EE562 Selected Topics in Development Economics 2

(Topic: A Global Perspective and Empirical Evidence in Thailand)

Faculty of Economics

Thammasat University

Summer Session 2017 (2560)

Time: Wednesdays and Fridays, 9AM – noon

Innovation & Technology Transfer

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Office of the National Economic and Social Development Board (NESDB)

Outline

Section I

Innovation

Section II

Innovation and Economic Growth

Section III

Evolutionary growth theory

Section IV

Digitalization

“What have you seen”

https://www.youtube.com/watch?v=IB95KLmpLR4

In-class group discussion

"Please name disruptive technology and business model"

Evolution of the bookstore

1994

Courtesy, Eric Kiaer, Doblin

Evolution of the bookstore

2003

Courtesy, Eric Kiaer, Doblin

Evolution of the bookstore

2007

Courtesy, Eric Kiaer, Doblin

Section I

Innovation

What is innovation?

- **Innovation** is the process and outcome of ***creating something new***, which is ***also of value***.

- Innovation *involves* the **whole process** from ***opportunity identification***, ***ideation*** or ***invention***

What is innovation?

- It is said to *involve the* **capacity to quickly adapt** by *adopting new innovations*

- Recently, new **business models** have come into focus, i.e. *the way a firm delivers value* and *secures profits*.

What is innovation?

- **Schumpeter** proposed that ***innovation*** comes through *combinations* made by an *entrepreneur*, resulting in
  - a **new product**,
  - a **new process**,
  - opening of **new market**,
  - **new** way of organizing the **business** *(business model)*
  - **new** sources of **supply**

Dimensions of innovation

There are several types of innovation

- Process, Poduct, Strategy,

which can vary in degree of newness:

- ***Incremental*** or ***Radical***,

Drivers for innovation

- **Financial pressures** to *reduce costs*, *increase efficiency*
- Increased **competition**
- Shorter **product life cycles**
- Stricter **regulation**
- **Sustainable development**
- **Demographic**, social and maket changes
- Rising **customer expectations** regarding service and quality

What is innovation?

- Gary Hamel argued that today's market place is **hostile to incumbents**, who now needs to conduct **radical business innovation**:
  - Radically reconceiving products and services, not just developing new products and services
  - Redefining market space
  - Redrawing industry boundaries

New conditions for innovation

- **Small start-up entrepreneurs** increasingly depend on **large firms**:
  - as suppliers or customers
  - for venture finance
  - for knowledge (production, markets and R&D)
  - for opening new markets

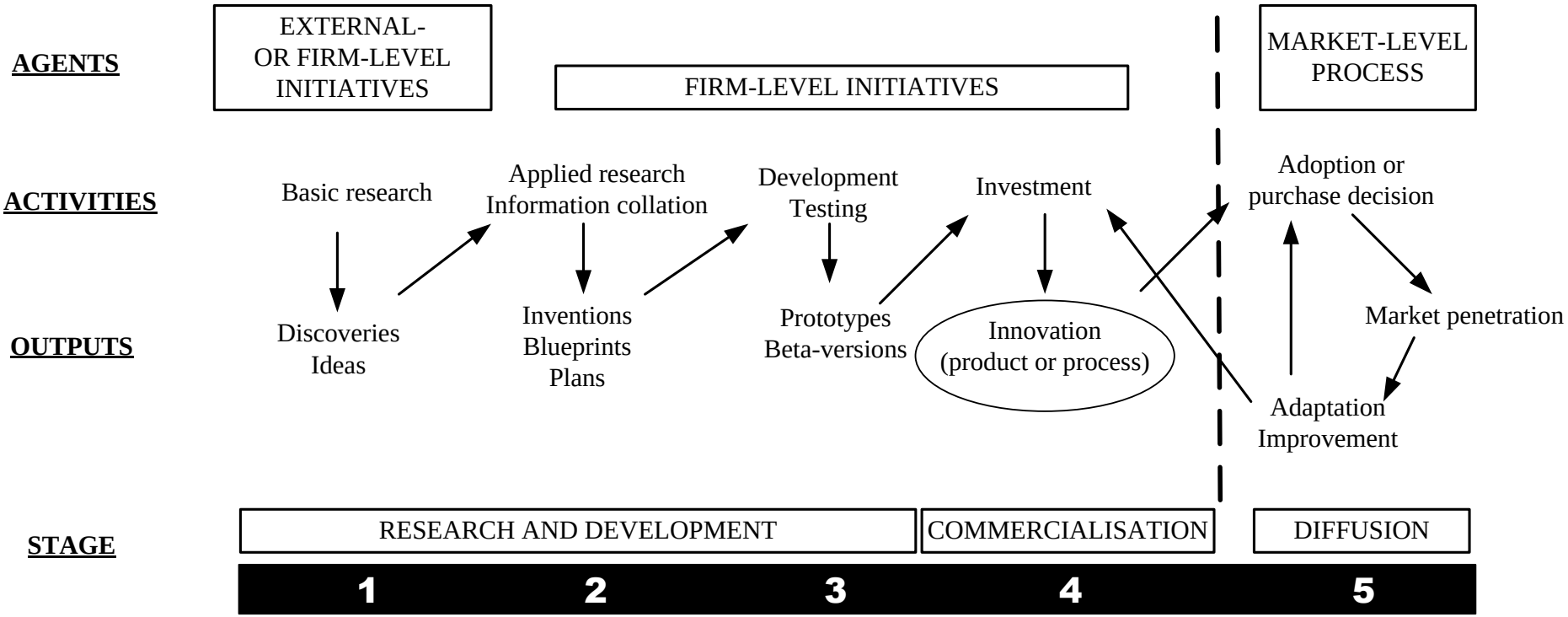
New conditions for innovation

- **Large firms** increasingly depend on **small start-ups**
  - as suppliers of new knowledge (which they cannot develop themselves),
  - or organizational renewal with business models,
  - for opening new markets

