ICT USE, PRODUCTIVITY, GROWTH & INNOVATION

Assessment from linking data across 200,000 firms in 13 countries

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Agenda

- Headline Results
- Why and how we ran the study
- Results, and what we learned
- Recommendations for next steps

Headline Results

- **ICT use in manufacturing** shows positive labour productivity effects for all 13 countries in the study, and positive multifactor productivity in majority
- **ICT use in services** has more varied links with productivity, depending on country and industry; for the UK, France, Nordic countries and Netherlands positive correlations are clear; elsewhere not
- **Nordic states, Netherlands, UK and France** are also countries in our study where ICT use by firms is more intensive; they appear to show 'increasing returns to ICT intensity' not (yet?) seen in others
- **High speed internet use** by employees is the measure of ICT intensity most closely linked to higher productivity, at firm and industry levels, and to the intensity of competitive substitution between firms
- **ICT use supports the innovation process** in multiple, measurable, ways
- **Complementary investments** in skills, organisation, help to secure gains from ICT, and so is competitive substitution.

Why?

What we set out to do

- **Build analytical capability** to compare results reliably across countries – essential to understand policy interactions
- **Integrate ICT analysis** alongside other complementary investments (skills, R&D / innovation, organisation)
- **Better understanding for policy** linking macro economic effects to firm level causes, helps show which policy levers matter most; we build this analysis by country, as micro data is confidential and cannot be shared
- **Use the data on business behaviour and ICT** available across all EU countries from common surveys (but unfortunately not yet in the US)
- **Deliver new evidence** on ICT impacts, without adding to the forms we ask firms to fill in.

How

- Launched 2006
- Funded by Eurostat
- Linking data sources "*To identify how ICT adoption affects business behaviour and performance*"
- Project focus developed:

  from Firm level analysis at national level

  ↓

  to Cross-country industry level analysis

Phase 1	Phase 2
U.K - Lead	Germany
Italy	Czech Republic
Denmark	Ireland
Sweden	Norway
Netherlands	
Finland	
Austria	
France	
Slovenia	

Types of analysis

New results; three main types;

- **Firm level regressions across all countries**, using standardised methods and data from ICT use surveys, production surveys and from business registers from all 13 countries
- **Firm level regressions across 'lead' countries**, on skills, offshoring, innovation, investment

  ... both the above tend to identify 'within firm' productivity effects of ICT use
- **Cross industry */* country analysis** using comparable indicators developed from microdata, combined with other sources

  *... this analysis catches 'between firms' effects as successful business drive out unsuccessful ones .. **and it can capture policy differences between countries***

ICT metrics used – from common surveys

Variables for most countries	'Lead NSI' variables
Firm uses computers % workers using computers Firm uses internet % of workers with access to internet Firm has website Firm orders via internet (or EDI etc) % of orders (or value) Firm sells via internet (or EDI etc) % of sales (or value) Firm has intranet % of workers with access to intranet Firm has fast internet access % of workers with access to fast internet access	Use of electronic business processes Mobility of access to technology Mobility of workers accessing technology IT investment (or expenditure) at firm level

How

Contextual variables – from surveys and admin

Variables for most countries	'Lead NSI' Variables
Firm size Firm age Employment Payroll Capital Stock Ownership (local or international) Outsource ratios (measured as purchases / sales or similar) Measures of labour 'quality' (measured in terms of pay per person) Industry characteristics (growth, entry / exit, firm share turbulence)	Multinational organisation of firms (from FDI and ownership data) Employee skills (from linked employer – employee datasets) Changes in organisation (from some local surveys, or CIS) Measures of innovation (from CIS)

Impact Measures – from production surveys

Levels	Growth rates
Productivity measured as - Gross sales / employee (vs industry) - V.A. / employee (vs industry) Productivity measured in terms of Multi-Factor Productivity (for countries which have firm level data on investment, IT investment, labour and other inputs)	Productivity change measured as - Gross sales / employee (vs industry) - V.A. / employee (vs industry) Growth rates measured for: - Gross sales (deflated by industry PPI) - Market share of IT using firms in industry - Value added (double deflated where possible) - Employment, or share of employment in industry

