

ICT and Productivity Growth: The Timing of Structural Breaks in Productivity
Growth and the Link to Information Technology

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Work in progress

Motivation of this study

- Understand the relationship between productivity growth and investments in information and communications technologies (ICT).
- Widely cited evidence for the US: Stiroh AER (2002)
 - Private sector labour productivity growth increased around 1995.
 - Break in growth rate significantly related to ICT intensity.
 - Productivity gains *not* confined to ICT *producing* industries.
- European evidence is scarce. New EUKLEMS data enables us to address this issue and compare to US results (obtained for a similar sectoral classification and level of aggregation).

Difference-in-Difference Estimation

- Simple pooled regression across industry i and time t :

$$d \ln A_{it} = \alpha + \beta D_t + \gamma C_i + \delta D_t C_i + \epsilon_{it}$$

$$D = 1 \text{ if } t > 1995, \quad D = 0 \text{ otherwise}$$

$$C = 1 \text{ if ICT intensive, } \quad C = 0 \text{ otherwise}$$

- β is the post-1995 acceleration in labour productivity in sectors that are *not* ICT intensive
- δ is the differential rate of acceleration af 1995 for ICT intensive sectors.

D-i-D Results: US (Table 1, first panel)

- Labour productivity measure based on gross output.
- ICT intensity measure: ICT capital services as a fraction of total capital services. Median used as cut-off for dummy.
- $n = 30$ industries at NACE 2/3 digit level. $T = 12$ years of data for each industry.
- US results closely resemble the results in Stiroh (2002):
 - No significant post-1995 productivity acceleration in sectors that are *not* ICT intensive.
 - Significant post-1995 acceleration in ICT intensive industries.
 - Productivity gains are not confined to ICT *producing* industries.

D-i-D Results: Europe (Table 1)

- Eleven European countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, and United Kingdom.
- ICT intensity measure: Two sets of results: Overall median cut-off and country-specific median cut-off.
- Country-specific ICT cut-off:
 - Significant post-1995 productivity *slowdown* if *not* ICT intensive.
 - Significant post-1995 acceleration in ICT intensive industries.
 - Productivity gains are not confined to ICT *producing* industries.
- Overall ICT cut-off: Does not correct for country-specific deviations in measurement of ICT intensity. Similar findings, smaller in magnitude and less significant.

Timing of the Break

- US near-consensus on dating the break in productivity growth to 1995.
- Europe: Less favourable overall productivity developments. Break time less clear.
- Stiroh used Andrews and Hansen methodology to a long series of quarterly data and obtained an estimate of the timing of the break.
- We consider using Andrews and Hansen methodology to the yearly EUKLEMS data. Feasible, although little precision in estimates of break date.

Timing of the Break (2)

- Two tables:
 - Andrews/Hansen test of *any* change in model parameters (Table 2).
 - Test of a change in *long-run* mean of the productivity growth rate (Table 3).
- Estimates of most probably break date: Wide range between min and max of significant breaks within many industries.
- Variation in break dates across countries within a given industry.

Outstanding Issues and Ongoing Work

- Check robustness of results against the particular ICT intensity measure adopted.
- Utilize two panel dimensions (in addition to time):
 - Analyze *within* industry variations *across* countries.
 - Analyze *within* country variations *across* industries.

Gain precision in establishing significance of break and in determining proper bounds on the breakpoint *via* panel dimensions of the data.

Table 1: Diff-in-diff estimates: Labour productivity growth for the US and for a group of 11 European countries (pooled estimates).

US			
Post ₁₉₉₅	0.954*** (0.286)	0.163 (0.319)	0.112 (0.339)
Post ₁₉₉₅ * IT ₁₉₉₅		1.581*** (0.491)	1.407** (0.546)
Without IT-Producing?			Yes
R ²	0.0184	0.0725	0.0453
Number of observations	360	360	312
Number of industries	30	30	26
Europe: Country-specific intensity cut-off			
Post ₁₉₉₅	0.147 (0.195)	- 0.532* (0.294)	- 0.547* (0.298)
Post ₁₉₉₅ * IT ₁₉₉₅		1.306*** (0.386)	0.869** (0.387)
Without IT-Producing?			Yes
R ²	0.0001	0.0034	0.0066
Number of observations	3948	3948	3420
Number of countries x industries	11 x 30	11 x 30	11 x 26
Europe: Overall intensity cut-off			
Post ₁₉₉₅	0.147 (0.195)	- 0.329 (0.299)	- 0.405 (0.305)
Post ₁₉₉₅ * IT ₁₉₉₅		0.909** (0.390)	0.545 (0.390)
Without IT-Producing?			Yes
R ²	0.0001	0.0020	0.0045
Number of observations	3948	3948	3420
Number of countries x industries	11 x 30	11 x 30	11 x 26