Invention, Innovation, Diffusion (Schumpeterian trilogy)

- **Invention**: ***creation of an idea*** to do or make something *(profitability not yet verified)*
- **Innovation**: ***new product/ process commercially valuable*** i.e. *successfully developed inventions*.
- **Diffusion**: the ***spread of a new invention/innovation throughout society*** or at least throughout the relevant part of society.
  - Without this cannot gain full benefits
  - Some of this represents 'spillovers' or 'positive externalities'

The innovation process



Scientists, Knowledge and Technology

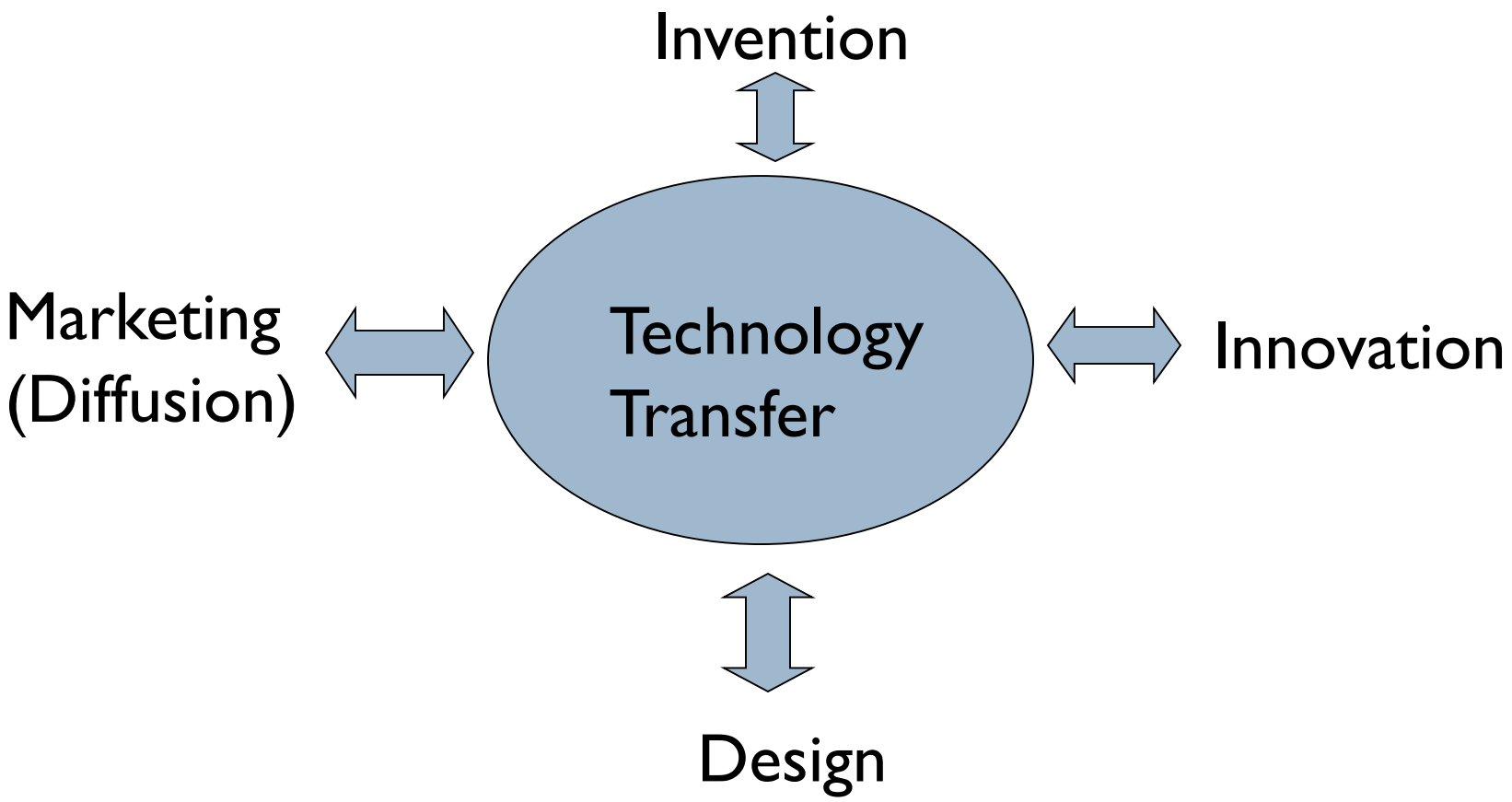
Scientists

- ***Discover*** knowledge *by research*
- ***Disseminate knowledge***
- ***Knowledge (innovation)*** *is* ***public good****; non-rival and non-excludable*
- Universities, government labs, some large firms

Technology

- *Application of knowledge* to ***'production'***
- ***Firms driven*** by profit incentive
- ***Private good:*** use of *intellectual property; patent and copyright*

Technology Transfer



Technology Transfer

- The **transactions** between *changing technology* and *invention, innovation, production, and diffusion*

Linking Organizations to Educational Establishments

Forming Links

1. **Graduate Employment** – companies *hire graduates* and create a *natural link back to their alma mater*
2. **Sabbaticals** – Companies hire university professors to *work on-site for a year or semester* to bolster in-house expertise
3. **Industry/University Research Units** – Organized *research units* where focused groups at the university partner with companies. Companies gain *access to professors, students, and earn results*
4. **University/Industry Liaison Units** – Universities are *creating internal organizations* that are in charge of protecting and developing valuable new technologies to *be transferred to industry*.

