



# **The big picture – from innovation to prosperity**

## **chap.1**

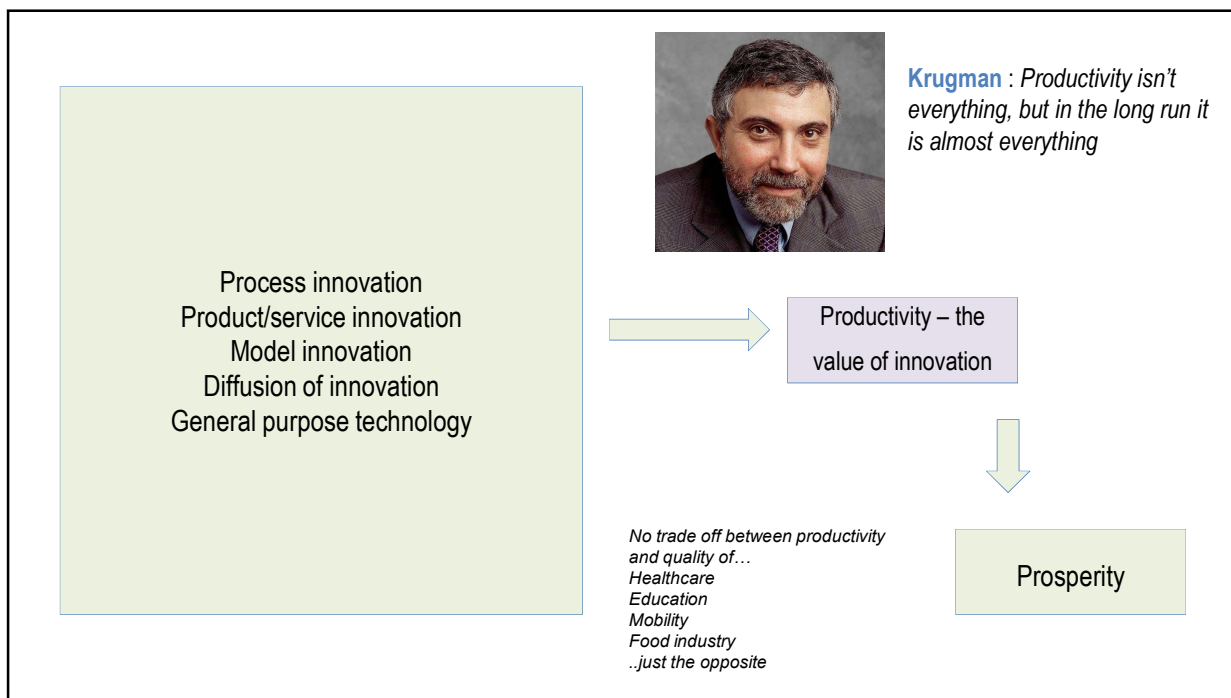
Dominique Foray (EPFL)

**MGT 403 - Spring 2019**

## **Outline**



- Framework – innovation → productivity → prosperity
- Types of innovation and potential impact on productivity
- Surplus as a measure to determine the value of innovation
- Issues in the relationships



## Productivity – definition and significance



- Output per worker – number of hours it takes to produce everything
  - $\alpha = \frac{\text{output}}{\text{input}}$ 
    - Input = labor : labor productivity
    - Input = all factors : total factor productivity (TFP)
  - Productivity is increasing if with the same level of inputs (labour, capital) you produce more or better
- « *Productivity isn't everything, but in the long run it is almost everything* »
  - Because a country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker
  - Most countries don't have extensive mineral wealth or oil reserves..so the only way to become wealthier (to improve the standard of living) is to keep getting more (or better) output from the same number of inputs – more goods or services from same number of people
- The improvement of standard of living reflects productivity growth