***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Note: For Italy the gross output variable contains 12 missing values for the industry “Real estate activities” in the period from 1989 to 2000.

Table 2: Andrews/Hansen test of break in labour productivity

Industry	Within industry			Average break year
	Number of countries with break [§]	Break year estimate		
		Minimum	Maximum	
Agriculture etc.	8	1986	2000	1993.0
Mining etc.	9	1987	2002	1995.0
Food, beverages etc.	4	1987	2002	1995.0
Textiles etc.	10	1995	2002	1997.3
Wood etc.	5	1988	2002	1993.0
Pulp, paper etc	10	1986	2002	1995.2
Coke etc.	7	1987	2002	1993.6
Chemicals etc.	10	1986	2001	1993.7
Rubber and plastics	5	1986	1995	1989.0
Other non-metallic	5	1992	2002	1996.0
Basic metals etc.	7	1987	1996	1991.4
Machinery, nec	8	1986	2000	1993.5
Electrical equipment etc.	7	1986	2002	1999.0
Transport equipment	7	1986	2001	1992.0
Manufacturing nec etc.	5	1987	2002	1996.0
Electricity, gas etc.	9	1986	2002	1994.4
Construction	6	1986	1995	1989.0
Sale, maintenance etc.	5	1986	1996	1991.0
Wholesale trade etc.	8	1986	1998	1992.3
Retail trade etc.	7	1987	2001	1993.4
Hotels and restaurants	7	1986	2002	1995.0
Transport and storage	7	1987	2002	1995.6
Post and telecom.	10	1989	2001	1995.6
Financial intermediation	8	1986	1997	1991.3
Renting of m&eq etc.	6	1988	1996	1992.2
Public admin etc.	7	1987	2002	1997.3
Education	6	1990	2002	1995.2
Health and social work	7	1987	2000	1992.6
Other community serv.	5	1986	2001	1993.2

[§]Based on ExpW with a 10 per cent level of significance.

Table 3: Test of break in long-run mean of labour productivity growth

Industry	Number of countries with break	Significance of break		Average break-time
		Minimum	Maximum	
Agriculture etc.	4	1990	1998	1993,5
Mining etc.	7	1987	2002	1992,7
Food, beverages etc.	4	1994	2002	1997,8
Textiles etc.	3	1995	2002	1998,3
Wood etc.	4	1986	2000	1993,5
Pulp, paper etc	8	1986	2002	1993,8
Coke etc.	4	1987	1994	1990,0
Chemicals etc.	5	1987	2001	1993,8
Rubber and plastics	3	1987	1994	1990,0
Other non-metallic	5	1992	2002	1996,6
Basic metals etc.	7	1987	1996	1992,0
Machinery, nec	8	1986	2000	1994,3
Electrical equipment etc.	4	2001	2002	2001,3
Transport equipment	5	1986	2001	1992,6
Manufacturing nec etc.	7	1986	2002	1994,9
Electricity, gas etc.	4	1987	2002	1996,0
Construction	3	1987	1997	1993,0
Sale, maintenance etc.	4	1989	1996	1993,5
Wholesale trade etc.	4	1990	1996	1993,0
Retail trade etc.	6	1988	1997	1992,2
Hotels and restaurants	5	1993	2002	1996,4
Transport and storage	5	1986	2002	1994,4
Post and telecom.	4	1992	2001	1996,5
Financial intermediation	7	1986	2001	1993,6
Renting of m&eq etc.	3	1988	1992	1990,0
Public admin etc.	6	1987	2002	1998,0
Education	5	1989	2002	1995,4
Health and social work	3	1986	2000	1993,7
Other community serv.	5	1986	1992	1989,4