Chapter 1 – XX° century innovation style

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École polytechnique fédérale de Lausanne

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- The great enrichment as measured by the growth of GDP per capita
- « Something happened strange.. »
- Did we order that?

- The extraordinary power of science, technology and innovation has triggered a **great enrichment** – as measured by GDP growth and GDP/capita increase
- Global GDP has increased more than 15 fold since 1950 to over $120 trillion and the proportion of people in extreme poverty has declined from more than 60% to less than 10%
- However people worry about the growth of our use of natural resources over the past century
  - Some of this reflects the higher resource demand from a growing population
  - It also reflects the growth of per capita output and consumption
- ‘’*Our trajectory of economic growth is irresponsible*”
- What is GDP?

Gross domestic product

GDP was adopted after WW2 as a common metric to measure the size of national economies and economic growth. It became possible to compare countries. Because you manage and take care of what you measure, governmental policies tend to focus on GDP growth

The Gross Domestic Product is a **monetary** measure of the economy’s total output – e.g. the market value of all the final goods/services that are produced by the residents of a country

There are different approaches to calculate the value of GDP – (e.g. summing all **added values** generated by firms – **AV** is final selling price minus the cost of production)

Growth of GDP = growth of the size of the economy = economic growth

GDP/capital or Y/N = standard of living (proxy for the wealth of a country)

Various problems with GDP

- GDP measures **just** the size of a nation's economy - nothing else
  - Problem with operations and activities which are not increasing welfare but as transactions they are counted. *If a firm is paid by a municipality to dig holes and then is paid to fill them again (because this was a wrong decision) – the value of the two services are added to the GDP while the impact is 0*
  - Problem with activities which are essentially ''free'' – produce large ''surplus'' but no added value (no price) and not counted into GDP – Wikipedia!
  - Problem to capture innovation effect on GDP while the considered innovation substitutes to many activities which contributed to the growth of total output (e.g. smartphone substitutes to many markets (photos, films and cameras, music, maps, communication devices, information & newspapers, books, more…)
  - GDP is not a measure of human well-being (issue of inequality)
  - GDP is not NDPwhich would be GDP minus capital depreciation – in particular natural capital decumulation.
    - While we are happy to see our GDP growing, we don't see that some essential elements of our wealth are degrading
    - This is why we will introduce the concept of productive base

The standard of living drivers

Mineral wealth, oil/gas reserves

$Y/N = Y/H \times H/N$

LIMITS

No LIMIT

with
Y: GDP –value of all goods produced in a given year in the economy (measure of the economy's total output
N : total population
Y/N – GDP per capita - measure of the wealth of the economy – determines the standard of leaving
H: hours of work in the economy,
Y/H : labour productivity - ratio between total output and the quantity of labour (person-hour); measure of the efficiency of the economy
H/N : hours of work per capita

Output per capita or standard of living by definition equals *productivity or output per hour* times *hours per capita*

USA: $ 20.000
India: $ 340
Not a measure of happyness – Inequality!

Process innovation: decreasing H for the same level of Y

Product innovation – increasing Y for the same level of H

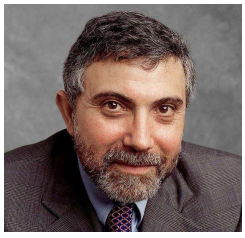
Other factors for increasing Y/H: education, capital deepening

H/N = hours per capita depends on:
Employment rate
(% of employable population – 15 to 64 - with a job)
Working time
(number of hours/year)
Increasing H/N reachs limits
Both scope of employable population and working time are decreasing – social progress
Child labour
Retirement age
Decreasing working time: hours per week/vacations)
Only contra-trend: – females move from home into labour market in the 70s

