Chapter Five

The Faster-Accelerating Digital Economy

Economic Growth: The New Perspectives for Theory and Policy

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Springer 2014

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5.1 Look at characteristics of Digital Economy
5.2 Investigate the structure of the Digital Economy’s faster growth
5.3 Forecast future of Digital Economy by looking at the real-life cases of the US, Finland, and Ireland
5.4 Revisit the core of the IT paradox, so that the potential of the digital economy can be reaffirmed
5.5. Summary
5.6 References
What is Digital Economy?

- Digitization of information in every part of the economy (Brynjolfsson and Kahin, 2000)
- Much faster economic growth than previous societies accelerated by ICT innovation (The US Department of Commerce, 1998)
- Considered as a step toward the knowledge-based society (Drucker, 1969 and Bell, 1973)
- Knowledge would be the basis of policy decision, and knowledge workers who created and used information would become more important
5-1 Characteristics of the Digital Economy

Driving forces of the Digital Economy’s faster economic growth:

- ICT converges with and improves the efficiency of traditional industries
- Production function of the ICT industry shows increasing returns to scale
- Development of ICT stimulates not only demand and supply but also the entire expansive reproduction system (ERS)
1. Efficiency improvement in traditional industries

The technological advancement due to increasing ICT use in traditional industries has resulted in:

- Raising the added value and improving the productivity of traditional industries
- Influencing the entire production process, introducing faster and more efficient procedures
1. Efficiency improvement in traditional industries

Improving added values by developing new convergence technologies into the existing systems

Table 5-1 Examples of technology convergence between traditional industries and ICT

<table>
<thead>
<tr>
<th>Industry:</th>
<th>Major convergence technologies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile industry</td>
<td>Web-based automobile, Integrated modularization of components, Intelligent safety system, Engine control, Gas emission control</td>
</tr>
<tr>
<td>Mechanical industry</td>
<td>MEMS*, Open PC-NC, Industrial robots, IMS*</td>
</tr>
<tr>
<td>Shipbuilding industry</td>
<td>Automatic sailing system, Automatic ship identification system, Integrated control system, Super-luxury passenger ship (car ferry), Special vessel-building technology</td>
</tr>
<tr>
<td>Textile industry</td>
<td>High-performance industrial textile (conductivity textile, smart textile, intelligent textile, etc.)</td>
</tr>
<tr>
<td>Construction industry</td>
<td>Intelligent construction system, Construction robots, Construction CALS/EC, Contractor integrated technology and information system (CITIS)</td>
</tr>
<tr>
<td>Health-care industry</td>
<td>Next-generation intelligent medical equipment, Sensory functions recovery devices for the disabled, Speedy EMS, Operating robots, Micro autonomous endoscope</td>
</tr>
</tbody>
</table>

*MEMS = micro-electronic-mechanical system, IMS = intelligent manufacturing system
2. IRS production function of the Digital Economy


- Production function of the Digital Economy has the increasing-returns-to-scale (IRS) characteristic whereas the traditional manufacturing industries of industrial societies show decreasing-returns-to-scale (DRS).

Characteristics of ICT:

- Path-dependent economy (Arthur, 1994)
- Network and tipping effect (Shy, 2001)
  - Unique characteristics of software products of easy reproduction and network effects
2. IRS production function of the Digital Economy

The increasing-returns-to-scale (IRS) production function: a certain trend in which the more the units of the input factor, the greater the output per unit of the input factor

- IRS appears due to the substitution of material capital for knowledge capital
- and its self-reinforcing nature in the process of knowledge accumulation as the driving force
5-1 Characteristics of the Digital Economy

3. Social changes in the Digital Economy

Five social changes by the digital economy

- Creates new demand generated by new products, enabled by digital technology
- Allows more flexible economic structures
- Mitigates price fluctuation
- Transforms the structure of firms and employment type, and creates new employment
- Prompts the emergence of the digital generation
The time-output relationship in the Digital Economy

The shift of DRS aggregate production functions (APFs) at different time frames according to technological changes as seen in agricultural societies.

Figure 5 - 1

Time-output relationships with DRS production function and slow technological change
5-2 Structure of the Digital Economy’s faster growth

The time-output relationship in the Digital Economy

The shift of APFs when technological innovation happens in each time frames, e.g. in an industrialized society

Figure 5 - 2

Time-output relationships with DRS production function and fast technological change
5-2 Structure of the Digital Economy’s faster growth

The time-output relationship in the Digital Economy

The shift of APFs from different DRS and IRS production function

Source: (a) Solow, 1957, p. 313, chart 1

Figure 5 - 3

Time-output relationships with IRS production function; the speed of technological change is the same as in Figure 5.2.
5-2 Structure of the Digital Economy’s faster growth

The time-output relationship in the Digital Economy

The shift of APFs from different IRS production function over time

Figure 5 - 4

*Time-output relationships in the digital economy*

The output curve from IRS production functions shows faster accelerating growth than the line from DRS production functions
5-2 Structure of the Digital Economy’s faster growth

The time-output relationship in the Digital Economy

- Figure 5 - 5
  Comparison of shifting APF patterns over time among agricultural, industrial, and digital economies
The time-output relationship in the Digital Economy

Both Agricultural and Industrial societies have a DRS production function in common.