# How to increase productivity?

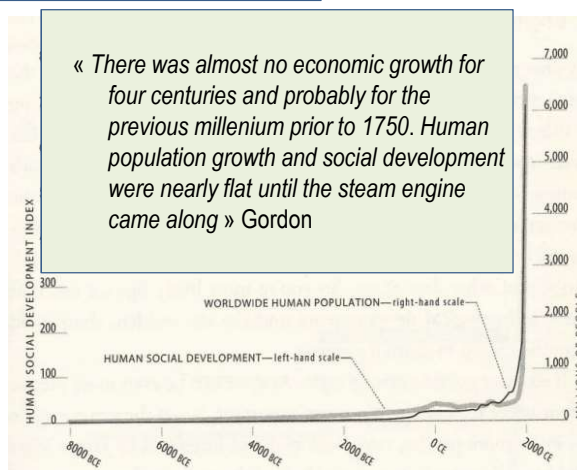


- Making people working harder? It was an important mechanism but subject to diminishing returns. There are natural limits to how much we can increase inputs – especially labor
- Making people working smarter – in more intelligent ways – to produce more or better goods – This is innovation
- Productivity growth reflects ability to innovate – it's limited only by our imagination
- Anecdote in CHUV on how much people misunderstand the issue of increasing productivity

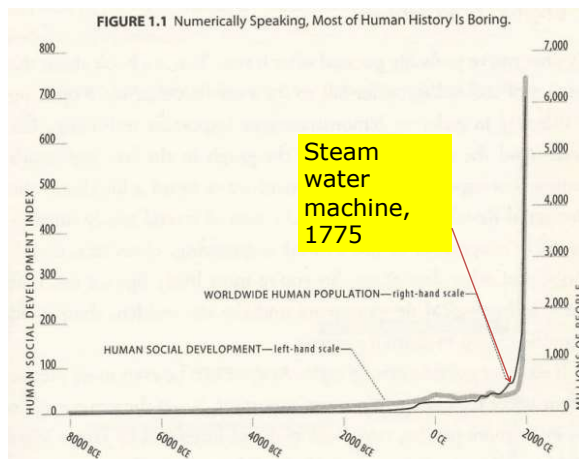


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*Numerically speaking, most of human history is boring!*

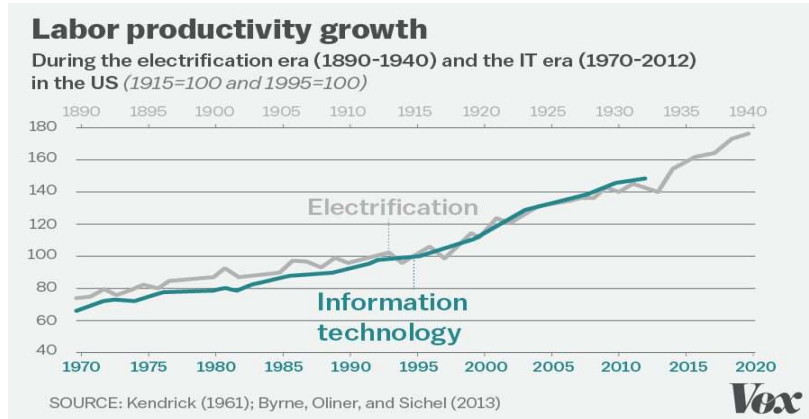


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## The computer and the dynamo