Y/N = Y/H x H/N

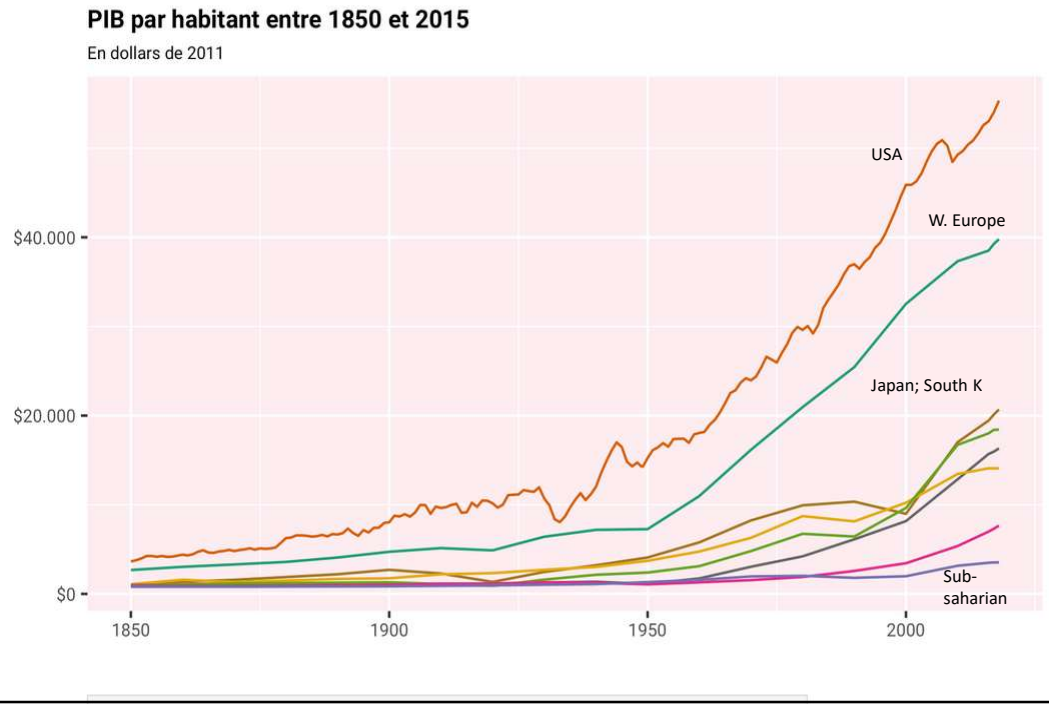
- What are the drivers of productivity?
- Innovation is how productivity growth happens without any limit.
  - « *The only limit is our imagination* »
- There is a great consensus about the fundamental importance of innovation
  - Product innovation – new or better product (services) – increases diversity; meets uncovered needs
  - Process innovation – more efficient methods to produce and distribute (incl organizational changes)
  - Business model innovation – combines product, process and new consumer experiences
- Process innovation reduces production costs (H) by making more efficient use of input factors, product innovation raises output value (Y) through improving quality of the output or creating entirely new products and services (Y), business model innovation raises Y and reduces H
  - Just an example - airbnb