The range and pace of technological changes in the long run are different for the two societies.

This causes the economic growth path divergence: decelerating vs. accelerating.

The economic growth of the Digital Economy is faster than that of the industrial society.

This difference occurs because the acceleration mechanism and the pace of the Digital Economy’s economic growth are based on the IRS production function.
ERS of the faster-accelerating Digital Economy

Restructured ERS in the digital economy

- Figure 5 - 6

Supply Expansion Stage
- Efficient uses of traditional industries
- Development of new products by new technologies
- Productivity improvement and mass production

Market Equilibrium Stage (Supply=Demand)
- Expansion of existing demand
- Creation of new demand

Capital Accumulation Stage
- Secure Profit ($ \geq 0$)
- Capital Accumulation
- Increase in income

Technological Innovation and Accumulation

3. The total reform of economic cycle
5-2 Structure of the Digital Economy’s faster growth

ICT’s impact on ERS

Efficient uses of traditional industries:
- Stimulates the development of new ICT convergence products.
- Improves productivity and reduces the production cost.

Creation of new ICT industries:
- Creates new industries that did not exist in previous industrial societies.
- Stimulates the expansion of supply in the ERS and creates new demands as well as new industries.
5-2 Structure of the Digital Economy’s faster growth

ICT’s impact on ERS

Total reform of economic cycle:

- ICT developments generate positive effects on the entire economy.

- Overall social change that occurs in the digital economy causes the cycle of ERS to accelerate faster.

- ICT developments exert mitigating influences on the management cycle of macroeconomics and improve its efficiency, leading to an overall market equilibrium.
The role of ICT increased rapidly between the early 1990s and the late 1990s, a period considered to be part of the New Economy phase.

### Table 5-2 Rate of productivity increase and contributions from ICT: the US and the EU

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US</td>
<td>EU15*</td>
</tr>
<tr>
<td>Total Economy</td>
<td>1.08</td>
<td>1.88</td>
</tr>
<tr>
<td>ICT Producing</td>
<td>0.51</td>
<td>0.33</td>
</tr>
<tr>
<td>ICT Using</td>
<td>0.43</td>
<td>0.42</td>
</tr>
<tr>
<td>Non ICT</td>
<td>0.23</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Source: Van Ark et al., 2002

* EU 15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.
The New Economy left a large gap between the US and the EU in terms of economic growth.

**Figure 5 - 7**

GDP per capita for the US and OECD-Europe (constant 2000 US$)

*Source: World Development Indicators Database, 2008*
The US Case

ICT is the main cause explaining the rapid increase of labour productivity in the New Economy (Stiroh, 1998, 2002; Jorgenson and Stiroh, 1999; Jorgenson et al., 2003)

Figure 5 - 8
Labour productivity of nonfarm business in the US (1992 = 100)
The accelerating growth trend of labour productivity in the New Economy after 1995 comes from ICT (Oliner and Sichel, 2003)

**Table 5-3 Contributions to the growth of labour productivity in the US**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth of labour productivity*</td>
<td>1.36</td>
<td>1.54</td>
<td>2.43</td>
</tr>
<tr>
<td>Contributions from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital deepening</td>
<td>0.77</td>
<td>0.52</td>
<td>1.19</td>
</tr>
<tr>
<td>Labour quality</td>
<td>0.22</td>
<td>0.45</td>
<td>0.25</td>
</tr>
<tr>
<td>MFP</td>
<td>0.37</td>
<td>0.58</td>
<td>0.99</td>
</tr>
<tr>
<td>Contribution from ICT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.68</td>
<td>0.87</td>
<td>1.79</td>
</tr>
<tr>
<td>ICT capital</td>
<td>0.41</td>
<td>0.46</td>
<td>1.02</td>
</tr>
<tr>
<td>ICT production</td>
<td>0.27</td>
<td>0.41</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Source: Modified from Oliner and Sichel, 2003, table 1

* In the nonfarm business sector, measured as the average annual log difference for the years shown multiplied by 100.
The GDP of ICT-producing industries in the US grew rapidly.

Although the size of ICT industries is relatively small, they play a key role in economic growth as its driving force.

