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One Knowledge Base or Many Knowledge Pools?

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Abstract:
It is increasingly realized that knowledge is the most important resource and that learning is the most important process in the economy. Sometimes this is expressed by coining the current era as characterised by a 'knowledge based economy'. But this concept might be misleading by indicating that there is one common knowledge base on which economic activities can be built. In this paper we argue that it is more appropriate to see the economy as connecting to different 'pools of knowledge'. The argument is built upon a conceptual framework where we make distinctions between private/public, local/global, individual/collective and tacit/codified knowledge. The purpose is both 'academic' and practical. Our analysis demonstrates the limits of a narrowly economic perspective on knowledge and we show that these distinctions have important implications both for innovation policy and for management of innovation.

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Introduction

In Lundvall (1992) we started the analysis of innovation systems from a characterisation of the current state of the economy as one where "knowledge is the most important resource and learning the most important process". But it was a declaration with limited analytical backing. We did not give much insight in how knowledge and learning relate to innovation and to economic performance. In this chapter we present a conceptual framework and we make distinctions between private/public, local/global, individual/collective and tacit/codified knowledge. The purpose is both 'academic' and practical. Our analysis demonstrates the limits of a narrowly economic perspective on knowledge but we also show that these distinctions have important implications both for innovation policy and for management of innovation.

The chapter introduces a conceptual framework for analysing knowledge in relation to economic development. It does so through a critical analysis of the perception that the economy has 'a knowledge base'. Over the last decade it has become commonplace among policy-makers to refer to the current period as characterised by *a knowledge-based economy* and increasingly it is emphasised that the most promising strategy for economic growth is to strengthen the knowledge base of the economy (Abramowitz and David, 1996; Foray and Lundvall, 1996; OECD 2000). This discourse raises a number of unresolved analytical issues. What constitutes the knowledge base? At what level can we locate and define a knowledge base? We will show that the idea of 'one knowledge-base' is misleading and that the kind of knowledge that matters for the economy should rather be regarded as many separate 'pools', each with limited access. Using the standard terminology of economics, most knowledge is neither a strictly private nor is it a strictly public good. Rather than regarding such knowledge pools as assets we should see them as constituting a 'community resource' that cannot be transformed into private property.

The economics of knowledge

Knowledge and information appear in standard economic models in two different contexts. One relates to *decision-making*. The other context is one in where knowledge appears as *technology* that is transformed into techniques used by firms to produce scarce tangible products. It is of interest to consider how knowledge is treated in these two contexts in the old and the new neo-classical economics.

Both the old and the new neo-classical economics sticks to the assumption that agents are rational – and sometimes hyperrational (i.e. assuming rational expectations). Here information is free and costless. The old neo-classical growth theory consistently regards technological change as exogenous. New technologies appear for reasons not spelled out in the theory and access to the technical knowledge is assumed to be unlimited. The image often used is a 'book-of-blueprints' free of use.

The new growth theory and the new trade theory is more ambitious in its attempt to explain technological change. In new growth theory, the output of the R&D sector is viewed either as a blueprint for a new production process more efficient than the previous one; it is assumed that it can be protected by private property instruments such as patents; or as a new semi-manufactured goods not easily copied by competitors (Verspagen, 1992, p. 29-30). But the assumption of rational agents is not fundamentally revised. Firms are assumed to optimise their investment in new products and processes.

The old neo-classical is consistent in treating knowledge as exogenous but it has nothing to offer in terms of explaining knowledge production and use. The analytical framework is valid for a stationary state corresponding to Schumpeter's 'circular flow'. In such a state all agents may have established access to all information they need and there is neither new information nor new technology emerging that needs to be explained.

The new neo-classical theory is not consistent in this respect. It operates on the basis of two types of knowledge with opposite characteristics. Some information – the information needed to make a decision – is not at all scarce; other elements of knowledge can be obtained only by investing or buying. The only solution to this inconsistency would be to assume that the information utilised by decision makers and the technological knowledge emanate from two different universes – one static and one dynamic.

The other major problem for standard economics when analysing knowledge is the dictum of methodological individualism. It is assumed that the agent operating as decision maker and as owner of knowledge is an individual. Either knowledge is the property of an individual or it is accessible for all individual agents.

The fact that fundamental elements of knowledge are *shared without being public* cannot be captured without abandoning methodological individualism. Languages, common codes, trust relationships, shared routines and standards shared within a community cannot be reduced to assets and neither can they be transacted in the market. But since access to them is restricted to a community neither are they public goods. The basic starting point that everything, including knowledge, is an asset and potentially 'property' that can be transacted in markets makes standard economics less well suited for analysing knowledge.

Evolutionary economics does not suffer from such inconsistencies. Bounded rationality and innovation are core elements in the theory and so are shared routines (Nelson and Winter 1982). Evolutionary economics is much better suited to analyse an economy where knowledge is a key resource.

Rational Choice

The very foundation of standard economics is the analysis of *rational choice made by individual agents*. Thus, *how much and what kind of information* agents have about the world in which they operate and their *ability to process the information* are crucial issues that draw the lines between major economic schools. While neo-classical economics sticks to the assumption that agents are rational – and sometimes hyperrational (i.e. assuming rational expectations) - Austrian economists (Hayek 1937), Keynesians (Keynes 1936) and organisational economists such as Herbert Simon assume bounded rationality – i.e. a combination of a complex and uncertain environment and agents with limited capacity to process information.

