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LECTURE 5

KNOWLEDGE AS PUBLIC GOOD, A PRIVATE GOOD

AND A LOCALIZED COLLECTIVE GOOD

THINK - Understanding Knowledge, FP6 Integrated Project Proposal
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Knowledge as a subject of study is not new. Two disciplines in particular stand out as having made knowledge their main focus: the **sociology of knowledge** has been concerned with the role of knowledge in societies while **cognitive sciences** (including brain sciences and psychology) has been seeking a better understanding of the way in which the individual mind works.

However neither the sociology of knowledge nor cognitive sciences can claim absolute authority over the study of knowledge. Understanding knowledge is central to several other disciplines. Much of **philosophy** is concerned with uncovering what is behind the thinking process and how this is translated into action; **anthropology and social psychology** have been seeking to unveil the knowledge universals behind different cultural or social forms of being and living while linguistics is concerned with the same with regard to language. Applied disciplines like **management**, education or **science and technologies studies**, on the other hand, have been concerned with the way knowledge is or can be codified and managed towards **its more efficient dissemination and use within society, the economy or in policy**.

State-of-the-art on knowledge

What is knowledge? And how does knowledge differ from information? In order to understand the role of knowledge for society and social action it is important to first define this sociologically. Defining knowledge sociologically means **understanding not only what knowledge is but also how or by whom it is produced and used, for what purpose and in what context**.

Forms and types of knowledge

A short excursion into philosophy shows that much of the reflection on knowledge over the centuries centred on understanding **how knowledge relates to facts**, on the one hand, **and rules or values**, on the other (Stehr 2003).

Another key issue in the long line of knowledge inquiry has concerned **the distinction between knowledge as an object** (which, in turn, one possesses), **knowledge as a process** (of thinking or creating) and **knowledge as experience** (life-based or historical).

- **Plato** distinguished two types of knowledge: *doxa* and *episteme*, **mere belief and true belief**.
- The **Sophists** questioned the **objective character of knowledge** and stressed the **active, creative role of the human subject**.
- The distinction between **practical** and **absolute** aspects of knowledge can be found in **Aristotle's concepts** of *phronesi* (**cleverness)** and *sophia* (**wisdom).**
- **Rationalism** postulated the existence of **truth and ideas a priori** to experience while empiricism argued that ideas are constituted only through **experience and hence are subject to change**.
- **Immanuel Kant** argued that we are not able to know **things as they really are in themselves** (*noumena*) butonly as **appearances** (*phenomena*). According to Kant, human knowledge is a process that relates to both **perception** and **understanding**.
- **Friedrich Hegel** pointed out the **historical and evolutionary character** of knowledge.

The distinction between **absolute or objective knowledge** and **subjective or practical knowledge** has been maintained throughout the history of science and can still be found today, albeit with nuances.

Karl Popper argues that there is knowledge in the **subjective sense** consisting of **dispositions and expectations**, but that there is also **objective knowledge** consisting of **linguistically formulated expectations submitted to critical discussion** (Popper 1981, p.66).

Karl Mannheim (1952) sees knowledge as **cognitive reality**, comprising **intellectual standpoints and facts**.

In a similar vein, **central sociology figures** like **Emile Durkheim** (1972), Alfred Schütz (1964) and Robert Merton (1946) conceive of knowledge as **fundamental ideas and categories of thought**.

Michel Foucault (1972) underlines the **inter-subjective and discursive character of knowledge** as well as the role of knowledge in the **exercise of societal power**.

For Niklas Luhmann knowledge is cognitive stylised sense (Luhmann 1990). **Action-related knowledge** (Mohr 1999) and **narrative knowledge** (Lyotard) have been added to **the classical philosophical distinction between scientific-technical and practical knowledge**.

Different conceptions or understandings of knowledge **arising out of different disciplines** – ranging from **engineering** to **ethics** and **communication theory** – often relay sub-types or specific expressions of either **subjective or objective knowledge** at the **interface between human actors and social structures**.

Another by now classical distinction is **the difference between 'knowing that' and 'knowing how'** (Ryle 1949) that has also been envisioned as the distinction between **declarative (fact-based, static) knowledge** and **procedural (dynamic) knowledge** (Baumgartner 1993). **Michael Polanyi** (1958) **distinguished between implicit/tacit** (based on experiences, learning) **and explicit/focal** (formalised, documented) knowledge, arguing **"we know more than we know how to say"** (Polanyi 1958, p.12). Recently it has been suggested to add **visual knowledge** to the distinction between implicit and explicit knowledge (Pöppel 2000).