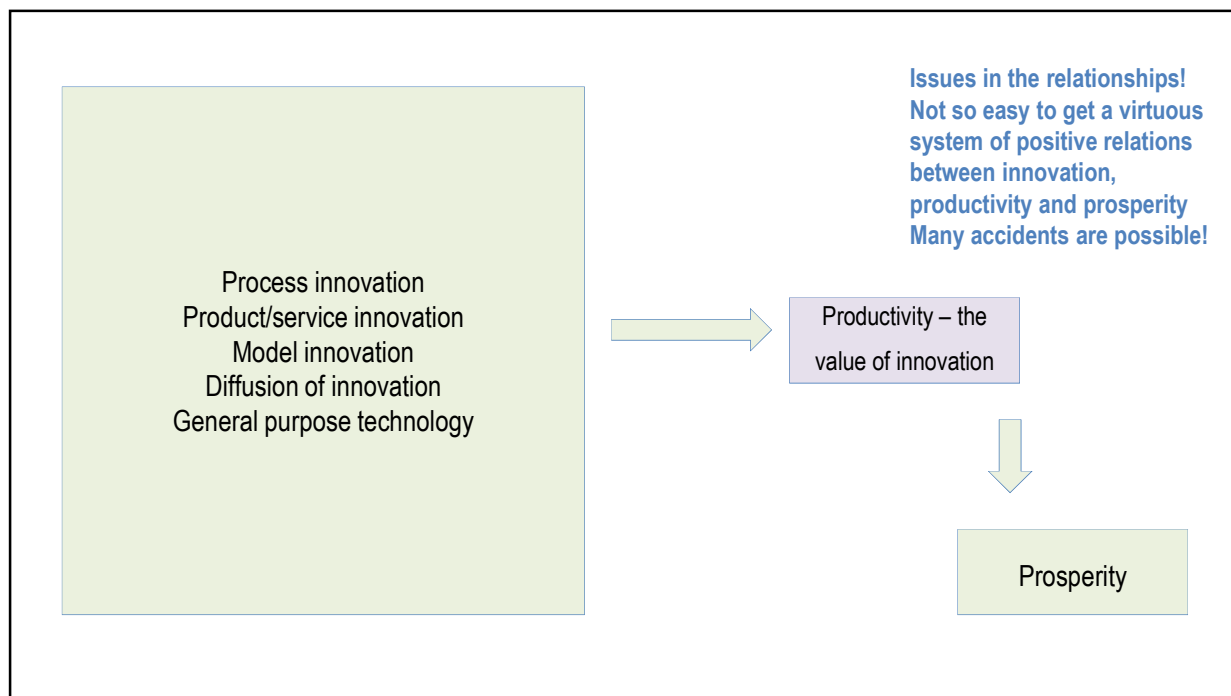
A strong relationships between major innovation (and diffusion) and productivity growth

## Productivity to prosperity



- Two channels of transmission
- Wages
  - If people are better in producing (more or better) goods/services – this should be reflected in increase of wages, incomes, wealth
- Consumer surplus
  - If there are better products/services for a constant level of inputs – consumers will have access to better things at equivalent cost – they enjoy a surplus
- «*The great inventions of the second industrial revolution were so important and far reaching that they sustain economic growth and wealth increase during almost one century (1890-1970)*» - Gordon

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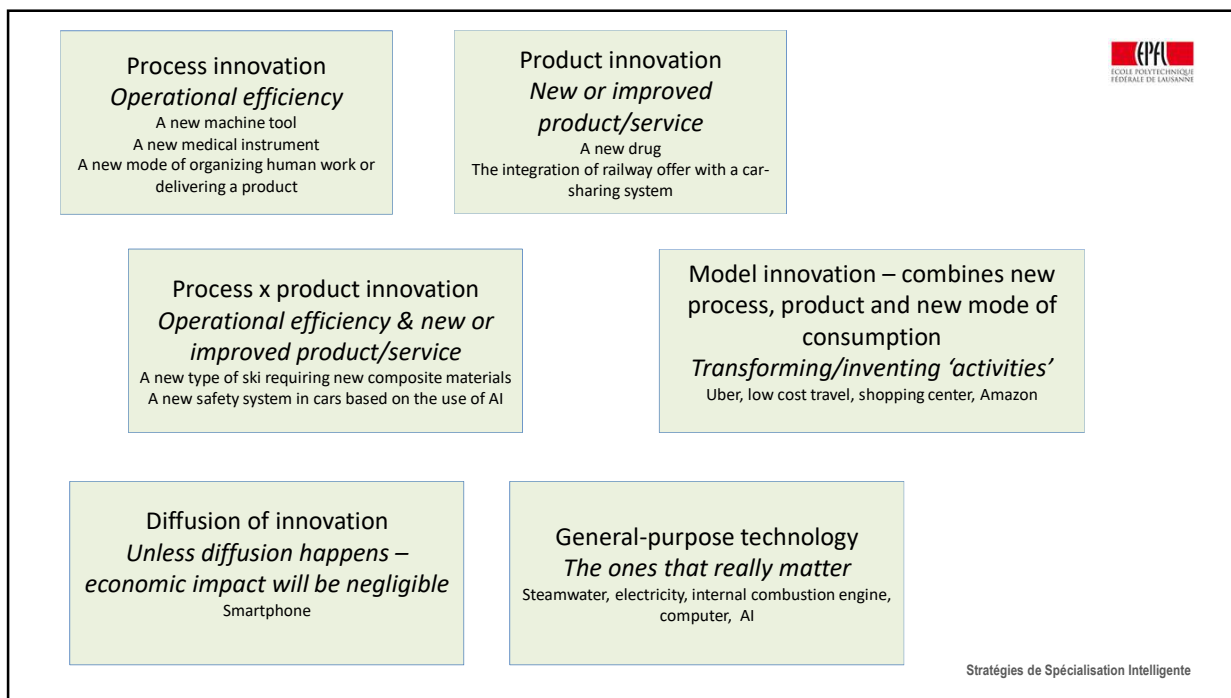
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## Innovation typology