It is obvious that agents do make choices between well-defined alternatives from time to time and that in some contexts these choices involve a calculation of costs and benefits in order to find the alternative that is most attractive in economic terms. But agents do not only make choices and they do not make choices all the time. Actually, most of the time agents follow routines or they do things without considering their own costs and benefits in economic terms. Many activities take place in interaction with others and the 'utility' of these activities are highly dependent on what pleasure the others get from the activity – this is true for sports, love-making and many other kinds of cultural and social activities (Mead 1934). These become more important as we get richer and less focused on filling our bellies and buying and driving cars. This kind of argument is however lost on neo-

classical economists. To give up the basic assumption about 'rational behaviour' would imply that even the most fashionable tools of game theory would have to be re-thought.

Therefore we will only state here that in a world where agents are involved in innovation and where innovation is important for economic performance – and this seems to be the case in the world we live in these days – the idea of explaining economic dynamics by models assuming that agents know all possible outcomes is *not reasonable.* Innovation is by definition a process where the alternative outcomes cannot be defined in advance – if these could be defined in advance we would not regard it as innovation. Actually we might say that not only do we operate under fundamental uncertainty in the modern economy – we operate under *radical* fundamental uncertainty: the only thing we know for certain is that there are constantly surprise outcomes of out decisions on their way. We *know* that there will be new technologies, new patterns of consumer behaviour and new forms of organisation that we cannot define in advance. Whatever neo-classical economics is useful for, it is not for explaining an economy where knowledge is the most important resource and innovation and learning the most important processes.

Is knowledge a public or a private good? Or is it a community resource?

The other context where knowledge appears in economics is as an *asset* that can be owned, exchanged and reproduced. It may also appear as input or output in an economic process.

Let us start with the classical question about the character of knowledge as public or private good. In economic theory, the properties that give a good the attribute of 'public' are the following:

- the benefits can be enjoyed by many users concurrently as well as sequentially without being diminished – the good is non-rival;

- it is costly for the provider to exclude unauthorised users – the good is partially non-excludable.

One reason for the interest in the public good issue is that it is crucial for defining the role of government in knowledge production. If knowledge were a public good, freely accessible for anyone, there would be no (economic) incentive for private agents to invest in its production. More generally, if it is less costly to imitate than to produce new knowledge, the social rate of return would be higher than the private rate of return and, again, private agents would under-invest in the production of knowledge.

Nelson's (1959) and Arrow's (1962b) classical contributions demonstrated that, in such situations, there is a role for government either to subsidise or to take charge directly of the production of knowledge. Public funding of schools and universities, as well as of generic technologies, is rational according to this analysis. It also brings to the fore the legal protection of property rights to knowledge, for instance by patent systems.

The analysis of knowledge as a private or public good may be contrasted to another perspective with roots further back in economic theory. Marshall (1923) made the observation that firms belonging to the same sector tended to be located together in 'industrial districts'. He also found that such groupings of firms often remained competitive for very long periods. He said that 'the secrets of industry are in the air' but specified this by pointing to skills in the local labour force and local specialised institutions that were local and which could be inherited from one generation to the next.

These two perspectives are opposed not only in their contrasting emphasis on respectively point to the need to protect knowledge and to the difficulty to diffuse knowledge. The industrial district perspective points to a more radical break with the neo-classical analysis since here knowledge is neither private nor public in the neo-classical sense. Since there is no simple way to enforce private ownership to the regional knowledge – to privatise the benefits from the knowledge commons – it is more correct to refer to knowledge not as an asset but as a non-marketable 'community resource'. In standard economics, this kind of phenomenon might be referred to as externalities or agglomeration effects. But we would argue that they represent 'typical' forms of economically important knowledge and that therefore their emergence and development need to be understood not as an exceptional phenomena but as regular outcomes of socio-economic processes.

But the two perspectives raise similar questions. Can knowledge be transferred from one place to another? How difficult is it to transfer knowledge and what are the transfer mechanisms? Is it possible to change the form of knowledge (for instance through codification) so that it gets easier (more difficult) to transfer? One reason for the distinctions between different kinds of knowledge proposed below is that they help to sort out these questions.

Responding to these questions is also a way of specifying how the knowledge base of the economy is constituted. If *knowledge were completely public it would be meaningful to speak of one common knowledge base* for the whole economy and there would be a strong need for co-ordinating

investments in knowledge production at the global level. If, conversely, *knowledge were completely individual and private there would be no common knowledge base at all* and investment in knowledge production could be left to the individuals themselves.

As we shall see below, as often is the case, reality is complex and most knowledge is neither completely public nor completely private. Some knowledge is 'in the air' locally but cannot easily be moved out of the local context. The knowledge base is fragmented and may best be illustrated as constituted by a number of semi-public 'community pools" with shared access regionally, professionally or through networking. Limited access means that some are excluded from even approaching these pools while others with access may lack the necessary tools to tap into them.

The last decades have witnessed two different tendencies that tend to change the private/public character of knowledge. On the one hand the widening use of information technology and the increasing importance of communicating scientific knowledge in the economy has given strong incentives as well as more efficient instruments when it comes to codify knowledge and make it explicit. This tends to make knowledge more widely accessible. But on the other hand, and to some degree as a response to the codification trend, there has been a strong political push in favour of de facto and legal protection of intellectual property. Led by the big US companies that operate science-based sectors multinational companies worldwide have successfully lobbied for more broad and strict legal protection first at the national level and later on at the global level.

This means that there are at least two different types of barriers around knowledge pools. Some reflect that competence is unequally distributed in space and lack of absorptive capacity. Others reflect political power and legal institutions denying access to those without formal ownership. The first ones may in principle be overcome by investment in knowledge and competence building and by joining networks. The height and character of the second type of barrier will reflect the use of political power in negotiations. Both these barriers tend to re-inforce the inequality of the distribution of knowledge and it might be argued that without a global 'new new deal' with focus on access to knowledge we will tend to develop an increasingly polarized world.