Section II

Innovation and Economic Growth

Joseph Schumpeter

"There is no reason to expect the slackening of output through the exhaustion of technological possibilities."

Innovation drives economic growth

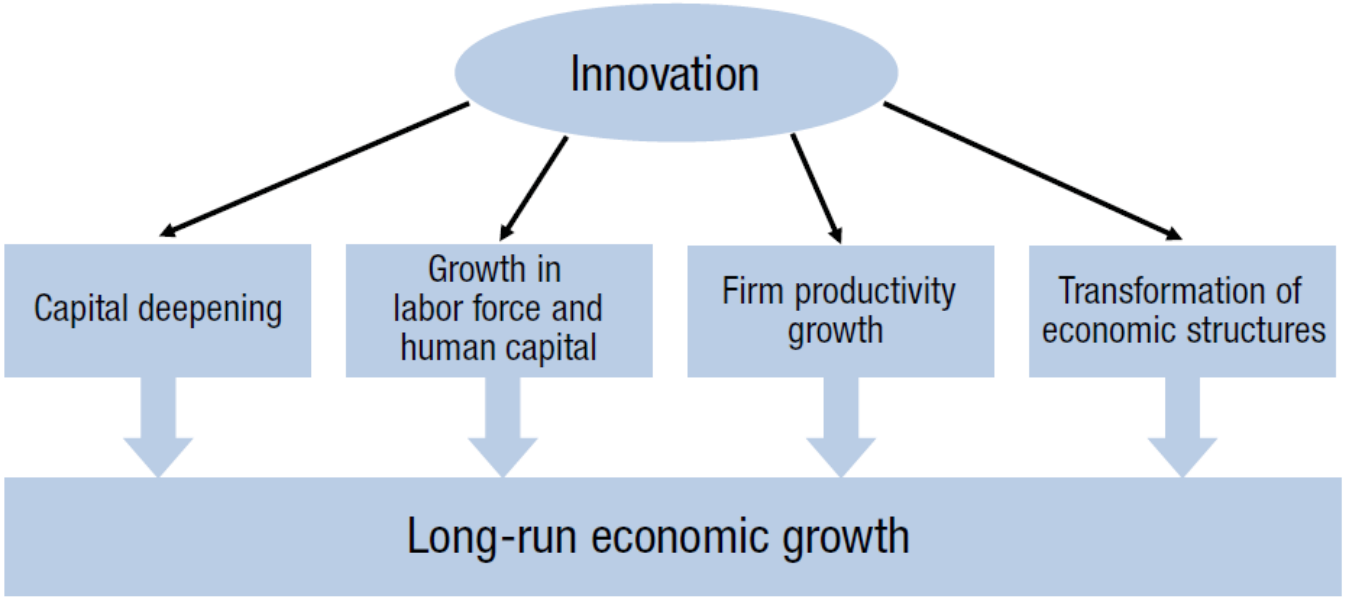
- The ***growth accounting framework*** goes some way to *explain why some nations have grown faster*
- For example, empirical studies have pointed to *high rates of investment* and the *absorption of surplus rural labor into the formal labor force* as key explanations for the rapid growth

Innovation drives economic growth

- However, the *growth accounting framework* faces two important **limitations**.
- First, even though **technological innovation** is often thought to be a ***key determinant of TFP growth***, it can also *have profound effects on factor accumulation*
- Second, empirical studies typically capture **TFP growth as the residual growth**.
- As such, they *cannot offer any* ***insight*** *into the precise forces* that lead economies to become ***more productive***.

Innovation drives growth: **Channel of Growth**

Figure 1.5: Innovation spurs growth through different channels



Innovation drives economic growth

Capital deepening

- Firms **invest** in **new capital equipment** based on the *future income they expect* those investments to generate
- The introduction of **new technologies** can **raise investment returns** and lead firms to undertake new investments.
- Historically, the introduction of major breakthrough *technologies* has often *unleashed investment booms, driving expansions in economic output.*

Innovation drives economic growth

Capital deepening

- More recently, as *information and communication technologies (ICTs)* took off in the 1990s, studies show that **US firms** throughout the economy rapidly **increased their ICT capital stock**, especially when *compared with other fixed capital assets*.
- **Intangible asset investments** – the establishment of *new business processes*, *databases* and other *knowledge-based activities* – have ***become an important component of overall investments***

Innovation drives economic growth

Growth in labor force and human capital

- Technological *innovation* has been a *key force behind the* ***expansion of the workforce***.
- Advances in *health technology* have prompted a *dramatic increase in life expectancy*.
- By reducing the burden of chronic disease and disability, technology has also contributed to a *progressively healthier* – and thus **economically more productive workforce**.

Innovation drives economic growth

Growth in labor force and human capital

- Innovation has been instrumental in facilitating *greater adult participation* in the workforce.
- The arrival of *speedy mass transportation reduced geographical barriers* in the labor market.
- In turn, advances in *educational technology*, have *widened and deepened educational achievements*, further *augmenting* the economy's **human capital** base.