How

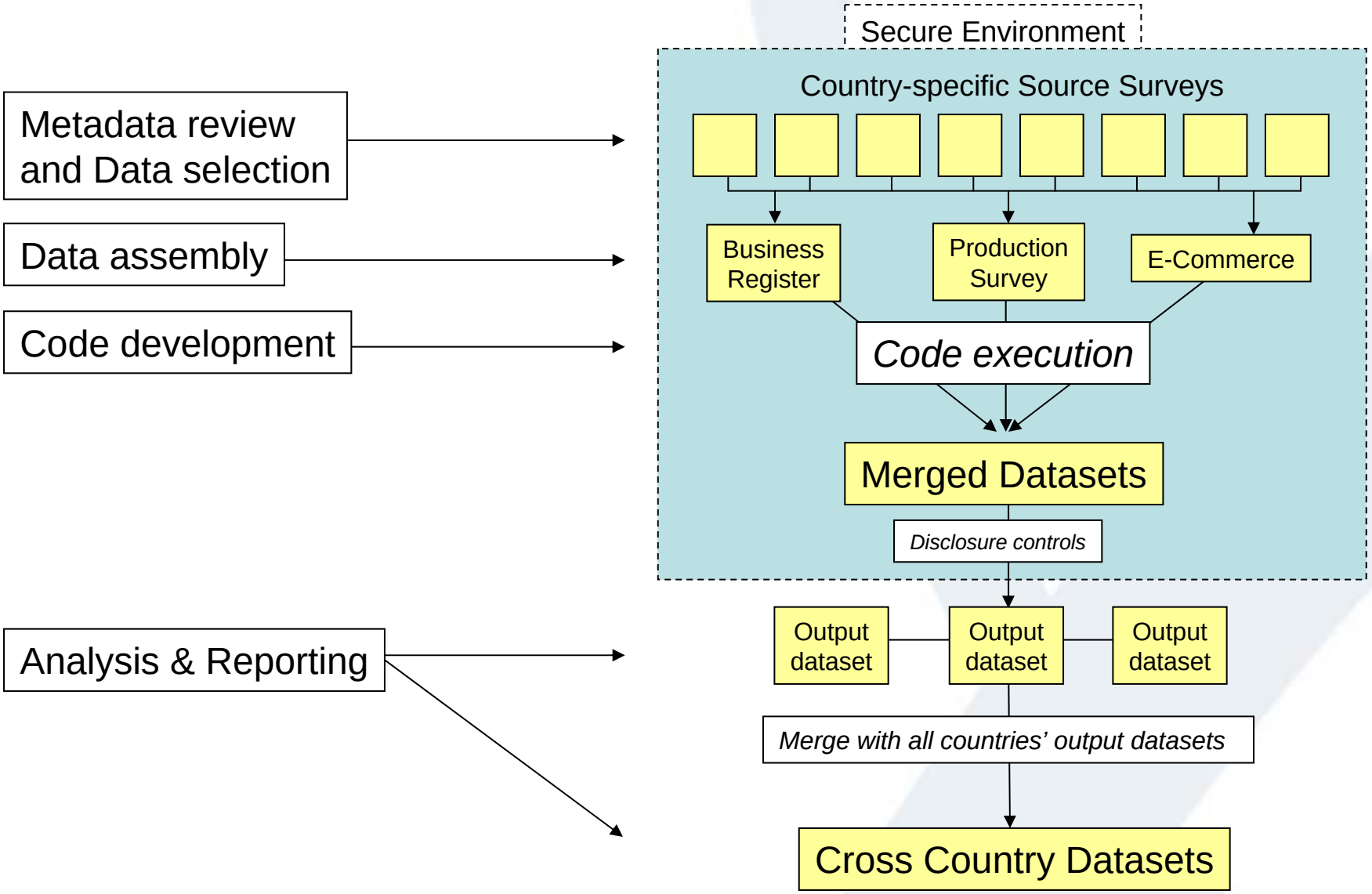
Data coverage across countries

ICT surveys

Year	AUT	CZE	DNK	FIN	FRA	GBR	GER	IRE	ITA	NLD	NOR	SLO	SWE
2000	•					•				•	•		
2001	•			•	•	•			•	•	•		•
2002	•	•		•	•	•	•	•	•	•	•		•
2003	•	•	•	•	•	•	•	•	•	•	•	•	•
2004	•	•	•	•	•	•	•	•	•	•	•	•	•
2005	•	•		•		•	•	•	•	•	•	•	•