A terminology of knowledge

In 1987, Sidney Winter concluded an important contribution on knowledge and management by pointing out that there is "a paucity of language" and "a serious dearth of appropriate terminology

and conceptual schemes" for analysing the role of knowledge in the economy (Winter 1987). Since then, the number of relevant publications has grown immensely and some progress has been made (see Foray, 2000;David and Foray, 2002: Amin and Cohendet 2004), but as compared to Winter's original analysis, little headway has been made in terms of a terminology acceptable to all. There is little agreement on questions such as: What is the meaning of knowledge? What separations and distinctions between different kinds of knowledge are most useful for understanding how knowledge affects economic development?

Knowledge of the Mind, Body and Soul

One classical distinction is the one between data, information, knowledge and wisdom. Data are the raw material used to construct information. Knowledge is necessary to get meaning from information. Wisdom is needed in order use knowledge.

These distinctions may be useful for some purposes but the selection and ordering of them reflect a bias in the way knowledge is regarded. The focus is on mental cognition where knowledge is something absorbed through access to information and analysed in the mind. An alternative understanding of knowledge is represented by the philosophy of Dewey and the pragmatist Chicago School. Here knowledge is seen as emanating from practise and as layered not in a separate mind but in the body as a whole (Kolb).

In modern society there are many specialised organisations and institutions that promote the training of the mind. Some of them are actually based on the assumption that knowledge is learnt through getting access to information and those who operate them may see learning as a cognitive process separated from practice. But closer analysis of scientific work shows that practice is fundamental for learning and that expert knowledge is located in the body. Actually you might define expertise as a stage where you do not have to go through a stepwise analytical process but can draw directly upon 'back-bone' knowledge.

There is a tension between mind and body in the historical and analytical understanding of knowledge. The distinction between explicit knowledge (mind) and tacit knowledge (body) illustrates this tension and so does the organisation of economic activities where certain parts of organisations (R&D-department) may be seen as mainly concerned with cognition (mind) where other parts (production departments) are seen as involved in practical action (body). In fact there is no learning and knowledge without involving the body and very limited learning in societies

without cognitive attempts to make elements of tacit knowledge explicit. We are going to use the distinction between tacit and codified knowledge below but we do so in order to demonstrate how the two are intertwined and mixed differently in different contexts. In order to see the close interdependence and between the two dimensions it is necessary to make the distinction between them.

The social character of knowledge

Each individual may be seen as a 'knowledge container' but what she contains will be more or less useful and meaningful in different social contexts. The knowledge of a professor in physics may be of little use as participant in a Safari in Africa while a professional lion-hunter may be of little use at a scientific conference in Boston. So the context makes all the difference.

Most meaningful knowledge is constructed in an interaction with others and gets a meaning in an interaction with others. Interaction involves communication and co-operation. Communication may be oral or take place via gestures or with the help of artefacts. It may take place in a more or less structured context – as speech or as conversation. Co-operation may be more or less purposeful as work or play (Amin and Cohendet, 2004).

Knowledge of importance for economic purposes may be rooted in the relationships within a team, in routines common to the firm or in a wider community extending outside the borders of the single firm. The team may be a formal working unit but it may also be a self-organising community. Here we will refer to it as a 'community team' we prefer to reserve 'community' tout court for social formations that cross the border of the firm. Community teams and communities may be based primarily upon epistemology or primarily upon practice. In the first case the major aim is to process and produce knowledge while in the second it is find workable solutions to a set of practical problems requiring skills that are interrelated (Wenger, 1998).

But not all community knowledge remains a community resource. There are strong incentives for capitalist firms to transform community knowledge into private property. Inside organisations codification of the skills, co-operation and interactions of employees may increase management control with the core knowledge of the firm. In relation to competitors there is a strong incentive both to protect key elements of the firms technology from access and more generally to block competitors access to strategic elements of knowledge.

This lies behind one of the major contradictions of current capitalism. On the one hand capital wants to subordinate knowledge under its own rule and transform it into private property. On the other hand knowledge thrives in communities and communities cannot be fully subordinated to capital and their knowledge transformed into private property without losing their effectiveness as sites for knowledge creation and reproduction. The current debate on commercialising university research is perhaps the best illustration of this contradiction.[1]

Four different kinds of knowledge

Following Lundvall and Johnson (1994) knowledge is here divided into four categories:

- Know-what
- Know-why
- Know-how
- Know-who

Know-what refers to knowledge about 'facts'. The number of people who live in Beijing, the ingredients necessary to make pancakes, and the year of the French Revolution are examples of this kind of knowledge. Here, knowledge is close to what is normally called information – it can easily be broken down into bits and communicated as data.

Know-why refers to knowledge about principles and laws of motion in nature, in the human mind and in society. This kind of knowledge has been extremely important for technological development in certain science-based areas, such as the chemical and electric/electronic industries. Access to this kind of knowledge will often make advances in technology more rapid and reduce the frequency of errors in procedures involving trial and error.

[1] While, as can be seen from Lundvall and Johnson (1994), we share many of Drucker's (1993) specific interpretations of the modern economy we do not see it as 'post-capitalist'. It remains capitalist but with new contradictions that relate to the production, use and protection of knowledge becoming more important than before.

Know-how refers to skills – *i.e.* the ability to do something. It may be related to the skills of artisans and production workers, but, actually, it plays a key role in all economic activities. The businessman judging the market prospects for a new product or the personnel manager selecting and training staff use their know-how. It would also be misleading to characterise know-how as practical rather than theoretical. One of the most interesting and profound analyses of the role and formation of know-how is actually about scientists' need for skill formation and personal knowledge (Polanyi, 1958/1978). Even finding the solution to complex mathematical problems is based on intuition and on skills related to pattern recognition rooted in experience-based learning rather than on the mechanical carrying out of a series of distinct logical operations (Ziman, 1979, pp. 101-102).

