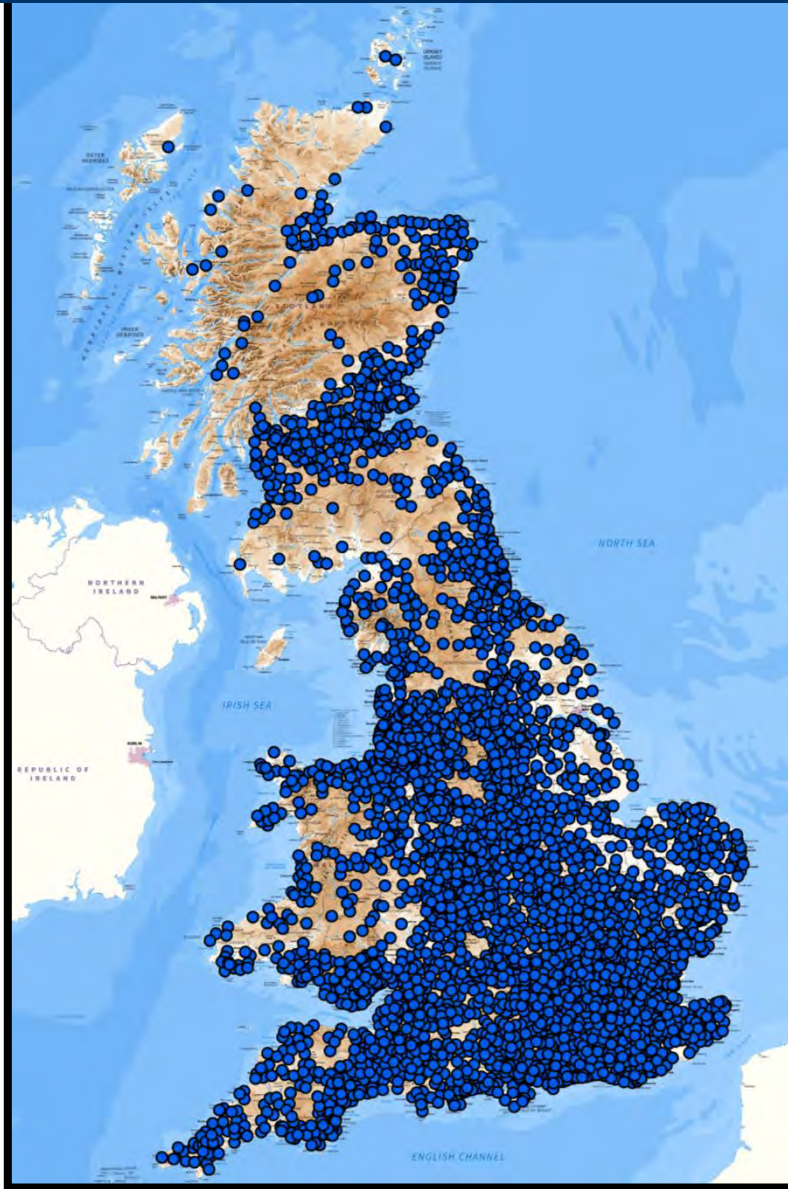


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