Innovation drives economic growth

Firm productivity growth

- ***Process innovations*** can *increase* the *efficiency*
- The *productivity* enhancements *free up resources* that can be used to **expand output** – in the same firm, in the same sector, or elsewhere in the economy.
- Similarly, process innovations that *lead firms to gain greater economies of scale* and greater output with the same level of capital and labor input.

Innovation drives economic growth

Firm productivity growth

- ***Product innovation*** can *increase* the *efficiency*
- One form of such innovation is the **quality upgrading** *of* ***existing products***. If firms manage to produce the same output level with the same inputs but the *output is of superior quality*, product innovation directly leads to improved firm productivity.
- A second form of product innovation is the *introduction of* ***new products*** that did not previously exist. Such products could either be sufficiently *distinct varieties* of existing products – for example, a new car model – or more *fundamental breakthroughs* such as the first tablet computer.

Innovation drives economic growth

Transformation of economic structures

- New technologies can ***change the face of industries***, leading to the *exit of some firms* and the *entry of others*. In addition, the intensity of competition may change.
- In many cases, these changes prompt growth-enhancing **efficiency gains** and **redeployment of production factors**. Vibrant competition can ***spur technology dissemination*** and ***future innovation***

Innovation drives economic growth

Transformation of economic structures

- Technological innovation often unleashes a ***reorganization of supply chains***.
- Typically, such reorganization involves ***greater specialization***, with firms developing *unique expertise* that serve a variety of companies, within and across industries.
- Technological innovation has also facilitated the ***globalization of supply chains***.

Innovation drives economic growth

Transformation of economic structures

- Technology prompts the ***decline* of older activity**.
- Such **technological disruption** may create *hardship for those whose tasks have become redundant*.
- However, in the longer term, the ***redeployment of workers in growing sectors*** of the economy represents one of the most important ways through which innovation can ***generate output growth***

Section III

Evolutionary growth theory

Frontier innovation

- **Frontier innovation** refers to technological devices, techniques or achievements that employ the ***most current and high-level of technology***; in other words, *cutting-edge technology.*

Frontier innovation and diffusion

- As seen the central role of innovation in driving long-term growth, however, it is ***difficult to make a precise link*** between **historical growth performance** and **different innovations**.
- The *adoption* of technologies takes time and the **technologies themselves evolve**, *rendering* any *attempt at causal attribution problematic*.

Frontier innovation and diffusion

- More generally, economists have gained important insights regarding **two questions** that are critical for **understanding the innovation-growth nexus**:
  - *How* does **frontier innovation** *come about*?
  - *How* do **technologies diffuse** *across economies*?

How does frontier innovation come about?

- At the *beginning of the 19th century*, technological innovation was largely performed by **individual inventors** and **small-scale entrepreneurs**.
- By *the 20th century*, modern innovation systems emerged, whereby a ***variety of organizations*** collectively push the knowledge frontier – *including scientific institutions, large R&D intensive firms and entrepreneurial startups*

How does frontier innovation come about?

- **Technological breakthroughs** have largely occurred as a result of *three forces*.
- First, **scientific discoveries** have been instrumental in *providing the foundations for commercial innovations*.
- Second, the **needs of government** – especially *in the area of defense* – have been a key impetus for the development of many technologies that found application throughout the economy later on.
- Finally, the **needs of the marketplace and competitive market forces** have prompted *firms to invest in the development of new technology* to gain an edge *over their rivals*.

How does frontier innovation come about?

- **Neoclassical growth theory** – which was among the first attempts to formally model the growth process – did not consider *how technological progress comes about*; it merely demonstrated that growth would come to a standstill without it.
- This drawback provided the impetus for **endogenous growth theory**, which explicitly *incorporated incentives for innovation* into models of economic growth.

How does frontier innovation come about?

- In particular, in formal models of **endogenous growth**, ***firms invest in R&D to generate future profits*** and to *avoid being overtaken by competitors*, mainly by introducing new and better-quality products.
- *Competition* between firms then generates a ***dynamic innovation race*** that *leads to sustained increases in productivity*.
- These models capture a key characteristic of today's knowledge-intensive industries: **firms invest in intangible assets** – *not only R&D, but also design, software, workers' skills and organizational know-how* – and they frequently **launch new products that replace older ones**.

Evolutionary Growth Theory

- **Aghion** et al (2005) formally *explored how competition and innovation interact*.
- Aghion, among others, ***criticized endogenous growth theory*** as too mechanistic.
- In particular, endogenous growth models *assume that they fall within a predetermined probability distribution*.
- However, many **innovative breakthroughs** of far-reaching importance *have* ***been accidental*** *in nature* – meaning that they do *not fall within a range of outcomes known in advance*.

Evolutionary Growth Theory

- A second strand of the growth literature – evolutionary growth theory – emphasizes the *specific historical circumstance of innovative activity* and the *complexity of interrelationships, with causal mechanisms* ***changing over time***
- In evolutionary growth theory, firms *cannot foresee all technological possibilities* when they engage in innovation.
- The *path of technological progress* is determined by a **selection process** in which market forces and other economic institutions play a key role.