Know-how is often developed individually through experience and kept within the borders of the firm or team. As specialisation evolves and complexity of technology and science increases, however, co-operation between people and organisations and knowledge sharing becomes increasingly necessary (Pavitt, 1998). The more fine-grained and the deeper the division of labour among experts the more crucial becomes the mechanisms that link different fields of expertise to each other. This is the reason why *know-who* becomes increasingly important. Know-who involves information about who knows what and who knows what to do. But it also involves the social ability to co-operate and communicate with experts. Know-who makes it possible to draw upon intellectual capital through the means of social capital.

How public or private are the four kinds of knowledge?

The public or private character of these kinds of knowledge differs in terms of both degree and form. Databases can bring together 'know-what' in a more or less user-friendly form. Information technology extends enormously the information potentially at the disposal of individual agents, although the information still has to be found and what is relevant selected. The effectiveness of search machines developed in connection with the Internet is highly relevant in this context, as it helps to specify how accessible the data actually are. Even with recent advances in this area, access to this kind of knowledge is still far from perfect (Shapiro and Varian, 1999). Still today, the most effective medium for obtaining pertinent facts may be through the 'know-who' channel, *i.e.* contacting an outstanding expert in the field to obtain directions on where to look for a specific piece of information.

Scientific work aims at producing theoretical models of the *know-why* type, and historically much of this work is placed in the public domain. Academics have strong incentives to publish and make their results accessible. The Internet offers new possibilities for speedy electronic publishing. Open and public access is of course a misnomer, in that it often takes enormous investments in learning before the information has any meaning. Again know-who, directed towards academia, may help the amateur to obtain a translation into something more comprehensible.

In some areas where new technological opportunities evolve very quickly and technological competition is intense the technical solutions introduced by engineers may get far ahead of academic know-why (Vincenti, 1990). Technology may solve problems or perform functions without a clear understanding of why it works. Only later on, science may explain the causalities involved. Here, know-how comes before know-why.

Know how is the kind of knowledge with most limited public access and for which mediation is the most complex. The basic problem is the difficulty of separating the competence to act from the person or organisation that acts. The outstanding expert – cook, violinist, manager – may write a book explaining how to do things, but what is done by the amateur on the basis of that explanation is, of course, less perfect than what the expert would produce. Attempts to use information technology to develop expert systems show that it is difficult and costly to transform expert skills into information that can be used by others.

Know who refers to a combination of information and social relationships. Telephone books listing professions and databases listing producers of certain goods and services are in the public domain and can, in principle, be accessed by anyone. In the economic sphere, however, it is often necessary to connect with specialised competencies and to find the most skilled and reliable expertise; hence the importance of good personal relationships with key persons one can trust. These social and personal relationships are by definition not public. They cannot be transferred and, more specifically, they cannot be bought or sold on the market. As Arrow (1971) has pointed out, “you cannot buy trust and, if you could, it would have no value whatsoever”. This is fundamental because it implies that the economics of knowledge in order to be relevant needs to seek support in other social science disciplines.

Most knowledge is neither strictly public nor strictly private

It is clear from what precedes that very little knowledge is ‘perfectly public’. Even information of the know what-type is unavailable to those not connected to telecommunication or social networks. Moreover, the current state of information technology still limits access for those who are in fact connected. Scientific and other types of complex knowledge may be perfectly accessible, in principle, but for effective access the user must have invested in building absorptive capacity. Know-how is never fully transferable since how a person does things reflects that individual’s personality (even organisations have a “personality” in this sense).

On the other hand, little economically useful knowledge is completely private in the long run. Tricks of the trade are shared within the profession. Know-how can be taught and learnt in interaction between the master and the apprentice. New technological knowledge may be costly to imitate but, when it is much more efficient than the old, there are several ways to obtain it. Even when the owner of private knowledge does not want to share it with others there are ways to obtain it, such as reverse engineering; taking products apart to find out how to produce them. If necessary, private agents will engage in intelligence activities aimed at getting access to competitors’ secrets.

Different parts of economic theory handle this mixed situation differently. Underlying much of neo-classical theory of production and economic growth is the simplifying assumption that there is a global bank of blueprints from which anybody can get a copy to be used for starting up production. This ignores the fact that only skilled agents can use blue prints and that skills are unevenly distributed geographically and socially. Since skill cannot easily be transformed into blueprints the idea of general access is not tenable.

The resource base view of the firm takes a different view and assumes that the competence of the firm determines the directions in which it may expand its activities (Penrose, 1958). It is the specificity of the knowledge base that determines the specific pattern of economic growth of the firm. In a long-term perspective this view leads to a more dynamic perspective – cf. the dynamic capability theory of the firm. It points to the need for firms to engage in continuous creation of new competencies within the firm and it points to the need to develop ‘learning organisations’. Without such efforts, imitation and innovations among competitors would, sooner or later erode the firm’s competencies.

On tacitness and codification of knowledge

There is currently a debate among economists about the role of tacit and codified knowledge (Cowan, David and Foray 1999; Johnson, Lorenz and Lundvall 2002). One reason for the interest is that tacit knowledge is definitely not a public good and cannot be transmitted as information. If transformed into explicit codes it *may both become* more easily transferable. The process of codification of knowledge is therefore important for understanding the on-going transformation of 'the knowledge base'.