**Figure 5 - 9**

*GDP of ICT-producing industries in the US (in billion $)*

Source: The Bureau of Economic Analysis, 2010
5-3 Case Studies: The digital economy in industrialized following countries

Overtaking economy model

Process of a faster-accelerating economy overtakes an accelerating industrial economy.

Figure 5 - 10

Overtaking model of the digital economy
Ireland Case

Ireland grew remarkably faster than other economies, starting from the early 1990s.

**Figure 5 - 11**

GDP per capita of Ireland, OECD Europe (average), and other European countries

*Source: World Development Indicators Database, 2008*
Economic growth of Ireland accelerated as ICT industries matured, and the proportion of ICT capital’s contribution to this growth continued to increase.

<table>
<thead>
<tr>
<th>Table 5-4 Contributions to gross-value-added growth in Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Contribution of capital input growth</td>
</tr>
<tr>
<td>(Contribution of ICT capital)</td>
</tr>
<tr>
<td>(Contribution of non-ICT capital)</td>
</tr>
<tr>
<td>Contribution of labour input growth</td>
</tr>
<tr>
<td>Contribution of multi-factor productivity growth</td>
</tr>
</tbody>
</table>

Source: EU KLEMS, 2009
Ireland Case

The role of ICT industries, particularly the producers, was crucial to the improvement of Ireland’s labour productivity.

Table 5-5  ICT industries’ contributions to labour productivity growth in Ireland

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labour productivity growth</td>
<td>Contributions to productivity growth</td>
<td>Labour productivity growth</td>
<td>Contributions to productivity growth</td>
</tr>
<tr>
<td>Total economy</td>
<td>3.0</td>
<td><strong>0.89</strong></td>
<td><strong>23.5</strong></td>
<td><strong>2.75</strong></td>
</tr>
<tr>
<td>ICT-producing industries</td>
<td><strong>11.2</strong></td>
<td><strong>0.89</strong></td>
<td><strong>23.5</strong></td>
<td><strong>2.75</strong></td>
</tr>
<tr>
<td>ICT-producing manufacturing</td>
<td><strong>17.1</strong></td>
<td><strong>0.82</strong></td>
<td><strong>42.3</strong></td>
<td><strong>2.77</strong></td>
</tr>
<tr>
<td>ICT-producing services</td>
<td><strong>2.2</strong></td>
<td><strong>0.07</strong></td>
<td><strong>-0.2</strong></td>
<td><strong>-0.02</strong></td>
</tr>
<tr>
<td>ICT-using industries</td>
<td><strong>1.4</strong></td>
<td><strong>0.42</strong></td>
<td><strong>2.9</strong></td>
<td><strong>0.89</strong></td>
</tr>
<tr>
<td>ICT-using manufacturing</td>
<td><strong>6.1</strong></td>
<td><strong>0.37</strong></td>
<td><strong>8.7</strong></td>
<td><strong>0.56</strong></td>
</tr>
<tr>
<td>ICT-using services</td>
<td><strong>0.2</strong></td>
<td><strong>0.05</strong></td>
<td><strong>1.4</strong></td>
<td><strong>0.33</strong></td>
</tr>
<tr>
<td>Non-ICT industries</td>
<td><strong>2.6</strong></td>
<td><strong>1.48</strong></td>
<td><strong>2.7</strong></td>
<td><strong>1.65</strong></td>
</tr>
</tbody>
</table>

Source: Van Ark et al., 2002
Ireland Case

The relatively high proportion of ICT industries in its economy helped Ireland achieve a faster-accelerating economic growth.

**Figure 5 - 12**

*GDP share of ICT-producing industries in Ireland*

*Source: The Groningen Growth and Development Centre, 2005*
Fuelled by ICT, the economy of Finland has been growing faster than OECD-Europe ever since (Part C).

**Finland Case**

**Figure 5 - 13**

*GDP per capita in Finland and OECD Europe, at 1995 prices and purchasing power parity (PPP) exchange rates*

*Source: Carl et al., 2006*
5-3 Case Studies: The digital economy in industrialized following countries

Finland Case

The contributions from ICT production and ICT capital to GDP growth from 1990 to 2004 increased almost 2.5 times.

