Discussion of
Do R&D and ICT Affect Total Factor
Productivity Differently?

Harald Edquist and Magnus Henrekson
IARIW Meeting, August 2016


*The views expressed today are my own and not necessarily those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.*
Disclaimer:

- These are my opinions and not those of the Federal Reserve Bank of Philadelphia or of the Federal Reserve System
Overview

• How – and when – do R&D and ICT capital affect total factor productivity?
• Impacts on TFP are here called “indirect” effects, as the direct effects of these capital have already been removed in the estimation of TFP
• Briefly, the authors argue that TFP is affected contemporaneously indirectly by R&D, and with a decade long lag, indirectly by ICT
R&D impacts are hard to capture

More important result:

- ICT, particularly software, appears to be a GPT, as argued by Basu and co-authors
- Initially, there are expenses associated with adopting ICT that reduce TFP
- In the longer run – 8+ years – there are important positive effects of ICT on TFP
**ICT**

Intended to fulfill or enable the function of information processing and communications by electronic means, including transmission and display

(OECD 2009)

**R&D**

Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society

(OECD 2002)
Overview

• ICT and R&D have been engines of growth

• Important to understand how investments in ICT and R&D affect productivity growth
Questions

• Is there any evidence of indirect effects from ICT and R&D on Swedish industry level data?

• Do investments in hardware and software affect TFP differently?
Indirect Effects

• We define indirect effects as the contribution from ICT and R&D to TFP at the industry level
  – After removing the standard direct effects
• Direct effect: Neoclassical theory predicts that ICT is a normal piece of equipment – effect on labor productivity through capital deepening
• Network effects – higher investments in ICT would result in higher TFP growth due to improved information management and more rapid diffusion of best practice
Data

- Based on Swedish National Accounts
- 47 industries for the period 1993–2013
- Value added based on double deflation
- Labor input defined as hours worked
- Capital services have been calculated for ICT, R&D and other capital
Annual Labor Productivity growth
1995–2014

EU15, Japan and the US. (GDP per hour worked)

Source: OECD (2016).
Estimating TFP

Growth accounting
Assumes: Constant returns to scale and perfect markets

\[ \Delta \ln TFP_{i,t} = \Delta \ln V_{i,t} - s_{ICT} \Delta \ln K_{ICT,i,t} - s_N \Delta \ln K_{O,i,t} - s_R \Delta \ln R_{i,t} - s_L \Delta \ln L_{i,t} \]

\( V \) is aggregate value added, \( K_{ICT} \) is ICT capital, \( K_O \) is other capital than ICT and R&D, \( R \) is R&D capital, \( L \) is labor input measured in hours, all for industry \( i \) at time \( t \).
Testing for Indirect Effects

\[ \Delta \ln TFP_{i,t} = \beta_{ict} \Delta \ln K_{ICT,i,t} + \beta_{o} \Delta \ln K_{O,i,t} + \beta_{R} \Delta \ln R_{i,t} + \beta_{L} \Delta \ln L_{i,t} + \delta_{t} + \nu_{i,t} \]

\( \Delta TFP_{i,t} \) is the TFP growth of industry \( i \),
\( K_{ICT} \) is ICT-related capital services and \( K_{O} \) is capital services other than ICT and R&D, \( R \) is R&D capital, \( L \) is labor input,
\( \delta_{t} \) are year dummies, and \( \nu_{i,t} \) is the differenced residual.

\[ K_{ICT,i,t} = K_{S,i,t} + K_{H,i,t} \]

It is also possible to divide ICT capital into hardware and software, where \( K_{S,i,t} \) is software capital and \( K_{H,i,t} \) is computer and communications hardware capital.
Results (I)

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable: TFP (current)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Drop ICT-producing</td>
</tr>
<tr>
<td>ΔHours worked (ΔlnL)</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
</tr>
<tr>
<td>ΔICT capital (ΔlnK_{ICT})</td>
<td>−0.04</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
</tr>
<tr>
<td>ΔSoftware capital (ΔlnK_{S})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>−0.07***</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
</tr>
<tr>
<td>ΔHardware capital (ΔlnK_{H})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>−0.02</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
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<tr>
<td>ΔOther capital (ΔlnK_{O})</td>
<td>−0.35***</td>
</tr>
<tr>
<td></td>
<td>(0.089)</td>
</tr>
<tr>
<td>ΔR&amp;D capital (ΔlnR)</td>
<td>0.10***</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
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<tr>
<td>Time dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Assumes: Constant returns to scale and perfect markets

| ΔΔL (hours worked change) | 0.08 |
| ΔΔK_{ICT} (ICT capital change) | −0.04 |
| ΔΔK_{S} (Software capital change) | −0.07*** |
| ΔΔK_{H} (Hardware capital change) | −0.02 |
| ΔΔK_{O} (Other capital change) | −0.35*** |
| ΔΔR&D (R&D capital change) | 0.10*** |
| Time dummies | Yes |
| Adjusted R² | 0.10 |
Lagged Indirect Effects

Instead of changing the length of the period we include lagged periods in the analysis by dividing the sample into two time periods: 1993–2003 and 2004–2013:

\[
\Delta \ln TFP_{i}^{2004-2013} = \beta_{ICT} \Delta \ln K_{ICT,i}^{2004-2013} + \beta_{ICT} \Delta K_{ICT,i}^{1993-2003} \beta_{O} \Delta \ln K_{o,t}^{2004-2013} \\
+ \beta_{R} \Delta \ln R_{i}^{2004-2013} + \beta_{R} \Delta \ln R_{i}^{1993-2003} + \beta_{L} \Delta \ln L_{i}^{2004-2013} + u_{i,t}
\]
## Results (III)

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable: TFP&lt;sup&gt;2004–2013&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base case OLS</td>
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<tr>
<td>( \Delta \text{ICT capital (}\Delta \ln K_{\text{ICT}})^{2004-2013}</td>
<td>(-0.11)</td>
</tr>
<tr>
<td></td>
<td>((0.135))</td>
</tr>
<tr>
<td>( \Delta \text{ICT capital (}\Delta \ln K_{\text{ICT}})^{1993-2003}</td>
<td>(0.19^{***})</td>
</tr>
<tr>
<td>( \Delta \text{R&amp;D capital (}\Delta \ln R)^{2004-2013}</td>
<td>(0.20^{**})</td>
</tr>
<tr>
<td></td>
<td>((0.088))</td>
</tr>
<tr>
<td>( \Delta \text{R&amp;D capital (}\Delta \ln R)^{1993-2003}</td>
<td>(0.002)</td>
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Additional Robustness checks

- Measurement errors
- Omitted variable bias – other intangibles
- Simultaneity
• Very nice paper, easy to read, very important topic, useful results!
• Highly recommended!
Minor data issue

- Maybe adjust capital utilization for business cycle effects, as in Basu et al?
  - These are smaller for Sweden, but not nonexistent
• R&D should have lagged effects on output
  – R&D is the creation of future products.

• Why does R&D have contemporaneous effects on TFP?
  – Reverse causation. Successful R&D causes successful firm and rivals to invest in R&D

• And why only contemporaneous effects?
  – R&D is very risky. A few big wins, many failures.
  – Economic outcomes of patents are highly skewed, lognormal
  – Difficult to catch in a regression
Comments on ICT

• Is ICT a general purpose technology that requires time to digest? Very important question!

• Software investments may cause firms to invest in complementary resources
  – Learning the software
  – Developing macros
  – Adopting other technology to best use the software

• Over the longer-run, the investments pay off
Congratulations

• And thank you!