One of the important consequences of the information technology revolution is that it changes both the incentives and the tools for codification. It makes it more attractive to transform knowledge into information that can be entered on to the Internet. At the same time, it also offers new tools to pursue codification and to extend codification to more complex bodies of tacit knowledge. The questions to be discussed here are, first, to what degree codification makes knowledge part of a generic knowledge base and, second, to what degree it makes knowledge more easily transferable across localities and firms. We will argue that the impact of codification is ambiguous in both these respects. We will also show that any idea about individual and economic progress as being running in parallel with a movement from tacit to codified knowledge is incorrect.

Codification in the Academic Community

The context for codification may determine what direction and form it takes – here it is especially relevant to make the distinction between the 'academic' sphere and the 'business' sphere. Scientific progress as it is organised by academic institutions is highly dependent on codification and codification is a way to make progress more widely diffused and recognised within the academic community (Dasgupta and David 1994). You might say that a high degree of codification is a necessary prerequisite for scientific progress.[2] Codification in the realm of academic research will

[2] But not sufficient: it would be a serious mistake to assume that scientific work is based exclusively upon codified knowledge. The personal knowledge of the scientist cannot be fully codified and personal knowledge is distributed unevenly in space reflecting local learning experiences. And therefore important elements of scientific knowledge are localised and embodied in scientists and scientific teams and localised. These elements can be transferred from one place to another only through the movement of people. This is why star scientists can earn a lot of money.

typically make access to knowledge more global. Scientific knowledge comes closest to form world-wide common knowledge.

But scientific progress goes hand in hand with increasing specialisation and complexity. In order to access the most advanced knowledge in any specific scientific discipline highly developed expertise and advanced infrastructure is needed. Therefore scientific knowledge is public only in a relative sense – there might be no barriers from the supply side but in order to establish effective demand 'absorptive capacity' that requires substantial prior investments is needed.

Second the access to a specific knowledge field among academia does not guarantee that the knowledge can be easily transformed into economic results everywhere. For instance, to make economic use of the codified knowledge in physics would be dramatically more realistic in a local context where there are private agents with R&D-efforts in the field than in a region where no such agents were present. To have access to academic knowledge but not to potential users may correspond to being rich in raw materials but lacking the tools and technology to exploit them.

So even if academically organised knowledge in principle can be accessed everywhere it has different economic value in different localities. Actually, an acceleration of the codification process in the academic sphere may increase global inequality since absorptive capacity is so different in the rich and in the poor countries. This lack of absorptive capacity emanates both from a more limited competence in the academic field and from a more limited competence in the business sector to effectively demand and use academic knowledge in innovation processes.

Developing countries will need to invest heavily in academic science in order to be able to draw upon what appears to be 'a common global stock of knowledge' and more importantly they need to establish absorptive capacity in the private sector. It is not correct when the World Development Report from 1998/99 starts with the following promising words: "Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. Yet billions of people still live in the darkness of poverty – unnecessarily." Not even the most accessible knowledge – i.e. codified academic science travels like light and it is even less true for the codified knowledge produced for profit in the private sector..

Codification in the business sector

Firms use knowledge in the form of information as the basis for decision-making and as skills for solving problems and designing innovative solutions. Firms may give different weight to codified versus tacit knowledge and they may make more or less big efforts to transform tacit knowledge into codified knowledge in relation to decision making, work organisation and organisation of innovation. The balance will reflect the technological and market context. But it may also reflect national/cultural context.

Within a specific context, firms face important dilemmas when deciding how far to go in terms of codification. Codification offers potential benefits but it is costly and it has negative consequences. In what follows we will make a distinction between codification in relation to respectively decision making, organisation of work and organisation of innovation process. We will focus on how codification affects world-wide access to knowledge.

On the use of expert systems within firms

With the wide use of information technology one might expect firms to substitute for scarce management skills by Management Information Systems. The basic idea would be to develop expert systems that could be fed by relevant information about business context and then leave it to the computer program to come up with the right decision. There is no doubt that there is some movement in this direction but it is a movement characterised by hesitation and set-backs.

Eliasson (1996) has illustrated the limits of using management information systems as a substitute for management skills by pointing to the strategic failures of leading producers of management information systems such as IBM and other big ICT-firms**.** Know-how, if it is not economically trivial, easy to copy, routines, is *never a completely public good* and normally firms get access to it only by hiring experts or merging with companies with the knowledge they want. It has also been demonstrated that the transformation always involves changes in the content of the expert knowledge (Hatchuel and Weil, 1995).[3]

3 The difficulty/impossibility to make a one to one translation of expert knowledge into information systems does not mean that the effort to make such a translation is meaningless. Actually the effort may be helpful in imposing a more systematic approach rather than trust 'trial and error' (Lazaric 2003). This

The reason is that strategic management decisions are based upon experience and that the make more use of pattern recognition and intuition than they use analytical models. They are not the outcome of a logical deductive process. What distinguishes the successful manager or team of managers from the less successful is that he/they can handle new and unforeseen problems as well as routine problems. This indicates one of the most important limits for the use of information management systems. They may be developed and used for rather simple repetitive decisions and in an environment that remains stable over time. The more complex the problem the less helpful and more dangerous it might be to rely on a management information system to find the right solution (Cowan 2001). Complexity in itself might not be a hindrance for codification, however. Other factors that refer to the social interaction among agents may be at least as important. From time to time new vawes of codification in a field of knowledge may be triggered by new insights into technical causalities (Lazaric et al 2003). Perhaps the most important limit to what management is willing to invest in codification efforts is related to the stability and change of the field of knowledge and of the problems that it has to tackle. If new types of problems appear frequently codification may actually invalidate the capacity to deal with the problems. If problems remain structured in a similar way the incentive to codify is strong.

Therefore the impact of information technology on incentives for codification of expert knowledge has been contradictory. Information technology has made it more realistic to simulate and reproduce complex decision processes. But at the same time the extended use of information technology has led to acceleration of change making it less unattractive for firms to get locked into pre-programmed routines. To this should be added that experts at all levels of organisation will resist attempts to codify their knowledge and that top management of all categories is in the best position to make this resistance effective.