Table 5-6  Factor contributions to the output growth of the Finnish non-residential market sector

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Growth of real gross value added at basic prices(^a)</td>
<td>3.15</td>
<td>3.15</td>
</tr>
<tr>
<td>Contribution(^b) from</td>
<td>Capital</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>Labour</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Multi-factor productivity</td>
<td>1.48</td>
</tr>
<tr>
<td>Total contribution from ICT(^b)</td>
<td>0.48</td>
<td>0.66</td>
</tr>
<tr>
<td>Contribution from ICT capital</td>
<td>0.22</td>
<td>0.44</td>
</tr>
<tr>
<td>Contributions from MFP</td>
<td>ICT production</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Spillovers from the use of ICT capital</td>
<td>—</td>
</tr>
<tr>
<td>Memoranda</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income share of ICT capital(^c)</td>
<td>2.45</td>
<td>2.62</td>
</tr>
<tr>
<td>Volume growth of ICT capital(^a)</td>
<td>8.80</td>
<td>17.00</td>
</tr>
<tr>
<td>Output share of ICT production(^c)</td>
<td>5.53</td>
<td>5.53</td>
</tr>
<tr>
<td>MFP growth in ICT production(^a)</td>
<td>4.76</td>
<td>3.97</td>
</tr>
</tbody>
</table>

Source: Jalava and Pohjola, 2008, pp. 270–287, table 3
Notes: (a) Estimates based on non-hedonic ICT prices, (b) Estimates based on hedonic ICT prices, a: In per cent, b: In percentage points, c: In per cent
Finland Case

The influence of ICT on the creation of new industries has been substantial.

Table 5-7  Average growth of labour productivity and its components in Finland, 1995–2005

<table>
<thead>
<tr>
<th>Component</th>
<th>Share of GDP (%)</th>
<th>Volume growth (ln %)</th>
<th>Contribution (ln %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP at market prices</td>
<td>100.00</td>
<td>4.06</td>
<td>4.06</td>
</tr>
<tr>
<td>Hours worked</td>
<td></td>
<td>1.19</td>
<td>1.19</td>
</tr>
<tr>
<td>Labour productivity</td>
<td></td>
<td>2.87</td>
<td>2.87</td>
</tr>
<tr>
<td>Capital deepening</td>
<td>34.62</td>
<td>1.86</td>
<td>0.66</td>
</tr>
<tr>
<td>Dwellings</td>
<td>9.92</td>
<td>1.15</td>
<td>0.13</td>
</tr>
<tr>
<td>ICT capital</td>
<td>3.27</td>
<td>13.95</td>
<td>0.46</td>
</tr>
<tr>
<td>Other capital</td>
<td>21.42</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Labour quality</td>
<td>65.38</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>Multi-factor productivity</td>
<td></td>
<td>2.07</td>
<td>2.07</td>
</tr>
<tr>
<td>ICT related contribution</td>
<td></td>
<td>1.41</td>
<td></td>
</tr>
<tr>
<td>Other contribution</td>
<td></td>
<td>0.66</td>
<td></td>
</tr>
</tbody>
</table>

Source: Jalava and Pohjola, 2007, pp. 463, Table 2
Notes: Numbers may not sum to totals due to rounding.
Finland Case

The effects of the creation of new industries by ICT was substantial

Figure 5 - 14
Changes in the GDP shares of ICT sector and forest industry in Finland
Source: Pohjola, 2008
IT productivity Paradox

‘You can see the computer age everywhere but in the productivity statistics’ (Solow, 1987)

Two arguments

- The effects of IT investments on production are not as apparent as we would expect because statistical methodologies are not sufficiently developed yet to calculate the relationship exactly.

- ICT is simply not yet fully mature to be effectively incorporated into every step of production and its organizations. (Hilbert, 2001)
IT productivity Paradox

Ongoing paradigm shift due to rapid technological revolution

Figure 5 - 15

An ongoing exponential sequence made up of a cascade of S-curves (linear plot)

Source: Kurzweil, 2005, p. 43
The theory of creative destruction of innovation proposes that one technological innovation pulled the next, the former becoming the foundation for the latter in the process.

*Figure 5 - 16*

*The creative destruction of innovation. Source: Hilbert, 2001, p. 53*
5-5 Summary

• With an investigation into the definition, characteristics, and mechanism of the Digital Economy, the Digital Economy is qualitatively different from the industrial society.

• The IRS short-term production function along with the rapid technological progress of the Digital Economy, in the long term, accelerates the growth curve of the Digital Economy faster than the growth curve found in previous industrial societies.

• The fundamental driving forces of the Digital Economy’s faster economic growth are: First, ICT converges with and improves the efficiency of traditional industries. Second, the production function of the ICT industry shows increasing returns to scale. Third, the development of ICT stimulates not only demand and supply but the entire Expansive Reproduction System.

• The ICT productivity paradox was based only on short-term and temporary situations at the incipient stage of the digital economy. The ICT productivity paradox arose from a contradiction when the effect of ICT investments for economic growth fell short of expectations.
**5-6 References**

5-6 References


• EU KLEMS 2009. EU KLEMS Growth and Productivity Accounts. (http://www.euklems.net)
5-6 References

5-6 References


5-6 References