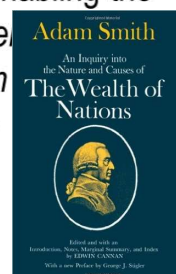
- Innovation is how productivity growth happens. There is a great consensus about the fundamental importance of innovation for productivity growth and hence for prosperity
- Innovation has a broad signification – a new tool or method or organization – a new product – a new (business) model
- Different types of innovations, different effects on productivity
- $\alpha = \frac{\text{output}}{\text{input}}$ 
  - Output constant & input decreases
  - Output increases disproportionnaly relative to input

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## Process innovation

- Effect on productivity is clear : a new machine, a new tool, a new organization increases output per worker
- $\alpha = \frac{\text{output}}{\text{input}}$
- Adam Smith – mentions a little boy who repeatedly opens and closes the valve between a boiler and a cylinder and who discovers a device enabling the valve to open and close automatically: «*One of the greatest improvements that has been made upon this machine, since it was first invented was in manner the discovery of a boy who wanted to save his own labour*»



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### Autonomous vehicles

In 2016 – 3.5 millions people worked in private industry as *motor vehicle operators* (drivers of any kind)  
 Assume AV were to reduce the number of drivers necessary to do the current workload to 1.5 million  
 Total nonfarm private employment was 122 million  
 So AV would reduce the number of workers necessary to achieve the same output to 120 million  
 Result – aggregate labor productivity increased by 1.7% (=122/120)  
 Assume this transition occurred over 10 years, this single technology would provide a direct boost of 0.17% to annual productivity growth over that decade  
 This is significant while not including gains from complementary changes (parking saving, etc..)

### Call centers

About 2.2 million people work in 6,800 call centers in the US. Improved voice recognition systems coupled with intelligence question-answering tools will handle 60-70% or more of the calls – especially since a large fraction of call volume is due to variants on a small number of basic queries. If **AI** reduces the number workers by 60%, it would increase US labor productivity by 1%, over 10 years

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## Product innovation



- A new product/service or a better product/service increases disproportionately the value of outputs relative to inputs
- $\alpha = \frac{\text{output}}{\text{input}}$
- There is an effect only if the value of output increases more than the cost of inputs
- If the cost increases more than the added value to output – this is not an innovation

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## Product innovation



- Proliferation - the practice of proliferating a wide variety of slightly differentiated products across the entire characteristics space
  - Market segmentation – from one drug covering needs of all patients to many drugs each targeting a special class of patients – productivity effect –if output values increase more than inputs – analyzing personalized medicine
  - Strategic behavior – breakfast cereals - no real productivity effect