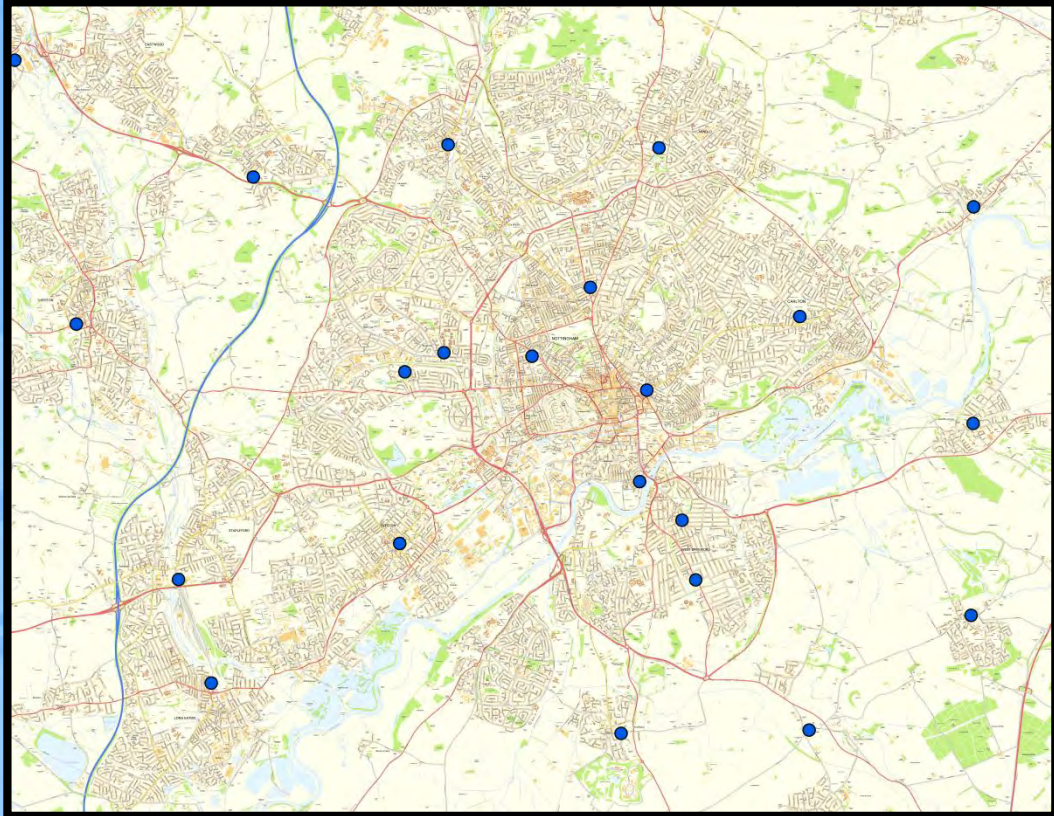
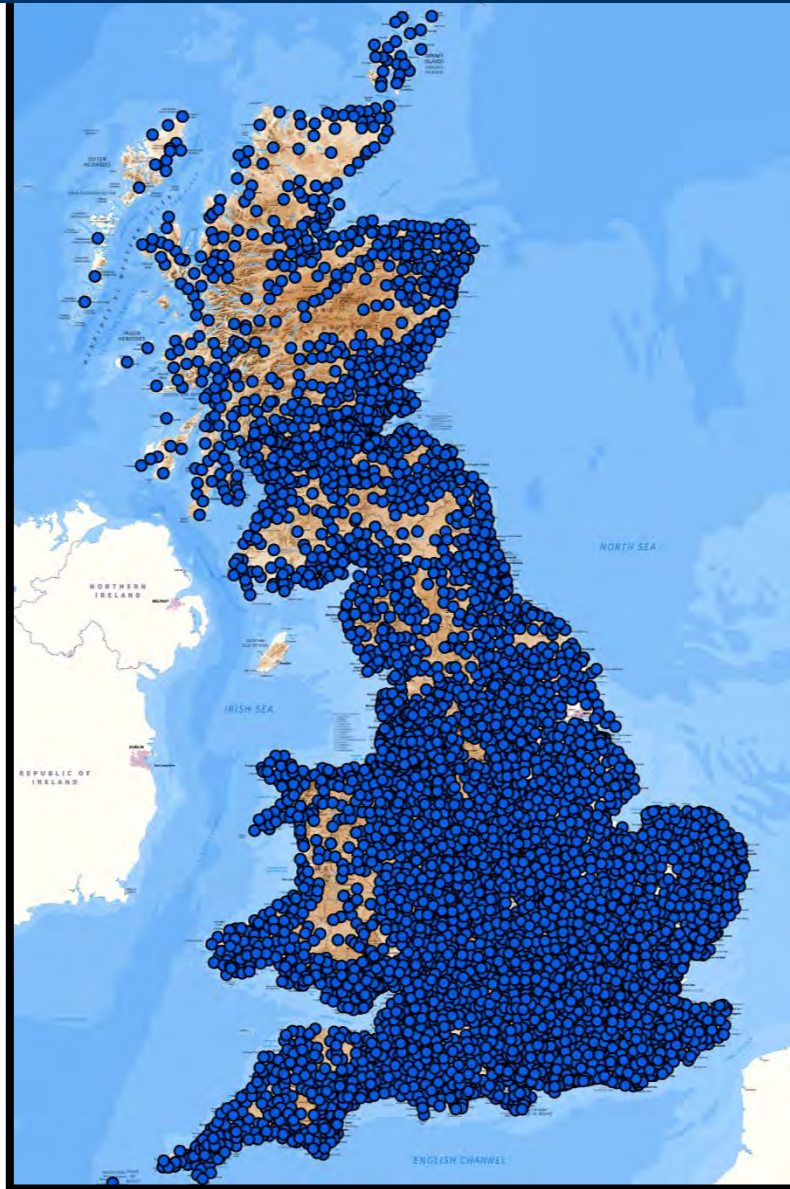