The **distinction between explicit and implicit knowledge** is also often seen to apply to the level of organisations. **Organisational, institutionalised knowledge** is stored in anonymous rule systems, artefacts, routines, patterns and practices that are **independent from single individuals** (Willke 2001, Argyris/Schön 2001, Etzioni 1971, Sveiby 1997).

Yet, equally important for organisations is **the know-how of its employees**, which is often much more implicit or tacit (Nonaka and Takeuchi 1995, Choo 1998, Boisot 1998). **Intellectual human capital** is a central element of **so-called knowledge (intangible) assets** but it is much more difficult to measure or benchmark than routine practices.

Another key distinction in the sociology of knowledge is that **between everyday knowledge and expert knowledge**. What distinguishes the two and contributes to making knowledge a commodity value that in specific forms **is accessible only to some or the few** and as such represents power is **"incremental" knowledge** (Stehr 2003). **Experts are necessary for transferring ideas from one domain to another and for translating knowledge into action or subjective knowledge into objective knowledge**. This is at the same time a **process of rationalisation and/or bureaucratisation** with both positive and negative effects (Gouldner 1976, Crozier 1963). The resulting **increasing dependence of modern societies on experts does not necessarily go hand in hand with an increase of trust vis-à-vis expertise and scientific knowledge.** The opposite indeed can be the case (Luhmann 1997, Mazur 1973, Nelkin 1975).

Knowledge as a key characteristic of contemporary society

Expert knowledge does not remain permanently expert knowledge and as such the ownership of only the few. **One key characteristic of modern societies has been the ever-wider diffusion of knowledge within societies** and its appropriation by **politicians and lay persons** alike. **The increasing 'knowledgeability' of many actors** is one characteristic aspect of our contemporary knowledge-based societies.

Another key aspect of knowledge-based societies is their increasing dependence on knowledge in terms of the internal management of economic and social processes and their drive towards the **creation of new forms of knowledge** (Lane 1966, Machlup 1962, Drucker 1969, Richta 1969, Stehr and Ericson 1993, Stehr 1994, 2001, 2003, Knorr Cetina 1999, Fuchs and Hofkirchner 2003). **The emergence of the knowledge-based society is a multi-dimensional shift that involves the rise of knowledge as strategic resource in all societal spheres**.

Related *economic concepts* are e.g. the **post-capitalist society** (Drucker 1994), the **post-industrial society** (Bell 1976), the knowledge order (Spinner 1994), the age of symbolic analysts (Reich 1991), the **information economy** (Porat 1977), the labour society (Offe 1984), **digital capitalism** (Glotz 2001), the activity society (Mutz 1997), the **professional society** (Perkin 1990), and information capitalism (Schiller 1981). These economic concepts stress aspects of knowledge-based production.

***Technological concepts* are e.g. the information society** (Lash 2000, Freeman/Perez 1988, Freeman/Soete 1994, Toffler 1980), the **media society** (Postman 1992, 1995), the **virtual society** (Bühl 1997), and the **network society** (Castells 1996). **These technologically oriented approaches conceive the knowledge-based society as a society that is based on new technologies**.

Anthropological concepts include the **flexible society** (Sennett 1998), and the **global brain** (Stonier 1992, Russell 1991). They stress **a close relationship between the human being and technology** whereby the human body is transformed by technology and integrated into technological networks.

***Political concepts* include the civil society** (Beck 1999, Dahrendorf 1997), **reflexive modernity** (Giddens 1990), the **polycentric society** (Willke 1996), and the **post-fordist society** (Lipietz 1987, 1992). **They stress the emergence of new knowledge-based forms of regulation.**

Socio-cultural concepts include the **knowledgeable society** (Lane 1966), the area of simulation and hyper-reality (Baudrillard 1983), the disintegrating society (Heitmeyer 1996), the **dynamic society** (Mayntz 2000), the experimental society (Schulze 1992), the functionally differentiated society (Kneer/Nollmann 2000, Luhmann 1985), the multi-optional society (Gross 1994), the **fragmented society** (Honneth 2000), the **postmodern society** (Lyotard 1979, Inglehart 1997), the risk society (Beck 1986), the **transcultural/ multicultural society** (Welsch 1999, Leggewie 1996), the transparent society (Vattimo 1994), and the **responsible society** (Etzioni 1991). **These cultural concepts stress the transformation of fundamental values and the increasing importance of symbols and sign systems**.