Productivity and standard of living

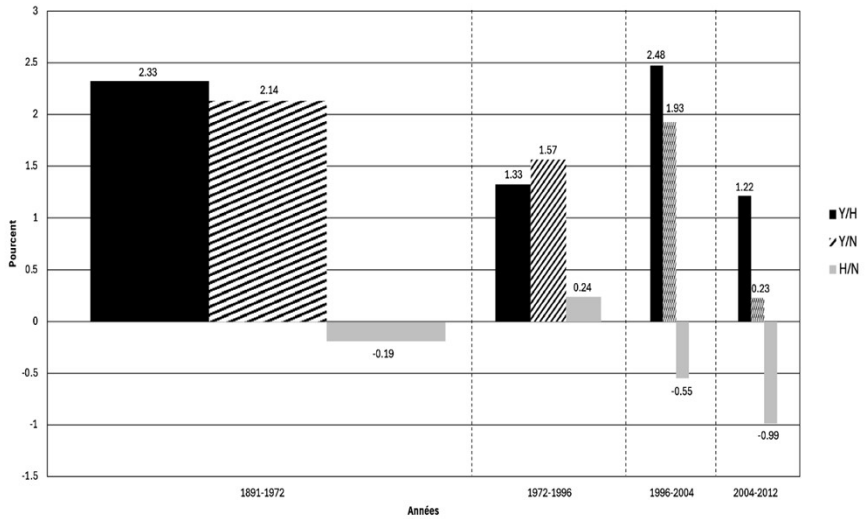


Y/N= Y/H x H/N

- **Krugman** : « *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..they can't any more increase working time - 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
- But a blinded indicator – not all costs are included (negative externalities) – again airbnb



Annualized growth rates of productivity (Y/H), standard of living (Y/N) and Hours per capita (H/N) US economy



- The great enrichment as measured by the growth of GDP per capita
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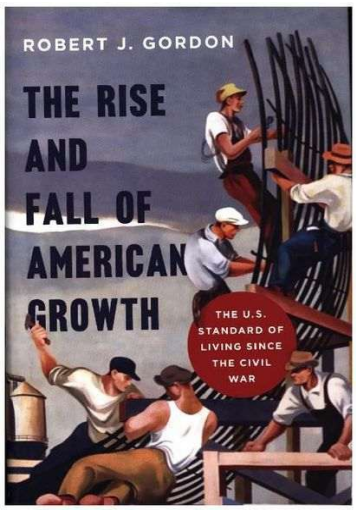
The great enrichment

- The global standard of living has improved enormously since 1850
- Per-capita global GDP has increased more than 5 fold since 1950 ; life expectancy at birth has increased from 46 to 72 years and the proportion of people in extreme poverty has declined from more than 60% to less than 10%
- « *Daily life has changed beyond recognition* » (Gordon)
- The great achievements : mobility, communication, access to decent level of material comfort both in domestic and professional lifes, healthcare, education, etc.
  - They transformed experiences that were rare and valued luxuries into common place features of life

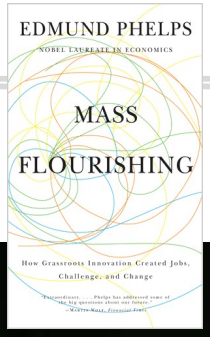
GDP growth and innovation have tremendous effects

- *"Think of daily life around 1850 made of painful manual labor, household drudgery, isolation, and early death.* ***Only one hundred years later, daily life had changed beyond recognition****. Manual outdoor jobs were replaced by work in air-conditioned environments, housework was increasingly performed by electric appliances ; darkness was replaced by light, and isolation was replaced not just by travel, but also by color television images bringing the world into the living room. Most important, a newborn infant could expect to live not to age forty-five, but to age seventy-two. The economic revolution of 1870 to 1970 was unique in human history.."*



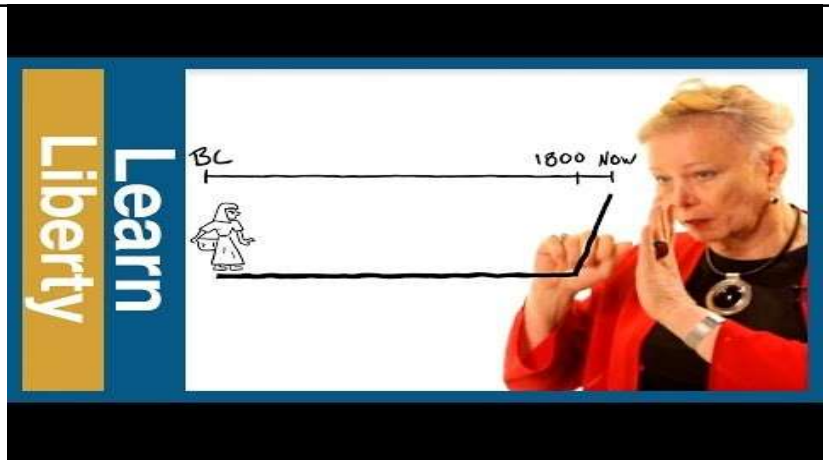
What happened? – Ned Phelps

"Something happened that was strange for its time, something that would change everything: exploding innovation and economic knowledge" Phelps



What was the cause of the great enrichment?