Description	AUT	CZE	DNK	FIN	FRA	GBR	GER	IRE	ITA	NLD	NOR	SLO	SWE
Employment	•	•	•	•	•	•	•	•	•	•	•	•	•
Sample Weight	•	•				•	•		•	•			•
Sample Reweighting	•	•			•	•	•		•	•	•		•
Multinational		•			•	•				•			•
Ownership flag		•		•	•	•		•		•		•	•
High growth firms	•	•		•	•	•	•	•	•	•	•	•	
Gazelles				•	•	•			•			•	
Human capital				•							•		•
Gross output	•	•	•	•	•	•	•		•	•	•	•	•
Value added	•	•	•	•	•	•	•	•	•	•	•	•	•
Nominal materials	•			•	•	•	•	•	•	•		•	•
Payroll (→ wage)	•	•		•	•	•	•	•	•	•	•	•	•
Capital Stock	•	•		•	•	•	•		•	•	•	•	•
Productivity – LPQ	•	•	•	•	•	•	•		•	•	•		•
Productivity – LPV	•	•	•	•	•	•	•	•	•	•	•		•
Productivity – MFP	•		•	•	•	•	•		•	•			•
Productivity – TFP	•	•	•	•	•	•	•		•	•	•		•

How


Secure Environment
Country-specific Source Surveys
Business Register
Production Survey
E-Commerce
Code execution
Merged Datasets
Disclosure controls
Output dataset
Output dataset
Output dataset
Merge with all countries' output datasets
Cross Country Datasets
Metadata review and Data selection
Data assembly
Code development
Analysis & Reporting

Productivity results (firm level)

Different models by industry / country

- Consistent results in manufacturing
  - Broadly similar across EU countries, positive effects on productivity associated with ICT use, measured several ways
  - Some variation in coefficients, but directionally similar
- Variation in services
  - Some country / industry combinations show negative correlations
  - Confirmed strong relationships shown in earlier UK work, but only replicated in some countries
  - Positive productivity effects tend to be strongest in countries with highest usage indicators
- IT links to complementary investments
  - ICT impact often (but not always) dependent on other factors / complements / co-investments

Productivity results (industry level)

Effects positive in ‘more networked’ countries

Industry level – BB workers Impact – country estimates

$$v_{jt} = a_0 + a_1 ICT + a_2 k^{IT} + a_3 k^{N} + a_4 hrs + dummies$$

Country	BB workers	(t-stat)
AUT	-.12	(.9)
FIN	.46	(3.5)
FRA	.45	(1.6)
GBR	.39	(3.9)
GER	-.22	(.5)
ITA	-.69	(1.4)
NLD	.37	(2.5)
SWE	.47	(2.9)

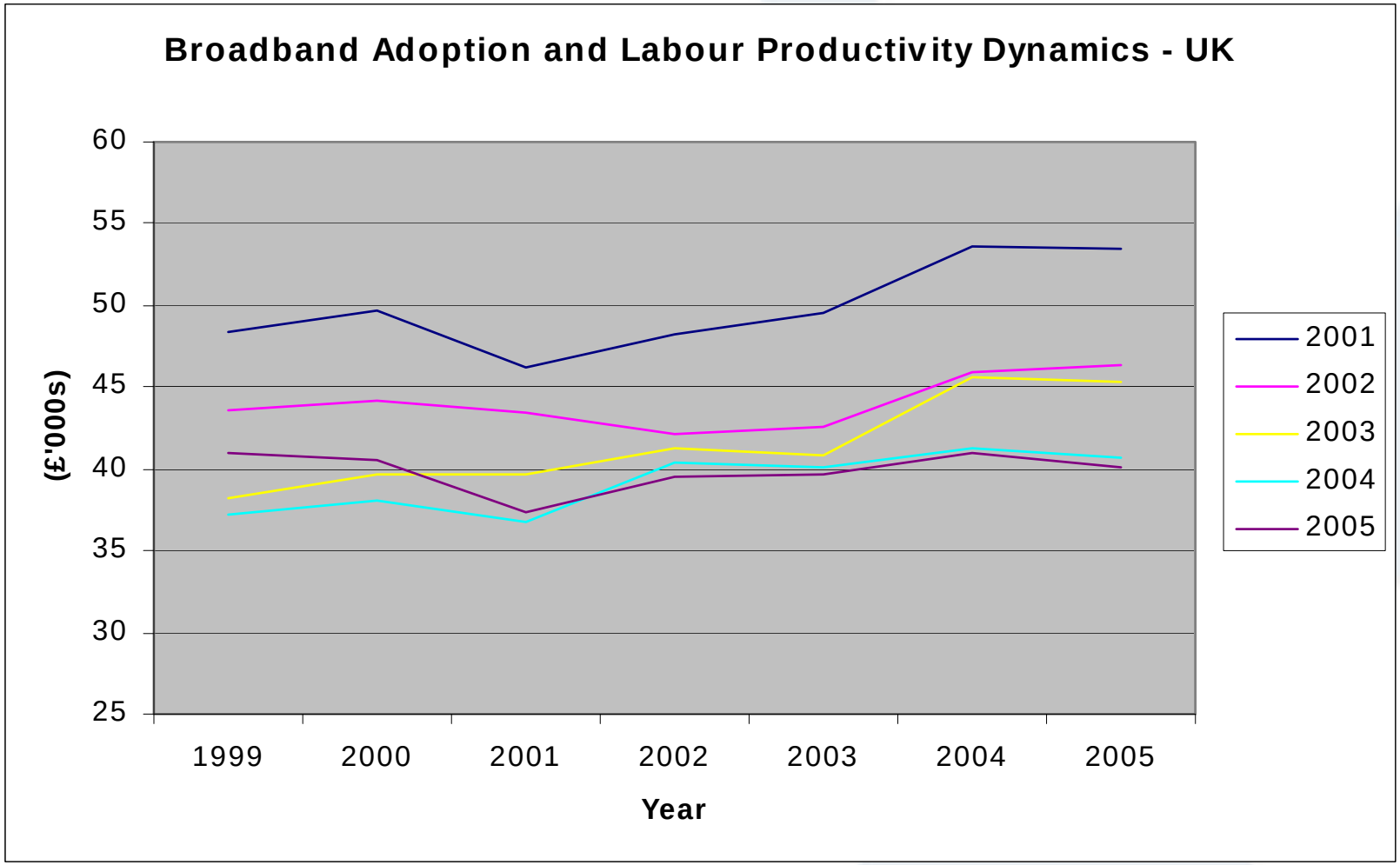
Productivity results (firm level)