Evolutionary Growth Theory

- In the evolutionary approach, ***innovation takes place <u>incrementally</u>*** and the ***direction of change only <u>becomes clear over time</u>***.
- Despite **occasional discovery** moments, this steps **took years and decades to develop**, thus ***<u>requires many incremental steps</u>***.
- In addition, their economy-wide impact relied on ***firms learning*** *how to use a new technology, undertaking capital investments*, and reorganizing business operations.
- Indeed, the arrival of new technologies typically *spurs organizational and business model innovations* that, in themselves, are responsible for major **productivity gains**.

Evolutionary Growth Theory

- **Incremental innovation** is also critical for the flourishing of so-called ***General Purpose Technologies (GPTs).***
- While there is no uniform definition, GPTs generally refer to *technologies that have a wide variety of uses and find application in a large range of economic sectors*, and that exhibit *strong complementarities* with existing or potential new technologies, providing grounds for follow-on innovation.

Evolutionary Growth Theory

- Most treatments of GPTs include *the steam engine, railways, the motor vehicle, electricity and ICTs* as key examples.
- Historical studies of GPTs have demonstrated their importance for stimulating growth, but have also found that their **growth stimulus often occurs with a long delay** – *estimated, for example, at 80 years for the steam engine and 40 years for electricity*.
- Recent *endogenous growth* research has linked the emergence and *adoption of GPTs* to long-run cycles of economic growth, providing an explanation for the *growth emerges and slowdowns*.
- Interestingly, the prediction of growth cycles mirrors the **concept of "long waves"** – *also called Kondratiev waves* – which feature in early evolutionary approaches, especially the work of **Joseph Schumpeter**

Evolutionary Growth Theory

Table 1: Growth contributions from steam technology and ICTs

	Steam technology in Britain					ICTs in the US		
	1760-1800	1800-30	1830-50	1850-70	1870-1910	1974-90	1991-95	1996-2001
Capital deepening	0.004	0.02	0.02	0.06	0.09	0.41	0.46	1.02
TFP	0.005	0.001	0.02	0.06	0.05	0.27	0.41	0.77
Total contribution	0.01	0.02	0.04	0.12	0.14	0.68	0.87	1.79

Source: Oliner and Sichel (2003) and Crafts (2004).

- To quantify the growth impact of specific innovations, they capture the growth contribution through (i) **capital deepening;** the growth of *capital inputs associated with a particular innovation* and (ii) **TFP growth** in the *sector that produces the goods underlying the innovation.*
- Crafts studied **capital deepening by the growth in horsepower associated with steam technology**. Although James Watt's steam engine was patented in 1769, Craft's estimates suggest that *its contribution to labor productivity growth was not higher than 0.02 percent per year until 1830*.

Evolutionary Growth Theory

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- Oliner and Sichel's study measures **capital deepening by the growth of ICT capital** – computer hardware, software and communication equipment.
- Their estimates suggest a *higher overall contribution to growth than from steam technology*, especially in the second half of the 1990s. In addition, *most of the growth contribution is due to capital deepening – the greater use of ICTs throughout the economy*.
- As in the case of the steam engine, **the growth impact of ICTs took time to materialize**, *though the delay is much shorter in comparison.*

Technology diffusion

- **Technology diffusion** is the ***dynamic consequence of adoption.***
- It characterizes the *accumulation of technology across adopters and over time*.

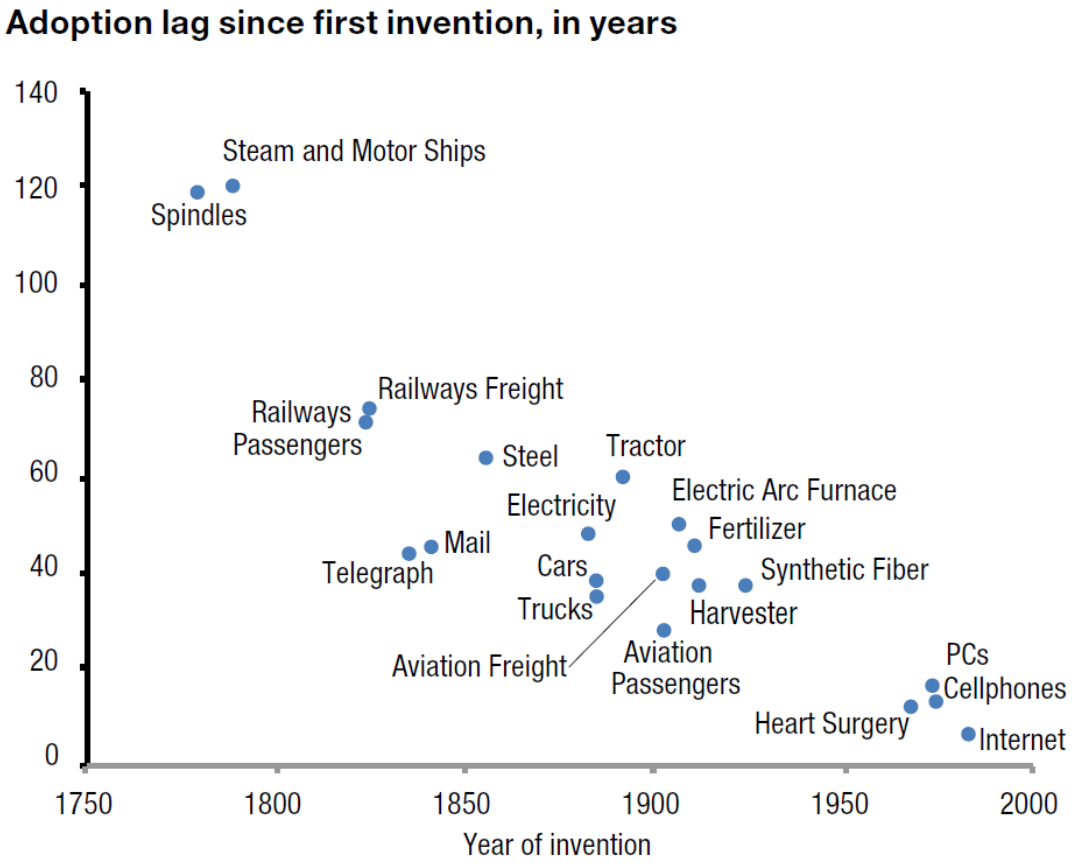
How do technologies diffuse across economies?