This implies that management skills cannot be easily transferred from one context to another. In developed countries the most effective way to develop and transfer good management principles

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is a point of more general relevance. In a similar vein it might be very useful for management to make an annual report on the knowledge assets of the firm in spit of the fact that the outcome on the bottom line may be of dubious and that the routinization of the reporting may be of little use (Edvinsson 1997).

may be to move managers from one organisation to another. Data from Denmark indicate that small family-owned firms that are stuck with the same top management for a long period are less successful in terms of innovation and growth; the most successful firms are part of multinational management cultures and here there is an ongoing change in management teams (Lundvall and Nielsen 2005).

For less developed countries this means that developing local management skills and selectively learning from management abroad is necessary. There are certainly information systems supporting accounting procedures, customer information and procurement and stock control. As far as there is a scarcity of management skills it might be rational to invest in such systems. However, these systems can be seen as supporting but not as substitutes for strategic decision-making. And their intelligent use requires strategic leadership.

Codifying the work process

Work may be organised so that it is more or less based upon codification and built in routines. The history of work organisation involves stages of codifying skills and building them into machinery or into routines to be strictly followed by workers. Scientific management and taylorist forms of organisations have in periods been highly productive and effective. Today there is a tendency to define the high performance workplace as one where workers have more autonomy – the work process is less structured and codified.

In important new contributions Lorenz and Valeyre (2004) have used employee survey data to develop taxonomy for work processes in terms of the learning opportunities they offer to employees. They distinguish between four categories:

- Simple production
- Taylorism
- Lean production learning
- Discretionary learning

In their work the focus is on the content of learning of these four forms of work organisation. But the four models may also be contrasted in terms of to what degree they codify the skills of workers and build them into machinery or into strict routines. Simple production is a mixed category of old and new services but it is the least structured while the taylorist organisation is the most highly

codified. Lean production learning model makes use of modern management techniques such as job rotation and team work but leaves little autonomy to the individual worker. This contrasts with the discretionary learning model where the employees are given more freedom to make choices. We would argue that Lean Production is less structured than Taylorism but more structured than Discretionary learning.

On the basis of the data developed by Lorenz and Valeyre we can get an idea of how the workforce is distributed between the four forms in fifteen European countries. It is interesting to note that there seems to be a tendency that the workforce of countries at different income levels are distributed differently over these four categories.

To illustrate we have ordered six European countries according to GNP per capita and presented how the workforce is distributed across the four archetypes of working organisation. The most important result is the complex relationship between level of economic development and degree of codification of the work process. At low income levels the work process will become more codified until a certain point and after that it will become less codified.

Table 1: National Differences in Organisational Models (percent of employees by organisational class)

	Discretionary learning model	Lean production	Taylorist organisation	Simple organisation
Denmark	60,0	21,9	6,8	11,3
Netherlands	64,0	17,2	5,3	13,5
Germany	44,3	19,6	14,3	21,9
France	38,0	33,3	11,1	17,7
Portugal	26,1	28,1	23,0	22,8
Greece	18,7	25,6	28,0	27,7
EU-15	39,1	28,2	13,6	19,1

Source : Third Working Condition survey. European Foundation for the Improvement of Living and Working Conditions

Economic development that involves a growth of manufacturing activities in a context of skill shortages will increase the proportion of workers in Taylorist organisations (cf. Portugal and Greece). At a later stage of development more demanding in terms of flexibility and innovation it becomes more rational to give workers more autonomy and the proportion of Taylorist work is reduced (Germany and France). In (small) economies with high income per capita the need for continuous innovation and adaptation to change is even bigger and here we find a movement toward discretionary learning (Netherlands and Denmark). The table shows that there is not a linear relationship between degree of codification of work and the level of economic development.

The background for this pattern is that codification of workers' skills has both advantages and drawbacks also seen from the point of view of management. Codifying the skills of employees may make the firm less dependent on employees. If it is possible to build the skills into machinery and routines the firm may succeed in establishing a situation where parts of the labour force may be substituted without negative effects on performance. In a context where there is a dramatic shortage of skilled labour a Taylorist organisation with much of workers' competence built into the machinery might be seen as attractive.

The negative side of this strategy is that the labour force may remain unskilled and that upgrading production will not take place. Also the firm will be vulnerable to external shocks. When the context – technology or market – changes the organisation will not be able to adapt since it is designed to solve a constant and narrow set of problems. Only in a context of stable technology and stable demand this kind of organisation may be attractive. Today this is typical for sectors where value-added per employee is limited. This is why developing countries with shortage of skilled labour risk to be stuck in such activities.

At the aggregate level of the national production system, having a strong presence of such rigid organisations would imply a high birth and death rate of organisations. The alternative to the adaptation of existing organisations is that they die when they cannot cope and that new ones appear. High frequencies of birth and death of firms are sometimes interpreted as signs of a sound entrepreneurial economy but it also reflects the degree of rigidity of existing organisations. To close down an existing organisation and establish a new one involves substantial 'transformation costs' in terms of lost community knowledge. This is why less developed economies specialised in the most taylorist steps in the global value chains may be victims both to lock in into low value added activities and high vulnerability to external shocks.

Box 1: Codification as refining knowledge and transforming it to a higher form

There is a bias in western philosophy favouring analytical and highly structured knowledge while regarding intuitive knowledge rooted in experience as being of a lower order (Nonaka and Takeuchi 1995). Our analysis of codification of academic knowledge, expert knowledge, work processes and innovation does not support this view.