Evidence from firm level analysis in UK / NL

- In UK and NL we have firm level data on ICT investment and use
- We can use this to test how ICT productivity impacts differ by business type
  - % e-procurement, and investment, matter most in manufacturing
  - % e-sales associated with higher productivity in distribution services
  - In business and financial services strongest relationship is with % employees using high speed internet
  - ICT capital is much more significant in UK (where measured including software) than it is in Netherlands (where they only count hardware)

Productivity results (firm level)

Most productive UK firms adopt first – but all gain



Value added / employee by year of broadband adoption

Productivity results (firm level)

Evidence from firm level analysis in lead NSIs

- On organisation
  - Manufacturing firms show correlation between TFP and e-links to suppliers
  - Service firms show productivity gains associated with links to customers
  - Some business process links associated with significant, positive, productivity effects, in some countries
  - External links (associated with reallocation) usually more powerful than internal (associated with efficiency)
- On flexibility / specialisation
  - Finnish evidence that flexibility associated with mobile access to IT has significant productivity benefits
  - Finnish evidence that outsourcing of IT services is associated with worthwhile labour productivity advantages

Innovation results

ICT shows strongly in the wider innovation story:

- ***Firm Level (UK, Netherlands, Sweden)***
- ICT networks support ‘knowledge production’
  - More broadband enabled workers => more external ideas in innovation
  - More networked employees=> more new products / services
- ICT helps marketing new products
  - Netherlands analysis shows e-commerce linked to innovation success
- often ICT is the innovation
  - ICT use and process innovation can substitute in productivity regressions
- ***Industry Level (across all countries)***
- ICT intensity changes degree of competitive innovation
  - US data shows that successful firms in ICT intensive industries are more successful in rolling out innovation via ICT based enterprise architecture
  - Our EU study shows relationship between ICT and competitive ‘churn’

Results (industry level)

Broadband Adoption and Impact

$$a: v_{ijt} = a_0 + a_1 DSL\% + a_2 k^{IT} + a_3 k^{N} + a_4 hrs + dummies$$

$$b: DSL\%_{ijt} = b_0 + b_1 w_{-1} + b_2 Cap\%_{-1}^{IT} + b_3 HiSkl_{-1} + b_4 Churn + dummies$$

v	(log) real value added
Kit	ICT capital service
Kn	Non-IT capital service
Hrs	hours
w	Average wage
Cap%it	ICT-capital as share of cap.
HiSkl	High skilled worker share
DSL%	**Broadband penetration**
Churn	**Interquartile range of firm-level growth rate distribution**