- **Innovations** are *rarely fully homegrown*.
- Within developed economies, **ideas are highly mobile**; even for a large economy like the US, about *half of productivity growth* derives from *foreign technology*.
- But how easily does technology really diffuse across economies, especially to less developed ones?
- Given the importance of new technologies in driving long-run growth, ***imperfect technology diffusion*** *could be one explanation for* ***economic divergence***.

How do technologies diffuse across economies?

- Comin and Mestieri (2013) have assembled data covering ***25 technological breakthroughs*** since the late 18th century and their adoption in up to 132 countries.
- They find that *average* ***adoption lags*** *for those technologies have* ***declined*** *markedly over the past 200 years.*
- Most dramatically, *recent technologies such as mobile telephony and the Internet* arrived in *developing economies* within a *few years after their introduction* in developed economies.

Faster technology adoption

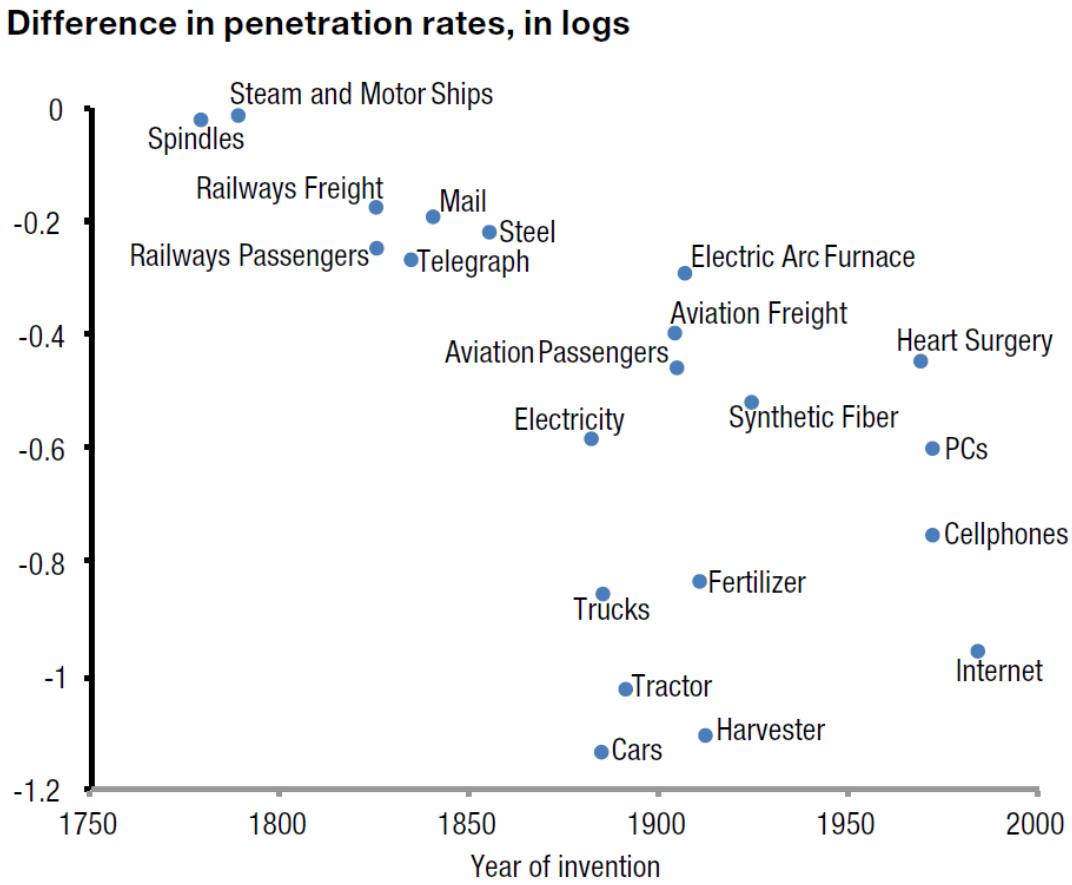


Notes: The adoption lag since first invention captures the average adoption lag across all countries for a given technology.
Source: Comin and Mestieri (2013).

How do technologies diffuse across economies?

- Comin and Mestieri also look at *how intensively different economies have used new technologies once they have been introduced*.
- In particular, they estimate **long-run penetration rates** for the same set of technologies, and *how differences in those penetration rates have evolved over time*.
- On this measure, they find that more recent innovations have seen a **greater gap in use between developed and developing economies**

Less pervasive technology diffusion



Notes: The difference in penetration rates captures the average difference in average penetration rate of which less developed countries relative to those developed countries. *Negative figures represent lower penetration rates seen in developing countries.*

Source: Comin and Mestieri (2013).

How do technologies diffuse across economies?