The closer we get to the frontier of science the more the scientist relies on experience and on her capacity to recognise patterns without being able to present her analysis as a logical sequence. The more complex the management task and the more dynamic the context the less can the firm rely on expert systems.

Highly codified work organisations such as those dominated by taylorism are characterising less developed economies where skills are scarce. In high income countries more and more employees are given more free reins to engage in unstructured problem solving, individually and in teams.

Innovation modes based upon science and giving major attention to codified knowledge cannot stand alone. They need to be supported by organisational forms that promote experience-based learning and resulting, not in disembodied codified knowledge, but in new skills and new products.

Work process codification has made knowledge more accessible worldwide. Today it is possible to establish industrial processes also in areas where skilled labour is scarce. This is reflected in the tendency toward more and more developed global value chains and more generally in the increasingly global competition for commodities. For developing countries it is a key problem to find a way of building change into such Taylorist organisations. One option is to develop elements of 'lean production learning'. Lean production implies that workers may work in teams, change tasks and get some limited discretion in solving problems as they appear. This might give the minimum of space for learning that in the longer run can increase the value added in such processes. But in big emerging economies such as China where the ambition is to develop home-spun innovations in highly dynamic technological fields there might be a need to move directly toward discretionary learning in certain parts of the economy exposed to rapid change in technology and market.

Codification in relation to the innovation process

Most authors using the concept of knowledge creation and knowledge production refer to technical innovation as the output of the process (Antonelli, 1999; Nonaka and Takeuchi, 1995). In new growth theory, the output of the R&D sector is viewed either as a blueprint for a new production process more efficient than the previous one or as a new semi-manufactured goods not easily copied by competitors (Romer 1990; Verspagen, 1992, p. 29-30).

The process of innovation may be more or less codified. One example of a highly codified innovation process would be the development of a new pharmaceutical product where a new chemical formula is the basis of the innovation. One example of a less codified innovation would be the development of a new machine where the operator changes the machine on the basis of his own experience.

In Jensen et al (2004) we make the distinction between two different modes of innovation. The STI-mode refers to the science, technology, innovation sequence and the process operates mainly on the basis of the codified knowledge while the DUI-mode operates mainly on the basis of experience based learning by doing, using and interaction. Here we will consider how the two modes affect the access to the outcome of the innovation process. Is a codified outcome easier to transfer across organisational boundaries and geographical borders than the outcome of a DUI process?

The STI-mode

The dichotomy, should not be taken to imply an absence of complementarities between the two modes. For instance, scientists operating at the frontier of their field in the R&D departments of large firms need to draw upon their tacit experience based knowledge when making experiments and interpreting results, and specific R&D-projects will often be triggered by problems emanating from practice. We may still define it as predominantly STI if immediate attempts are made to restate the problem in codified form. The R&D-department may start going through its earlier work, looking for pieces of codified knowledge, as well as looking for codified knowledge that can be drawn from outside sources. In order to communicate with scientists and scientific institutions outside it may be necessary to translate the problem into a formal scientific code.

All through the process documenting results in a codified form remains important. It is not sufficient that the single scientist keeps results in his own memory as tacit knowledge. Often the

project involves teamwork and modularization where single results are used as building blocks for other members in the team. At the end of the process – if it is successful - a transfer of the results within the organization or across organizational borders will call for codified documentation as well. When an patent application is made the documentation needs to be made in a techno-scientific language that allows the patenting authority to judge the originality of the innovation.

This means that, on balance, the STI-mode of learning even if it starts from a local problem will make use of 'global' know-why knowledge all the way through and, ideally, it will end up with 'potentially global knowledge' – i.e. knowledge that could be used widely if it were not protected by intellectual property rights.

The DUI-mode

The DUI-mode of innovation (Doing, Using, Interacting) refers to an innovation process where there is emphasis on the utilisation of know-how and know-who that is tacit and often highly localized. This mode may result in incremental innovation in simple organisations but it is also present when it comes to realise radical innovation. Here it requires organisational structures and relationships that enhance and utilize learning by doing, using and interacting in order. In terms of the work organisation patterns it implies combinations of discretionary and lean production learning.

Box 2: Adam Smith and the two modes of innovation - DUI and STI

Adam Smith's links the development of the division of labor to innovation in two different ways and doing so he actually indicates two different modes of innovation. One *experience-based* that corresponds to *DUI-learning* while the other is *science-based* and corresponds to *STI-learning.*

Adam Smith (1776: p. 8) on the DUI-mode of innovation:

> *A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it. Whoever has been much accustomed to visit such manufactures, must frequently have been shown very pretty machines, which were the inventions of such workmen, in order to facilitate and quicken their own particular part of the work.*

Adam Smith (1776: p. 9) on the STI-mode of innovation:

> *All the improvements in machinery, however, have by no means been the inventions of those who had occasion*

> *to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is not to do any thing, but to observe every thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects.*

The DUI mode of learning is characterised by on-going change that continuously confront employees with new problems and incite learning by doing (Arrow 1962a). Finding solutions to these problems enhances the skills of the employees and extend their repertoires. Some of the problems are specific while others are generic. Therefore learning may result in both specific and general competencies for the operator. When the process is complex – a good example is the learning-by-using of new models of airplanes - it will involve interaction within and between teams and it may result in shared routines for the organization. As the whole organization gets more insight in the actual working of the system it might find more efficient ways to organize work and solve problems as they pop up. This is the kind of case that Rosenberg (1982) uses to illustrate learning-by-using. Both learning by doing and using normally involve interaction between people and departments and this is why such practices as cross-functional groups and job rotation show positive relations to learning and performance.