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# Instrument Two: Firm Distance from the Exchange (Internet speed)

ADSL broadband is a distance dependent (BT, 2014):

- Firms farther away from the exchange have access to slower internet which lessens its impact on the returns to ICT

Distance from the exchange box is exogenous to firm performance:

- Location of box is based on the pre-existing telephone line infrastructure dating back in some cases as far as the 19<sup>th</sup> century
- Phone calls can maintain good quality anywhere between 5 kilometres to as far as 16 kilometres (Macassey 1985)
- Firms born before the development of ADSL would not have chosen an optimal location to exchange for ADSL

# OLS Results 1997-2005

IT Effects on TFP 1997-2005

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
IT	.095***	.096***	.090***	.076***	.081***	.059***
	35.6	36.15	32.77	27.54	27.47	26.48
Control Variables						
Year		✓	✓	✓	✓	✓
Region			✓	✓	✓	✓
Foreign Owner				✓	✓	✓
Age					✓	✓
Sector						✓
Adjusted-R <sup>2</sup>	0.0582453	0.0622605	0.0717555	0.094217	0.0958045	0.5620646
N. of cases	19,748	19,748	19,748	19,748	19,748	19,748

# OLS Results of Wave Comparison

IT Effects on TFP Stage one and Stage two Comparison

Variables	Model 3	Model 4	Model 5	Model 6	Model 3	Model 4	Model 5	Model 6
	1997-2002				2003-2005			
IT	.087***	.072***	.080***	.060***	.090***	.075***	.077***	.0520***
	23.42	19.09	19.56	18.9	37.99	29.04	28.5	26.4
Control Variables								
Year	✓	✓	✓	✓	✓	✓	✓	✓
Region	✓	✓	✓	✓	✓	✓	✓	✓
Foreign / USA		✓	✓	✓		✓	✓	✓
Age			✓	✓			✓	✓
Sector				✓				✓
Adjusted-R <sup>2</sup>	0.066938	0.088254	0.086455	0.575298	0.073406	0.096896	0.100841	0.552761
N. of cases	9,075	9,075	9,075	9,075	10,673	10,673	10,673	10,673