Diffusion channels

- The extent of **diffusion** *differs greatly across technologies and recipient countries.*
- There are a *variety of diffusion channels*, notably *international trade, foreign direct investment (FDI), direct technology licensing, skilled worker migration and cross-border information flows.*
- However, a crucial element of successful technology diffusion in these cases is that ***technology recipients*** *do not need to fully* ***understand*** *the technology* in order to apply it.

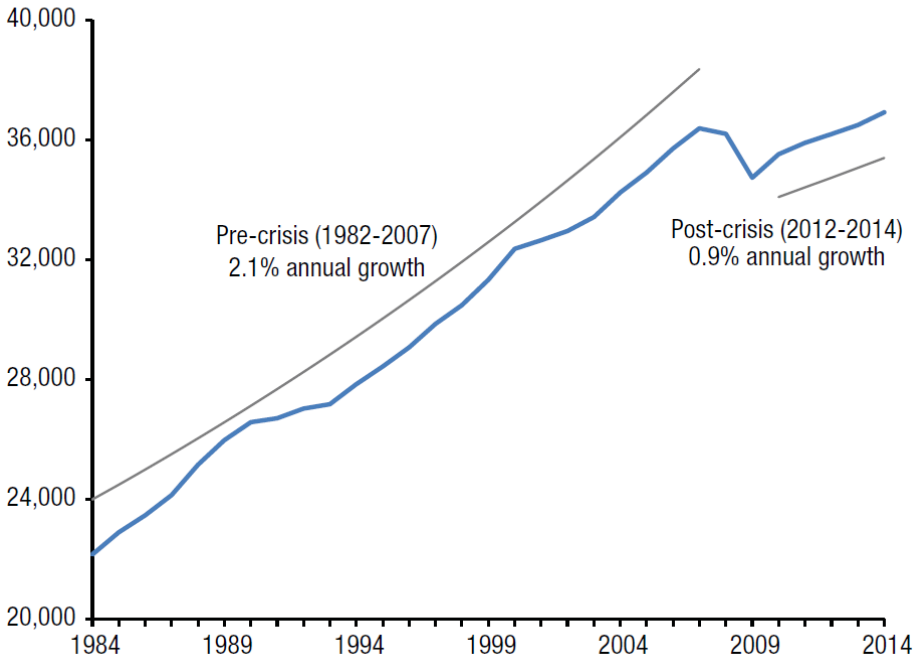
How do technologies diffuse across economies?

Absorptive capacity

- For many other technologies, **absorptive capacity, *or understanding***, may be necessary and their *successful technology diffusion* may *require substantial organizational know-how*
- Effectively absorptive capacity relies on **human capital** *able to understand and apply technology,* organizational and managerial *know-how*, and institutions that *coordinate and mobilize resources for technology adoption*.

The end of spectacular post-Second World War growth?

Real GDP per capita in high-income OECD countries, 1984-2014



Notes: GDP values are in constant 2005 dollars. Annual growth rates are the slopes of the logarithmic trend lines for the two periods.

Source: World Bank World Development Indicators.

- The evolution of per capita GDP in high-income countries since the mid-1980s until before the crisis, seen by growth of averaged 2.1 percent per year, matching the post-war frontier growth.
- However, **the 2008-2010 global financial crisis prompted a sharp decline in economic output**, average growth since 2010 has fallen to 0.9 percent.

The end of spectacular post-Second World War growth?

Secular stagnation

- The *length of the economic downturn* and the *failure to restore full employment* in many developed economies suggests that some structural change.
- Lawrence Summers *doubted the potential of innovation to contribute to future growth*, so-called **"secular stagnation"** – the presence of low inflation and a zero lower bound on policy interest rates, *output gaps persist*, generating *subdued growth*

The end of spectacular post-Second World War growth?

Secular stagnation

- *Persistent output gaps* may negatively affect the transmission channels through which *innovation generates growth*.
- In particular, ***weak overall demand*** may lead firms to ***shun investment*** opportunities created by new technology, *long spells of unemployment* may lead ***workers to lose or not acquire skills***, and *fewer* firm startups and *"scale-ups" may slow the structural transformation* of the economy.

The end of spectacular post-Second World War growth?

Secular stagnation

- Robert Gordon argued that *ICTs have seen faster adoption and follow-on innovation* compared with previous GPTs, with key ***productivity*** benefits such as the *replacement of tedious and repetitive clerical labor* by computer already occurring in the 1970s and 1980s.
- More recent ICT innovations have consisted of entertainment and communication *devices that are smaller and smarter*, but which do *not radically spur economic productivity*.