Why did'nt this cause work earlier?



D.McCloskey

Laisser faire was a great step forward for innovators

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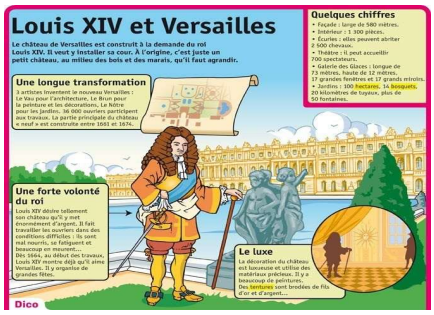
- Freedom to experiment and autonomy were not taken for granted
- Corporations controled innovation and impeded new talents to enter an industry
- Privilege granted to one (only one individual can print books in the city)
- Influence of political power on inventors
- But freedom to experiment and inventor's autonomy are crucial (previous slide)
- The final arbiter of whether something new is desirable is not the government or religious clergy or guild members but the market place
- Modern values were key to trigger an innovation revolution (1850s) which drove the great enrichment
- However *laisser faire* does not help to govern/control innovations

« *A man invented unbreakable glass and demonstrated it to Tiberius in anticipation of a great reward. The emperor asked the inventor whether anyone shared his secret and was assured that there was no one else; whereupon his head was promptly removed.* »
The most interesting point is that the inventor turned to the emperor for a reward, instead of turning to an investor for capital with which to put his invention into production

For a long time, human ingenuity did not translate into economic values

- Human ingenuity and creativity have always existed from the birth of humanity – but did not generate any effect on the economy and society
- Either creativity was just dissipated into brillant technologies (pyramids, cathedrals, etc..) which only profit to the king and the church – e.g. château de Versailles
- Or, when creativity was used to develop practical techniques to solve problems – markets did not work well enough to enable wide and rapid diffusion – the techniques remain stucked int the local community
- So for a long time the economic impact was from negligible to 0 (or negative) – « *output per worker did not increase AT ALL between 1500 and 1800* »
- To have an impact, creativity and ingenuity need an innovation economy



What happened?

- An innovation economy which translates science, technology, ingenuity and creativity into economic value for ordinary people
  - Inventors, entrepreneurs imagine and develop **new products, services, processes of practical values for ordinary people – which are introduced on a market** – consumers are interested and willing to pay for…
  - Economic experimentations and early adoption push innovators to improve quality and costs - reduce buyer's uncertainy – increase willingness to pay - this generates economic and social values
  - Consumers get a surplus, innovators receive a profit which provide incentives to innovate further; this attracts investors, etc.
- A complex set of institutions and values
- The corollary of innovation is the creation of new firms or the growth of existing firms
  - Law and legislations to limit liability of investors, provide easy marketability of ownerships shares, reduce risks, define obligations within principal agents relationships
  - IPR institutions
  - R&D institutions
  - **Modern values – freedom to experiments, to enter a market, competition, autonomy vis-à-vis governments**

Institutions to support economic discovery and innovation

Funding mechanisms:
VC, start ups and stock markets
Large firms
Institutional (social) investors
The State

Laws and legislation to favour firms' creation and growth:
Limit the liability of investors
Provide for easy marketability of ownership shares
Establish stock markets which were essential for the achievement of ready marketability
Reduce risk by the technique of insurance
Define the obligation within principal-agents relationships

Intellectual property:
Experimenting in the economy increases risk of imitation and piracy