Note: \*\*\* represents 1%, \*\* 5% and \* 10% levels of significance

# IV Estimation, Wave One



IV Estimation: IT with Broadband & Distance\*ADSL, Single Plant 1997-2002

Variables	TFP1		TFP2		Lev Pet	
	a	b	a	b	a	b
<b>Second Stage</b>						
IT	0.269*** 3.44	0.262*** 3.68	0.297*** 4.48	0.236*** 3.67	0.184** 2.42	0.132* 1.77
<b>First Stage</b>						
ADSL	1.371*** 4.14	1.090*** 3.77	1.371*** 4.14	1.09*** 3.77	1.371*** 4.14	1.09*** 3.77
Distance*ADSL	-0.157*** -3.36	-0.122*** -3.01	-0.158*** -3.36	-0.123*** -3.01	-0.158*** -3.36	-0.123*** -3.01
Control Variables						
Foreign / USA	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓
Sector		✓		✓		✓
Wald F-Statistic	27.66	20.56	27.66	20.56	27.66	20.56
Hansen Statistic	0.5635	0.6446	0.5311	0.8211	0.5297	0.3804
Endogeneity	0.0082	0.0004	0.0000	0.0005	0.0117	0.0523
N. of cases	9,075	9,075	9,075	9,075	9,075	9,075

Note: TFP1 is estimated as our baseline estimate, TFP2 includes sector/factor input interaction dummies to the baseline estimate, and Lev Pet is estimated with via the Levinsohn Petrin algorithm using gross value added

# IV Estimation, Wave Two



IV Estimation: IT with Broadband & Distance\*ADSL, Single Plant 2003-2005

Variables	TFP1		TFP2		Lev Pet	
	a	b	a	b	a	b
<b>Second Stage</b>						
IT	0.062	-0.05	0.083	-0.023	0.035	-0.135
	0.62	-0.64	1.15	-0.32	0.36	-1.3
<b>First Stage</b>						
ADSL	0.826*	0.837**	0.827*	0.837**	0.827*	0.837**
	1.94	2.41	1.94	2.41	1.94	2.41
Distance*ADSL	-0.076	-0.082*	-0.076	-0.082*	-0.076	-0.082*
	-1.28	-1.7	-1.28	-1.7	-1.28	-1.7
Control Variables						
Foreign / USA	✓	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓	✓
Sector		✓		✓		✓
Wald F-Statistic	9.38	9.77	9.38	9.77	9.38	9.77
Hansen Statistic	0.7747	0.7688	0.8122	0.9944	0.3812	0.3861
Endogeneity	0.8771	0.123	0.8334	0.2319	0.814	0.2594
N. of cases	10,673	10,673	10,673	10,673	10,673	10,673

Note: TFP1 is estimated as our baseline estimate, TFP2 includes sector/factor input interaction dummies to the baseline estimate, and Lev Pet is estimated with via the Levinsohn Petrin algorithm using gross value added

# Falsification Test, Multi-plant Firms



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IV Estimation: IT with Broadband & Distance\*ADSL, Multi-Plant 1997-2002

Variables	TFP1	TFP2	Lev Pet
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## Second Stage

IT	0.098	0.12	0.071
	0.86	1.08	0.51

## First Stage

ADSL	0.528	0.528	0.528
	1.65	1.65	1.65
Distance*ADSL	-0.061	-0.061	-0.061
	-1.33	-1.33	-1.33
Wald F-Statistic	5.25	5.25	5.25
Hansen Statistic	0.0509	0.9783	0.035
Endogeneity	0.6109	0.4494	0.4608
N. of cases	12,369	12,369	12,369

Note: TFP1 is estimated as our baseline estimate, TFP2 includes sector/factor input interaction dummies to the baseline estimate, and Lev Pet is estimated with via the Levinsohn Petrin algorithm using gross value added.



# Conclusion

- OLS results suggest a positive and significant relationship between IT and productivity
- Using IV estimation a causal link between IT and productivity is found
  - Results are only robust for the first wave
- A 10% increase in IT capital stock increases TFP by around 1.8% to 2.9% at the 1% level of significance
- Positive relationship between ADSL and IT and a negative relationship between distance and IT
- The availability of ADSL broadband at an adequate speed incentives IT upgrading thereby increasing productivity.

# Questions?



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