Section I

Digitalisation

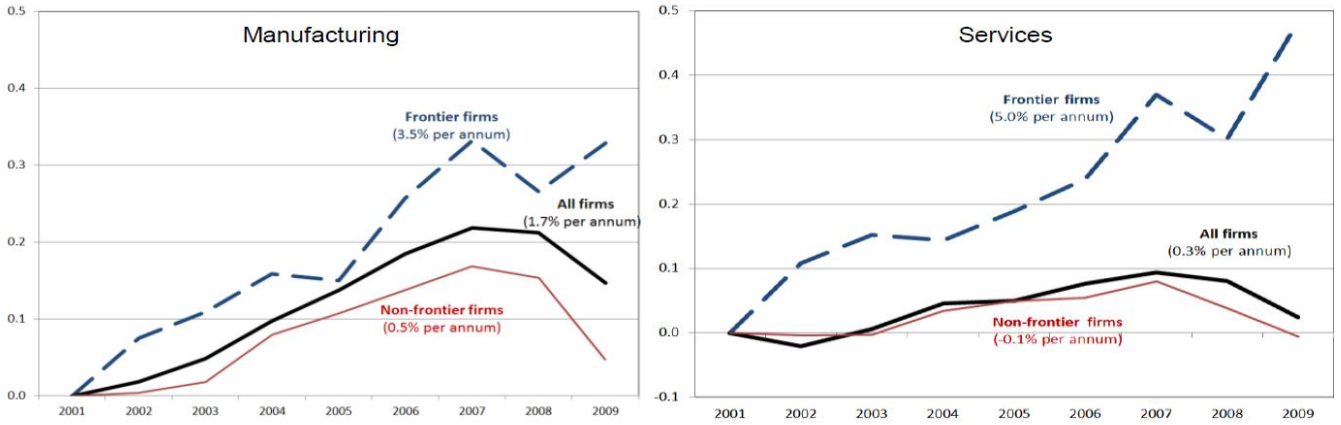
Digitalisation

- **Digitalisation** promises to ***boost productivity growth*** *and economic competitiveness*.
- This promise is much sought-after in current times of *stagnating to declining working age population* and productivity growth, which are increasing the risk of a slowing of GDP growth or a *"secular stagnation"*

Digitalisation

Figure 1. Labour productivity growth, 2001-09

Index 2001 = 0



- Recent OECD work by Andrews et al. (2015) suggested that the **main source of the productivity slowdown** is <u>not</u> so much a slowing of innovation – which is continuing apace in the most globally-advanced firms – but ***rather <u>a slowing of the pace at which innovation spread</u> through the economy***, a *breakdown of the diffusion machine*.
- This *breakdown of the diffusion machine i.e. cloud* may be leading to a **widening digital divide** between frontier firms that are able to take advantage of digitalisation, and the rest of an economy.

The role of digitalisation for growth

- Digitalisation **contributes directly to economic growth** through the *Information and communication technology: ICT* by enhancing the *contribution of ICT goods and services in total value added*.
- In 2013, the ICT sector accounted for 5.5% of total value added, equivalent to about USD 2.4 trillion, in the OECD
- The adoption and use of ICTs, and software in particular, continue to have a profound impact across the economy.
- In 2014, **ICT investment** in the OECD area ***represented 13.5% of total fixed investment*** or 2.7% of GDP, *with almost two thirds of ICT investment being devoted to software and databases*

The role of digitalisation for growth

- Some studies have concluded that the **stagnation** may be the result of a *break in the ICT productive capital diffusion*
- Others have highlighted that this stagnation or decrease was mainly due to a ***shift in favour of the intermediate use of ICT services*** *(such as cloud computing)*, which has decreased the need to invest in ICTs.

The role of digitalisation for growth

- In any case, evidence shows that the *diffusion of ICTs (including the use of ICT services) across the economy may remain short of its potential.*
- Current surveys on the diffusion of ICT tools and activities in enterprises, for instance, confirms that many businesses, and in particular **small- and medium-sized enterprises (SMEs),** which *lag in productivity relative to larger firms,* ***lag in the adoption and use of ICTs***

The promise of converging technologies

Figure 13: Characteristics of the hyperefficient and flexible factory of the future

Smart supply network
Efficient supplier network that enables optimized decision-making

IoT-enabled
Integrated sensors in process stream data continuously

AI-enabled
Real time analytics with own engine for decision-making

Mobile workforce
Workforce enabled with wearable technology uses AR/VR

Digital-physical systems
Advanced robotics and 3D printing complement processes

Advanced materials
Nanotechnology and new materials used extensively

Smart products
Products carry information to manufacture themselves

Smart products
Customer interaction through the process chain

Source: A.T. Kearney

The promise of converging technologies

The hyper-efficient and flexible factory of the future

- The *factory of the future* is a *more digital, virtual and resource-efficient space*
- Digital shop floor processes that are *connected, automated and flexible*.
- IoT combined with analytics and AI will ***improve asset efficiency***, ***decrease downtime and unplanned maintenance***, and allow manufacturers to ***uncover new sources of value in services***; from higher customer satisfaction, quality, innovation and agility to better economics and value creation.

The promise of converging technologies

The hyper-efficient and flexible factory of the future

- New relationships between operators and machines.
- Technologies are changing the nature of the work and skills required of operators.
- Robotics is automating most dull, dirty and dangerous tasks, and increasingly *collaborative robots are moving out of the cage to work side by side with operators*.
- *Augmented reality and wearables* are also changing the ways operators train, *assemble and make decisions on the shop floor, increasing flexibility, productivity and quality*

The promise of converging technologies

The hyper-efficient and flexible factory of the future

- The factory of the future is sustainable, increasingly modularized, with interchangeable lines that can be reconfigured easily for multiple production batches.
- Distributed manufacturing will become the norm as technology diminishes the role of low-cost labour and economies of scale.
- With producers augmenting their production with smaller and more flexible units located next to points of consumers, allowing them to meet local requirements with a more responsive supply chain.

The promise of converging technologies

The hyper-efficient and flexible factory of the future

- Smarter insights from AI and smart algorithms will *allow more real-time and faster data-driven decision-making among leaders*.
- Advances in analytics, AI and AR, among others, can *help ramp up new employee training, as well as, augment staff capabilities through embedding best practices – so called* ***economies of skill***.

End of Lecture