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## Model innovation



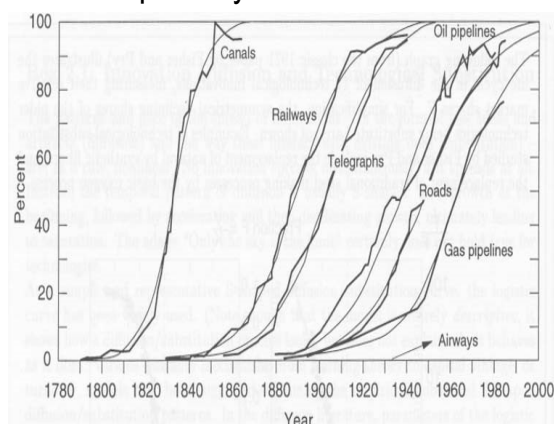
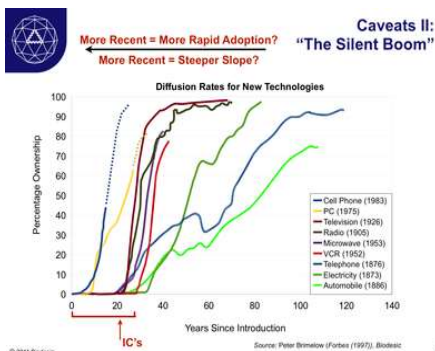
- Effects are multiplied because it involves a combination of new process, new product and new user experience
- Low cost
- Uber

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## Diffusion



- Innovation *per se* is not enough to have big impact if only one firm can use it or only a small fraction of consumers can access to it.
- Productivity needs diffusion in other firms and adoption by consumers



## General purpose technology

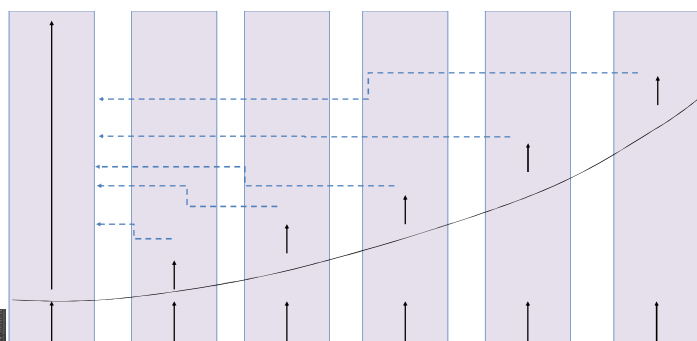


- Electricity, computer, artificial intelligence
- A technology which has a big potential of vertical improvement + a vast potential of horizontal propagation (numerous applications of the technology in a multitude of sectors) + positive feedback between vertical improvement and horizontal propagation

**GPT – general purpose technology: electricity, internal combustion engine, computer, digitalisation**



Computer Car industry Finance Architecture Agro-food Sport



Computers

«Vertical» innovations (sectoral patterns) ↑

**Computer** – Potential of horizontal propagation in n sectors and feedback on the main innovation trajectory in the long run  
 Productivity effect in the computer industry  
 Productivity effect in all sectors and therefore in the whole economy