Maintain freedom, limit risks, provide funding and increase the prospect for large financial rewards

Autonomy of innovators vis-à-vis government and freedom to experiment:
Freedom from arbitrary and interventions from authorities, liberalism

Decentralization

Inability of the incumbents to prevent entry and new experiment and of the experimenters to influence the outcome of market evaluation of the new product

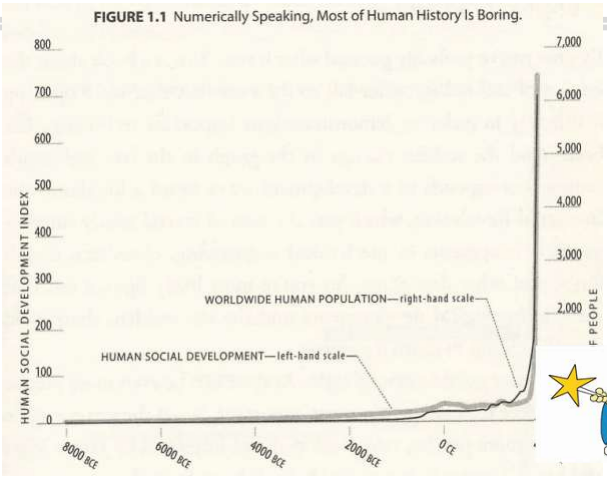
A great change vis-à-vis former periods where: corporations and privileges blocked ***entries;*** governments impede some innovations

Competition :
Free entry, freedom to try and propose new things (against corporations, privileges, regulations which protect incumbents)

"Capitalism" is unique not in invention but in innovation

The big picture

Brillant technologies but impact on productivity was from negligible to 0 (or negative) – « *output per worker did not increase AT ALL between 1500 and 1800* »



Wanted! An innovation economy as the missing link between human creativity & ingenuity and the economy

Stratégies de Spécialisation Intelligente

The great enrichment

- *« Modern humans first emerged about 100,000 years ago. For the next 99,800 years or so, nothing happened. Well, not quite nothing. There were wars, political intrigue, the invention of agriculture, arts and cathedrals – but none of that stuff had much efffect on the quality of people's lives. Almost everyone lived on the modern equivalent of $400 to $600 a year, just above the subsistence level…Then – just a couple of hundred years ago – people started getting richer. And richer and richer still »*.

- *« There was almost no economic growth for four centuries and probably for the previous millenium prior to 1750. Human population growth and social development were nearly flat until the steam engine came along »* (Gordon, ibid.)

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- Did we order that?

From admiration to consternation – « *did we order that?* »

- XX° century innovation economy plays a central role in the climate/biodiversity crisis as well as healthcare/education issues
- XX° century innovation economy generates inequalities
- XX° century innovation economy does not create enough ‘’good jobs’’
- Poor regulation for ‘’bad innovations’’

- Between agressive planning and *laisser faire*, a need for some ‘’command-control’’ policy logics
- How to influence the direction of innovation to solve grand challenges while not impairing freedom to experiment and inventor’s autonomy?
- The course will provide a collection of approaches and tools to do that

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A century of productivity improvement – 1870 - 1979

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Country	Growth in real GDP per capita (wealth) in %	Growth in real GDP per person-hour (productivity) in %
UK	325.0	585.0
Switzerland	472.0	830.0
United States	691.0	1,080.0
Italy	493.0	1,220.0
Germany	1,396.0	1,510.0
France	694.0	1,590.0
Finland	1,016.0	1,710.0
Sweden	1,084.0	2,060.0
Japan	1,653.0	2,480.0

Living standard: hours of work per capita, productivity

Efficiency of the economy: educating, capital deepening, innovating

Output per labor hour increased from 585% in the UK to 2480% in Japan (second column) after no substantial increase for at least 15 centuries!
This rise in productivity was sufficient to permit a rise in output per capita of more than 300% in the UK to more than 1,600% in Japan