# Industrial Economics

## Economics of Knowledge and Information

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# Economics of Knowledge and Information

- Speaking of the knowledge economy we distinguish two distinct phenomena:
  1. A long-term phenomenon that involves education, training, human capital, R&D, knowhow etc.
  2. A short-term phenomenon that regards in particular the new technologies of information and communication (NTICs).

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- Combined, the two phenomena have profound effects on our economic system. This includes:
  - Increased positive externalities due to network effects
  - Acceleration of change
  - Growth of sectors with a high content of knowledge and NTICs
  - A premium on qualification and knowledge.

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- In this context, we must distinguish "knowledge", a dynamic concept, and "information", a static concept. "Knowledge can create itself new knowledge (Foray, p. 7)". Knowledge thus refers to a cognitive ability with a dynamic element that generates positive externalities and is associated with
  - Memory
  - Solving new tasks
  - Interaction, dialogue
  - Cognition, understanding
  - The production and reproduction (learning) of knowledge can be costly but due to positive externalities there are still increasing returns to scale also with knowledge.

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- Information instead is, in its purest definition, a statistical concept with a limited number of well-defined possible outcomes, whose characteristics are known in advance. Information has zero cost of reproduction. Its generation and codification can be costly though. A good definition of information is "data that have been recorded, classified, organized and related within a framework so that meaning emerges". Statistics instead would be "a type of information obtained through mathematical operations on numerical data".
- Both phenomena are characterised by strong economies of scale (stronger in the case of information). This gives them public good characteristics. Due to the absence of complete codification, these public good characteristics are even stronger with knowledge than with information.

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- In both cases, costs and value are very difficult to measure, also due to the phenomena of learning by doing and learning by using.
- The activity of codification turns knowledge into information or a message (software, computer code, book, CD etc. NB: while the cost of transmitting information is today virtually costless (this was not always the case, think of monks copying parchments), its assimilation, actualisation and retransformation into knowledge can be expensive. Otherwise copying a book would be equivalent to reading it.

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- Knowledge and information pose both major property rights ownership problems but not always for the same reasons :
  - Both have public good characteristics, including non-exclusivity: my utility does not decrease if somebody else the information, sometimes it is quite the opposite as we have seen in network effects. This then begs the question how to remunerate the inventors in a competitive market. Tendency towards monopolisation which poses other issues.
  - The value and usefulness of information and knowledge is difficult to determine since they can be used several times.
  - In the case of knowledge, the value is only revealed (sometimes with a considerable time lag) after the purchase. Think of a university education. However, the value of a "diploma" can also lie in its "information", as it constitutes a signal for potential employers on the labour market.

# Economic Impact

- We are currently seeing the interaction of a long-trend and a short-term trend with an enormous increase in the share of intangible capital (related to information and knowledge) in the economy.
- The proportion between tangible and intangible capital was roughly 2/3 to 1/3 in the late 19th century. It has switched to $\frac{1}{4}$ and $\frac{3}{4}$ in the late 20th century accompanied by a significant growth of labour productivity. This is due to education, training, human capital formation, R&D, better organization of business (marketing, services, computer control, logistics...) and other knowledge- enhanced economic functions.

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- In parallel we witness the more short-term phenomenon of an explosion of information and knowledge-based industries (computer, space, pharmaceuticals, telecommunications, finance etc.). They now constitute far over 50% of GDP and generate a high demand for qualified workers.
- Both tendencies are reinforced by the new technologies of information and communication (NTICs) that:
  1. Allow enormous productivity gains in the storage and processing of information;
  2. Promote the creation and growth of new industries;
  3. Allow for new and original organisational models (auto-entrepreneurs, global networking etc.).

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- In principle, these combined effects would allow for huge productivity gains. We are faced, however, with the Solow paradox that "you can see the computer age everywhere but in the productivity statistics." The paradox has been defined as the "discrepancy between measures of investment in information technology and measures of output at the national level". Growth declined during the 1990s when computers became ubiquitous. In particular, the "Solow residual", or multi-factor productivity, has been stable or even declining in advanced economies:

$$SR(t) = \frac{\partial Y/\partial t}{Y} - \left(\alpha \frac{\partial K/\partial t}{K(t)} + (1-\alpha)\frac{\partial L/\partial t}{L(t)}\right)$$

# How can we explain the paradox?

- Measurement problem; as the quality of human capital increases, the residual declines but if the human capital increases due to ICTs, their effect is still there;
- Time lags; computers need time to contribute to productivity (difficulties in setting up, reorganization, learning, incompatibility, connectivity, losses ...);
- Organisations required change; there is a certain catch-up in the statistics from 2000 onwards;
- Bad management of ICTs as well as decreasing returns to scale;
- More fundamental problems with the quantification of technological progress and the drivers of economic growth.

# The impact on distribution

- Shares in GDP between labour and capital during the 20th century were roughly 2/3 (labour) and 1/3 (capital) but the labour share has declined in advanced industrial economies during the past 20 years (OECD).
- Equivalently, Thomas Picketty has shown that in recent years the share of capital accumulation (r) tends to be higher than the rate of growth of the economy (g), which precisely means that the share of capital increases if $r > g$. If capital is unequally distributed, which it usually is as it tends to concentrate, this implies an increase in inequality.
- The question is whether this is a "fundamental law of capitalism" or the result of autonomous changes in the mode of production and in industrial structure. The knowledge economy for instance favours the emergence of information-based networks and thus the emergence of "winner takes all"-industries.
- Many study shows that the return on education has relatively increased, which also implies an increase in inequality among the working class.