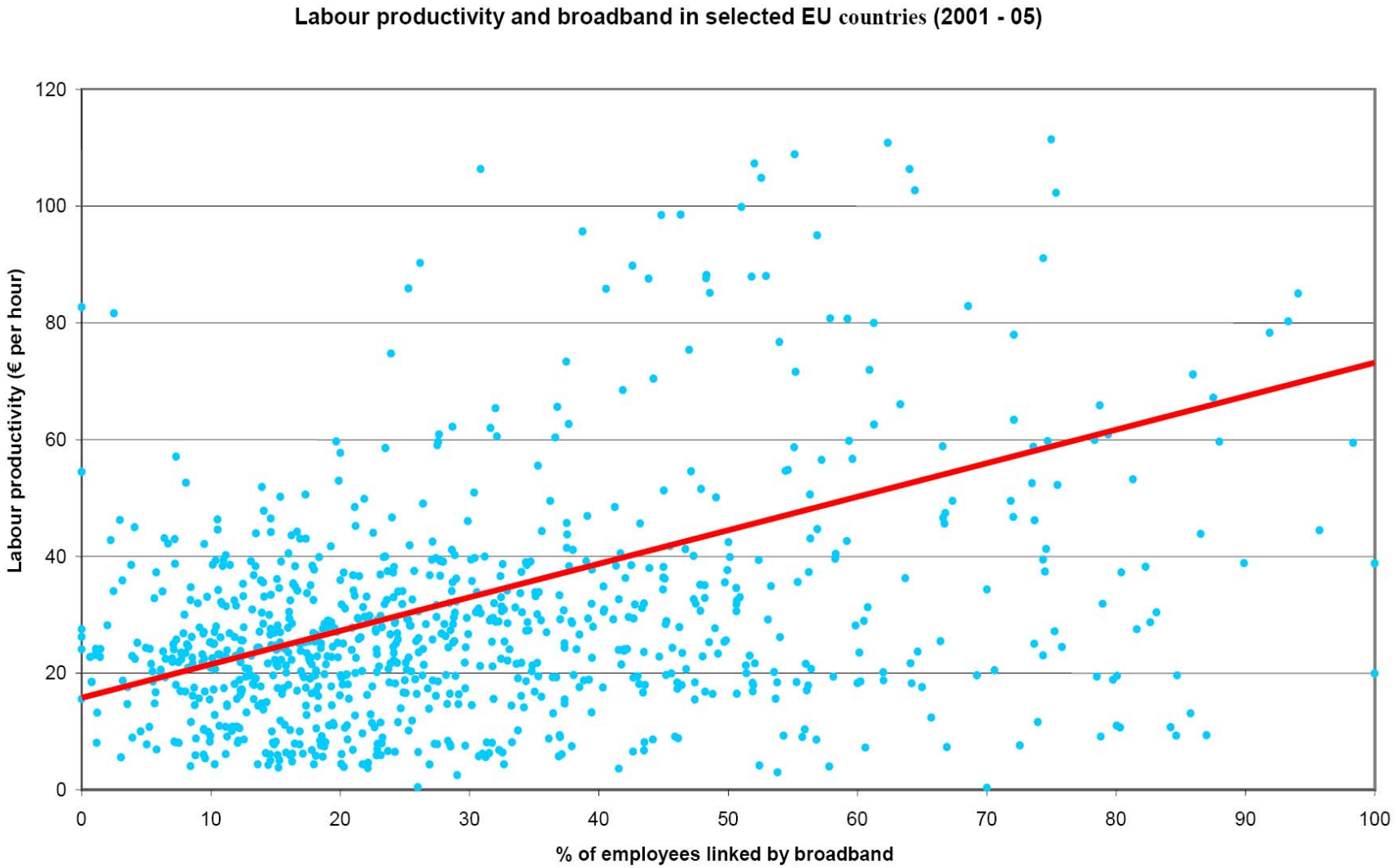
Results (industry level)

Broadband Adoption and Impact

Coef	Variable	DSL%		Internet%	
a1	ICT-indicator:	1.24	.90	1.20	1.05
a2	Kn	.35	.27	.34	.27
A3	Kit	-.07	.05	-.08	.05
A4	Hrs	.72	.68	.72	.68
B1	w(-1)	.24	.02	.30	.01
B2	Cap%it	.31	.20	.32	.17
B3	HiSkl	.18	.38	.19	.33
B4	Churn	.30	.15	.28	.14
	dummies	c,t	i,t	c,t	i,t
	D.F.	659	646	649	646

Kit generally insignificant; Other coefs significant at 1%-level;.