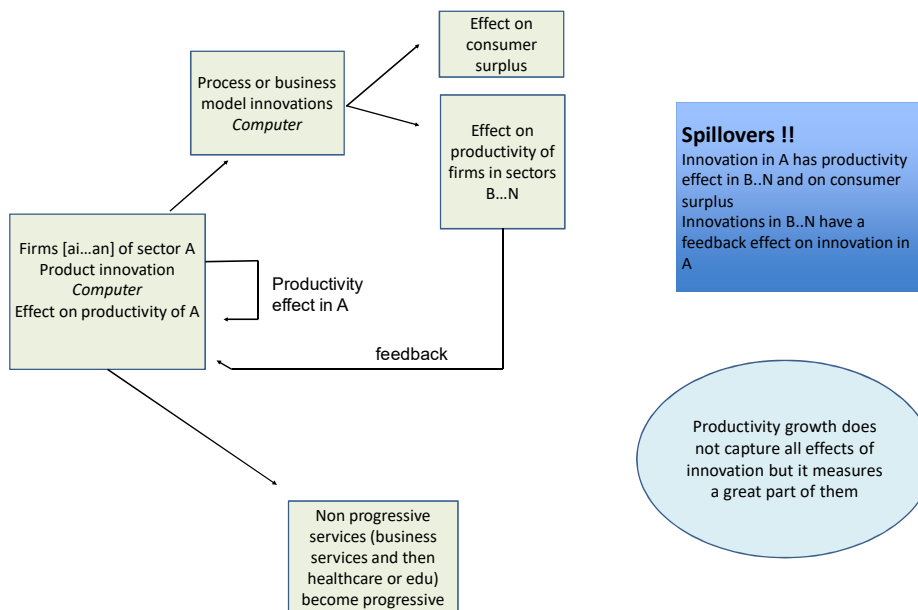
Time – 1950 - 2000

**Spillovers**

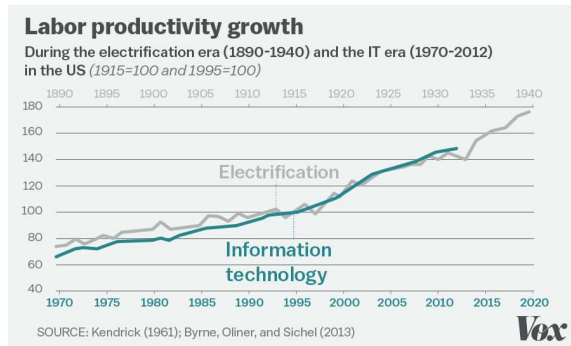
Innovations in the sector of origin impact productivity in the other sectors and innovations in the other sectors (based on computers) have feedback on innovations the initial sector



**Complex relationships between GPT innovation and productivity**



## From introduction to impact – a great time lag: *The computer and the dynamo*



### General purpose technologies

« GPTs always need complements and time to build these complementarities. Coming up with those can take decades and this creates lags between the introduction of a technology and the productivity benefits »

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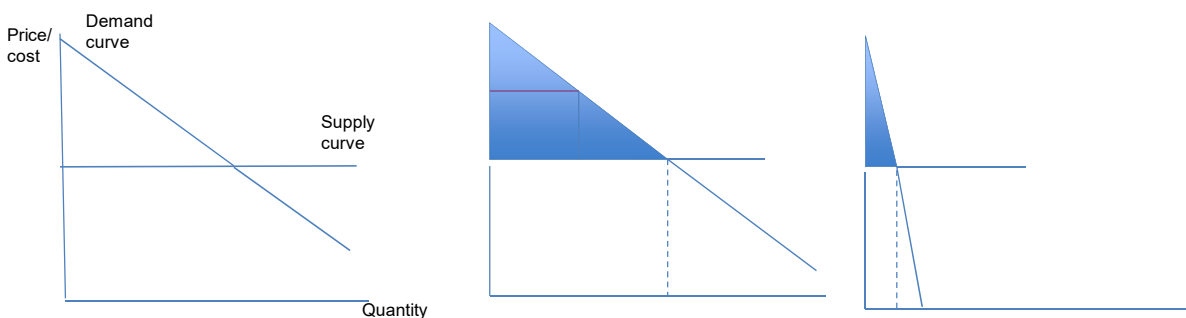
## Consumer surplus



- Economists have been thinking for decades about one measure to determine the value of innovation. It is consumer surplus
- Let's assume a product innovation – this is a better product but it costs something.
- It generates productivity gains if the improvement of the product is higher than the cost of the innovation – we can capture this positive effect on consumer
- Consumer surplus is the aggregate net benefits that consumers receive from using a new good or service after subtracting the cost (the price) they pay
- Technically we compare the *willingness to pay* (how much the consumer is prepared to pay for increases in quality) to the cost of the innovation

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## Consumer surplus



The demand curve describes the *willingness to pay* the innovation. It is downward sloping  
The supply curve describes the cost of innovation and (in this case) the price

The shaded area below the demand curve but above the supply curve (the price) represents consumer surplus  
If price declines (process inn.) the consumer surplus increases – if WtP increases (product inn), the consumer surplus increases as well  
The total revenues from the sale of the good or service are represented by the rectangle created when the price is multiplied by the quantity

In this case, the value of the innovation is lower: very few consumers are prepared to pay a price above the cost : consumer surplus is small as well as productivity effect – Concorde!