# The impacts on workers and organizations

- NTICS and the information society require a permanent disposition to change, permanent flexibility. There is no more time for learning by doing.
- Thus "agents of change" (managers, fixed costs) are required who "manage" productive workers. Formerly the relationship between managers and workers was 20%/80%. Today it is rather close to 80%/20%. And those 20% can be out-sourced to other countries.
- However, increasingly also the 80% can be out-sourced. Think of IT services in India. Change itself is becoming codified. Certain pharmaceutical companies outsource their research and testing.

# The impacts on workers and organizations

- Change generates change, which can lead to exponential growth in change. This effect is called the "ratchet effect" or hysteresis. Consumers and competitors get used to a certain pace of change and penalize those who do not keep the rhythm.
- Change has obvious benefits such as new and cheaper products. However it also has costs in the form of uncertainty, rapid obsolescence of human, social and physical capital due to the destruction of established contacts, networks, organizations, skills, ways of doing and institutions.
- Standards, contracts and conventions can slow down and manage change.

# The production of knowledge (research and learning)

- The value of research is very difficult to measure due to the positive externalities that it generates.
- Research is also characterised by network effects and increasing returns (clusters of innovation), both are, of course, related to positive externalities.
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- Learning is equally characterised by increasing returns (learning by doing, experience). Already Adam Smith remarked that the benefits of the division of labour are due to increasing dexterity (learning), invention and faster transitions from one task to another. The last point is closely related to "codification".
- The positive effects of learning by doing are frequently expressed in the form of "learning curves":
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- Not everything can be codified. There is such thing as tacit knowledge, which might be implicit in learning by doing. One can dis-invent the production of certain goods. Consider Europe's ability to build nuclear power plants.

# The importance of codification

- Codification transforms knowledge into information, a message on a physical or electromagnetic medium, so that it can be reproduced with precision an infinite number of times.
- This generates very large savings in the transitions between the initial production and reproduction. Re-production is, of course, not always re-actualisation, at least not with humans.
- Codification is not always possible. Consider Messi explaining to a newcomer how to execute penalty kick). Some knowledge is tacit, not codified, dependent on the context or the personality, a certain "je ne sais quoi".
- However, were possible and when well managed, codification has huge economic benefits.

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- Outsourcing, complex supply chains and globalisation would not be possible without it:
  - It reduces the costs of reproduction and increases reliability; the alternatives are master-student relationships through time; the question is real: to which extent can MOOCs substitute for physical presence in teaching?
  - The costs of storage, transportation and transfer, classical transaction costs, are greatly reduced.
  - The codified process can be far easier marketed and commercialized.

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- Of course, one must not forget that codification itself has costs. This fixed costs contributed to the increasing returns to scale prevailing in the information economy. Codification can thus be likened to the creation of a new language or of a community of experts.
- Codification to the extent that it constitutes a reduction of transaction costs is also essential for the creation of a market. Consider the existence of negative environmental externalities, which is likened by Arrow to the non-existence of a market for the good in question. Environmental externalities are the paradigmatic example of a non-codified good.
- Without codification of knowledge there would be no "labour market". The alternative would be a community of users with tacit, personal knowledge, a romantic notion still vivid in the 19 th century, the guild economy, but unsuited to modern life.

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- It is a challenge for universities to maintain the balance between the transfer of codified and non- codified knowledge. How do books, hand-outs videos, websites and electronic course compare to the regular attendance of a class?
- Codification and NTICS:
  - NTICS enable simple coding at low cost.
  - They provide languages for more complex coding.
  - However, most importantly, they greatly increase the benefits of successful codification.

# Externalities

- An externality is an effect on the utility of another agent that is not taken into account by the agent that causes it. It always refers to the difference between the private and the public value of a good or an action. Goods that generate large amounts of positive externalities are frequently provided as public goods. Caution with the classical definition of a public good being a good with non-rivalry in consumption. That is a sufficient but not a necessary condition. The complexity of adequately allocating individual benefits is a more solid perspective.
- Both knowledge and information are characterised by such externalities and public good characteristics. Potentially these are greater with information than with knowledge, as the former is inexhaustible and possesses a zero cost of reproduction is zero. Internet strongly reinforces this effect (think of Wikipedia). In earlier times, the costs of the re-production of information and knowledge, e.g., through books were costly.

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- The fact that information benefits more from NTICs than knowledge leads to a natural displacement of knowledge by information. This has negative impacts by itself, knowledge and its transmission needs to be protected. In fact, in earlier times knowledge and information were much less distinct than today. All information was embedded in knowledge. The distinction we draw today is also due to the fact that we call information, the part of knowledge that benefits from NTICs.
- In the case of information, copy and original are identical. This is not the case with knowledge, see the Messi example, also the costs of reproduction are higher.

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- Knowledge and information also are also cumulative due to learning by doing. This increases the public good characteristics.
- At the same time intellectual property rights obviously seeks to limit the "non-exclusive character" of information goods and to reduce the public good characteristics and the externalities of knowledge and information. Intellectual property right must arbitrate between encouraging the production of new information and the ability to use existing information.

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- This arbitration takes the form that the governments concentrates on areas that generate the greatest externalities (public research, elementary education and historical). Private provision will take place in more commercially relevant applied research with solid protection of intellectual property rights.
- These trade-offs are important. It is said that the refusal of James Watt (1755-1800) to patent his steam-engine retarded the industrial revolution by 20 years. Private-public partnership maximising profit and social benefits of innovation can in appropriate circumstances, i.e., the possibility to identify the benefits, a good solution.