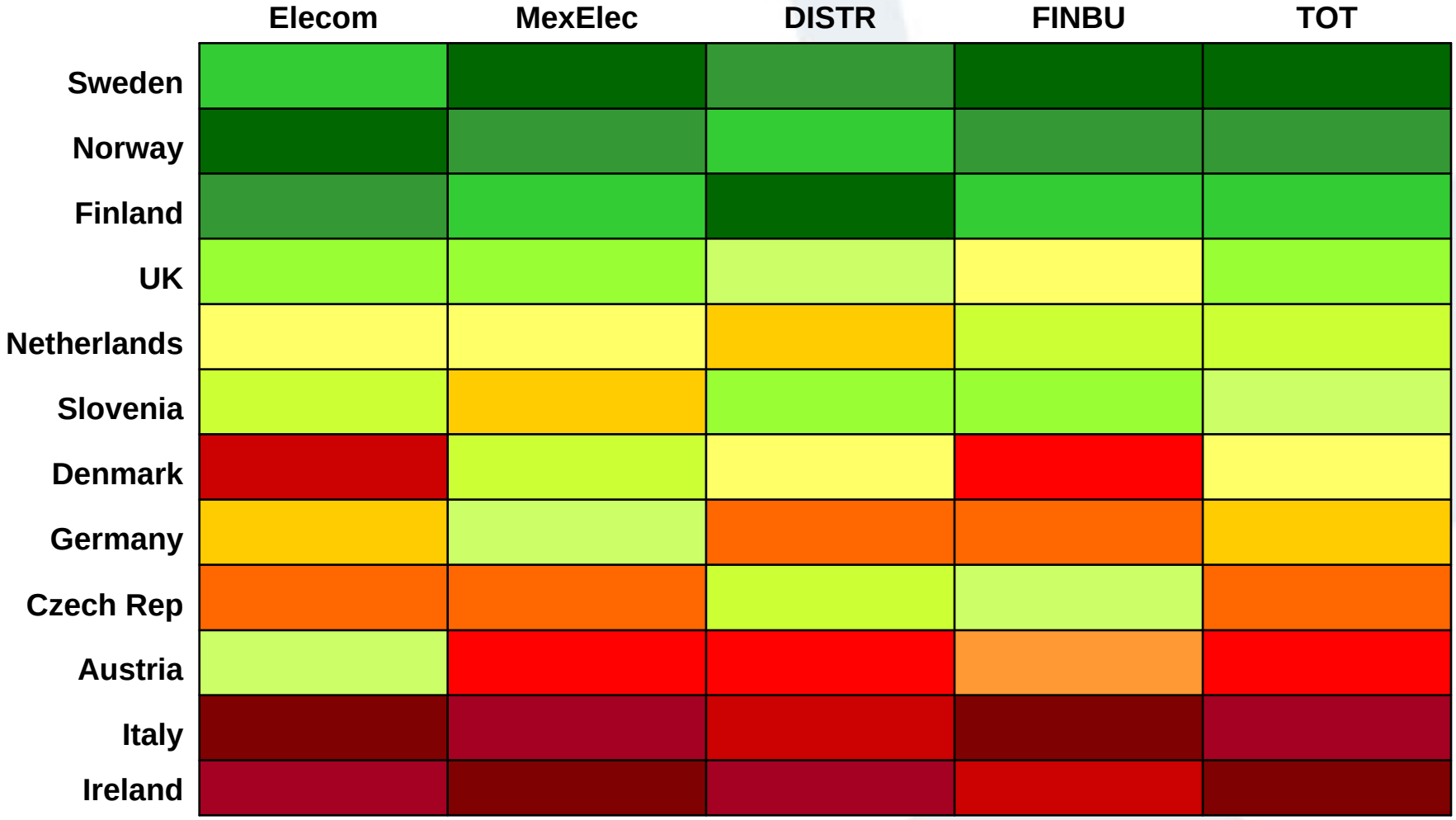
Results (industry level)



Value added / employee vs % broadband enabled employees; 33 industries x 13 countries

Results (industry level)

Industry based ‘network’ indicators => new perspectives



Colour coded indicator for % broadband enabled employees; green highest, red lowest (2004)

Recommendations

Interpret ICT within a set of complementary factors

- Intangibles framework
  - Software
  - Technical R&D
  - Non-technical innovation spending
  - Workplace training
  - ‘Organisational’ investment
  - Reputation
  - Done at macro level in US / UK – we should ‘dig down’ to firm level
- Competitive effects are key
  - US and EU data tell same story
  - ICT => market ‘churn’ => innovation and productivity

Recommendations

ICT measurement and analysis should reflect interaction with other innovation related assets