I has been argued that learning by doing and learning by using only result in 'local' knowledge and that without codification and transformation of the knowledge into codified knowledge the impact on the economy as a whole would remain limited. In a recent paper I have argued that this argument neglects the outcome of learning by interacting involving users and producers. The introduction of new products emanating from this kind of interaction is an alternative way of transforming local learning into more global knowledge. The new products will embody experiences made by several users. From the view-point of the whole economy *the learning by interacting has the effect of transforming local learning into general knowledge embodied in for instance new machinery, new components, new software-systems or even new business solutions* (Lundvall 2006).

How does the STI- and the DUI-mode of innovation affect the transferability of knowledge?

While the output of the DUI-mode may be a tangible new product with embodied technical knowledge – such as a numerically controlled machine tool – the outcome of the STI-process may be disembodied knowledge that can be widely distributed. But the more codified form makes it also more easy to protect this kind of knowledge through intellectual property rights in the form of a patents or a licenses.

The codification process that results in a patent may be seen as contributing to the cumulative knowledge creation process by making explicit fundamental characteristics of the new product or process. This contrasts with the outcome of the DUI-mode where the new knowledge is embedded in the new product or process but not made explicit and not transformed into disembodied knowledge that can be traded in the market. If the outcome is a new product reverse engineering may be an option for competitors. If it is a new process for internal use the access will be limited. Here the mobility of employees may be an alternative transfer mechanism.

Normally one would expect codified output of the innovation process to contribute to making new technology more accessible worldwide than embodied knowledge. In the current period where protection of codified knowledge has become a major concern of firms that are world leaders in advanced technology this might not be the case. The STI-mode resulting in disembodied codified knowledge may actually result in more restrictive access than the DUI-mode where the final product is a new system or product with embodied but unprotected knowledge. If this is so, it might give the most advanced firms in different technological fields an incentive to go even further in the direction of codification but with increasingly negative impact on the distribution of knowledge.

Another important contradiction in modern capitalism is reflected in the codification process. While codification in principle makes knowledge disembodied and more accessible worldwide it also makes it easier to exclude others from using it. This tension is reflected in knowledge politics and knowledge management. With the most recent developments in the field of intellectual property rights where these tend to be stretched to cover new areas including living organisms as well as soft-ware the net effect of codification on global access might actually be negative. This may be detrimental for the progress of knowledge creation and use worldwide. The creativity of people and communities finds itself blocked by too many barriers.

Conclusions

The debate on codification has been complicated by the fact that different kinds of codes have been alluded to. Some codes are explicit and available in the form of textbooks, manuals, formulas and organisational diagrams. Others have developed spontaneously as a local means of communication within or between organisations (Arrow 1974). Communities of practise may have their own code that gives them privileged access to community knowledge. Epistemological communities that bring together scholars contributing to a specific scientific field certainly have their own code.

Actually a lot of economically relevant knowledge is communicated in such specialised and local codes. One of the most important sources of innovation is not codifying knowledge but to establish social interaction and communication between such communities. We need more of the idealised agents referred to by Adam Smith:

> *philosophers or men of speculation, whose trade it is not to do any thing, but to observe every thing; and who, upon that account, are often capable of* ***combining together the powers of the most distant and dissimilar objects***.

The current scientific as well as business community is highly specialised and there may be a scarcity of 'men of speculation' with the kind of background that makes it possible for them to combine *distant* and *dissimilar* objects. To foster such men and women may be a major challenge for education systems and for designing career paths in the labour market.

Another characteristic of intellectual capitalism is the growting urge to privatise what can be privatised and to transform shared knowledge into private and legally protected property. The ambivalence in the business community between the wish to share knowledge with others and the wish to protect your own knowledge from the others has become biased in favour of privatisation. To some degree this may be seen as a response to the tendency to make explicit and codify knowledge. Whatever the reason it makes access to the knowledge pools even more dependent on financial resources and political power.

The chapter started from the idea of 'the knowledge based economy'. Our conclusion is that the idea of 'one knowledge-base' for the economy is misleading and that the kind of knowledge that matters for the economy should rather be regarded as many separate 'pools', each with limited access. Using the standard terminology of economics, most knowledge is neither a strictly private nor is it a strictly private good. We would prefer to refer to most useful knowledge as being a 'community resource'. More often then not it can neither be appropriated by individuals and nor be transformed into a commodity.

In the rich part of the world knowledge management and knowledge politics should therefore be seen as similar to the management of an eco-system. Besides focusing on the growth and quality of each pool it is necessary to promote diversity. Establishing new links between separate pools, for instance by letting experts with access to one pool get access to another pool, or stimulating experts

with access to different pools to interact are fundamental elements in an innovation oriented knowledge policy.

In less developed countries innovation policy is about tapping into foreign pools and linking them to domestic pools and transforming the combination either into innovation and market value or into social and collective use. To refer to this process as knowledge *transfer* or knowledge *spill-over* is to underestimate the efforts necessary and the barriers that may exist. Often it is necessary for the less developed economy to go through a process of institutional transition in order to overcome the barriers. And some of the knowledge pools in the rich world are surrounded by high fences and guarded by company lawyers armed with law-books spelling out intellectual property rights. Others may be difficult to localise since they are integrated in networks of more or less invisible academies and communities of practice.

Actually there is a need for a global new new deal where the focus is upon giving less privileged parts of the world easier access to the pools of knowledge now controlled by the rich countries and by transnational companies. This implies both a reform of the intellectual property right regime of WTO and a major investment in competence building in the less developed economies.[4] Without such an effort the gaps between rich and poor countries will grow, perhaps with the exception of a few big economies, such as China, where the effort to accumulate capital and invest in endogenous innovation is enormous (Gu and Lundvall 2006).

[4] For an example of an effort to redistribute capacity building in the field of innovation research see www.globelics.org.

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