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## Consumer surplus



- Example – the rapidly growing consumer surplus from price declines in computers increased economic welfare by about \$50 billion each year
- If there is no price to pay - the product is already free – consumer surplus can be created by saving time – compare your time to search something on Internet with the time you would need to search the same thing without Internet (in the library, etc..)
  - 22 minutes versus 7 minutes (not counting travel time to go to the library)
  - Multiply that time difference across all the queries people make and use the average hourly wage (in US \$22) – you get a surplus of \$500 per adult worker per year

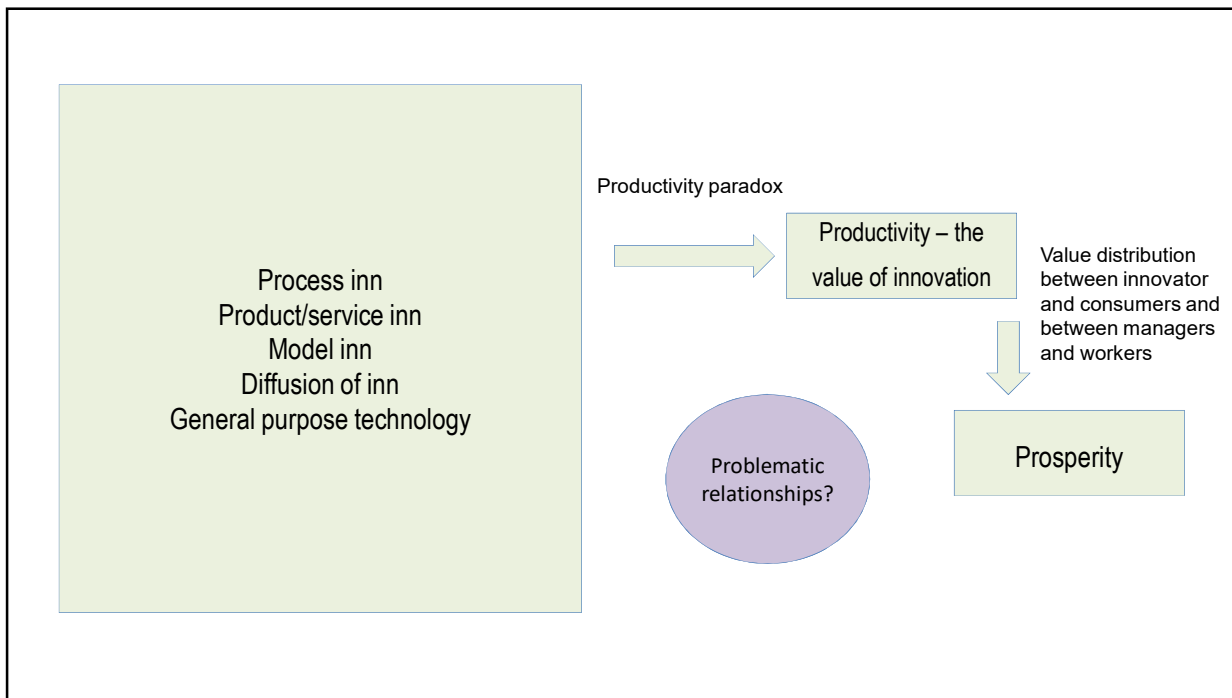
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**Innovation to productivity : the productivity paradox (Solow)**

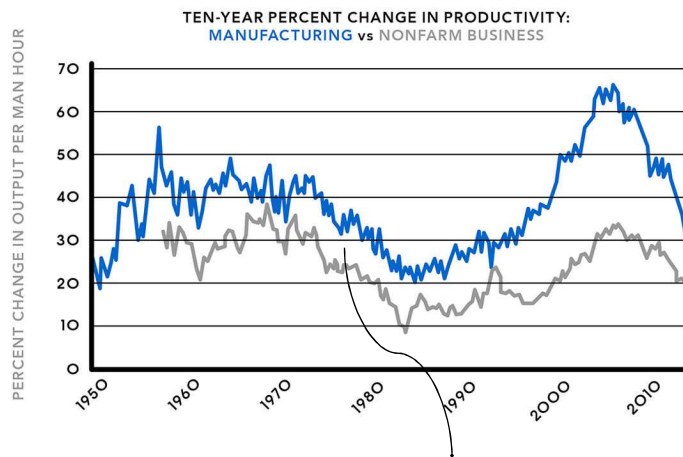
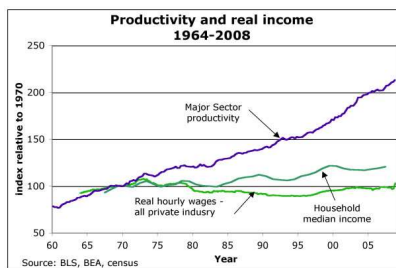
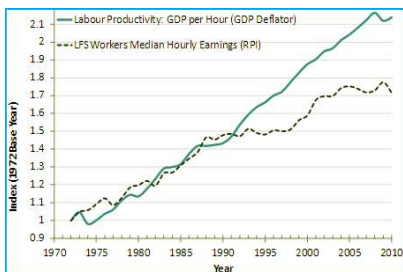


CHART: BLOOMBERG VIEW



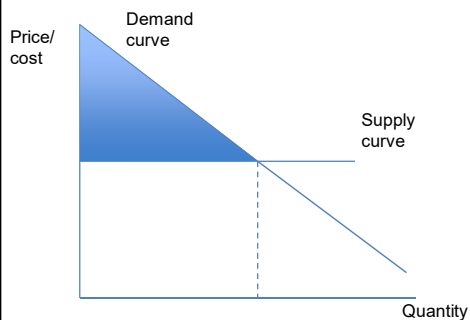
*«I see computers everywhere but in the statistics»* Robert Solow

# Productivity to prosperity – the wage gap

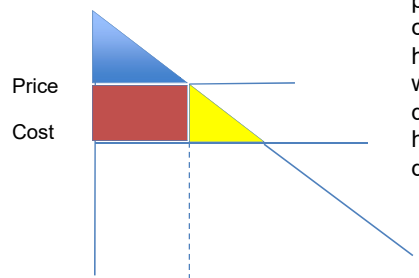


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# Productivity to prosperity - Surplus distribution



The shaded area below the demand curve but above the supply curve (the price) represents consumer surplus  
 The total revenues from the sale of the good or service are represented by the rectangle created when the price is multiplied by the quantity



Now price and cost are different. The firm decides to price above cost because she can do it without losing all the market  
 The shaded area below the demand curve but above the supply curve (the price) represents consumer surplus  
 The shaded area below the price but above the cost represents the producer surplus  
 The triangle in yellow represents the lost value. It measures the inefficiency of the price above cost

The same innovation – same potential value for consumer will have different welfare effect – depending upon how the surplus is distributed



## To take home



- Economics of innovation is a *social science* (not like your (life) science)
- Social trends and events are *hard to observe and hard to measure*
- *Innovation* – its occurrence and impact are hard to observe and hard to measure
- Economists agree for a long time that *productivity growth* is a pertinent indicator for innovation and surplus helps to determine the value (productivity effect) of innovation
- But the relationships from innovation to productivity and from productivity to prosperity are far from straightforward – a lot of issues
- Productivity paradox
- The gap productivity and wages – the distribution of surplus