Even though all of **the above concepts that have emerged in parallel with the notion of the knowledge society** or are subsumed under the latter are undoubtedly related, they are also distinct in specific ways that are worth investigating further. Thus, **according to Stehr (2003), a knowledge-society differs from the information society in that the latter relies more on codified knowledge and the flow of the latter while the former lays more emphasis on the active process of knowledge production, use and diffusion.** Even though such distinctions are difficult to draw and to sustain in discourse about modern societies, the societal models underlying these two ideal types are quite different in the role they foresee for the citizen and the expert and, hence, forms of economic and social (re-)production.

Knowledge policies and politics

The increase of the symbolic and real power of knowledge along with the diffusion of several new forms of knowledge **raises anew the question of monitoring or controlling the (negative) social impacts of new knowledge and technology**.

Biotechnology, in particular, **has raised deep questions in bioethics**, the answers varying across cultural and civilizational givens. Stehr (2003) has coined the term knowledge policies and politics to refer to this emerging new field.

Biotechnology and biomedicine are the areas currently closest associated with **societal endeavours to contain and control new forms of knowledge in view of ethical concerns** or because **the middle- and long term effects of this new knowledge cannot yet be established**.

However **there are many other areas, including cognitive science, meteorology and pharmaceutics, which may necessitate some controlling, not least in view of the potential military applications of related technologies**. What forms such controlling mechanisms may take, what their implications might be in terms of science or research policy and how effective they turn out to be remains to be seen.

Knowledge management In the economic realm, the increasing importance of knowledge in modern societies has given rise to a new field of activity and research, namely knowledge management. **Knowledge management has been defined broadly as that process through which organisations / regions / countries generate value from the intellectual and knowledge-based assets**.

This new field of research includes both **measurement approaches** (for measuring knowledge-based assets or intellectual capital at different levels) as well as **approaches – largely driven by ICT – for using technologies to share knowledge across institutional and spatial boundaries**. Much of the related research is concerned with **finding ways to measure but also to codify know-how or tacit knowledge** (Abecker 2002, Bach 1999, Borghoff 1998, Bornemann 2002, Bürgel 1998, Finin 2001, Fuller 2002, Golshani 1997, Götz 2002, Haun 2002; Holsapple 2003, Jung 2000, Liebowitz 1997, 1999; Morey 2000, Myers 1996, Oluic-Vucovic 2001, Reinmann- Rothmeier/Mandl 2000, Rollett 2003, Roy 2001, Willke 2001).

Knowledge discovery based on finding useful patterns in data has been called **data mining, knowledge extraction, information discovery, information harvesting, data archaeology and data pattern processing** (Jurisica 2000). Knowledge discovery is sometimes nudged by metaphors drawn from other disciplines or from metaphors and knowledge elements drawn from other cultures or civilizations (Turner 1987, Rothbart, 1984, Goonatilake 1999).

Knowledge management is believed to contribute to collective intelligence and learning capabilities through its emphasis on sharing (Levy 1997, 1998, 2001). Knowledge management as a new field of research but also a paradigm of thinking about knowledge has not been uncontested within the social sciences.

There is a tendency within at least parts of the knowledge management field to reduce 'knowledge' to an object of management, **treating it as raw material to be cultivated rather than as a (public) good to be produced and provided as a service** (Fuller 2002). This critique has been particularly relevant against the background of recent university and research policy reforms in several countries.

MODELS OF KNOWLEDGE AND SYSTEMS OF GOVERNANCE

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1. INTRODUCTION

The economics of knowledge has gradually emerged as a discipline in a context characterized by a sharp evolution of the analysis as well as of the basic foundations. Such an evolution has made it possible **to increase substantially our understanding of the economic characteristics of the generation and use of knowledge in the economic systems**. Its evolution is the consequence and the cause of much change in the economic **understanding of technological change** and more generally in the **new thinking about economic growth.** This work provides an analysis of the changing foundations of the economics of knowledge and of their effects upon the assessment of the design, the characteristics and the performances of the institutions and processes that shape the generation and distribution of technological knowledge. The ongoing debates on science and technology policy often reveal that inappropriate analytical conceptions can lead to significant errors in terms of institutional design.

2. KNOWLEDGE AS A PUBLIC GOOD

The seminal contributions of Kenneth Arrow and Richard Nelson have marked for more than twenty years the economics of knowledge, since the late 50s. The Arrovian frame shaped the debate about the economic organization for the supply of knowledge and provided the theoretical foundations for the build-up of the public knowledge commons.

n the Arrovian approach technological knowledge was seen as a public good for the high levels of indivisibility, non-excludability, non-exhaustibility, non-appropriability and hence non-tradability. In this context markets fail to provide the necessary coordination and the case for undersupply takes place. **Markets are not able to provide the appropriate levels of knowledge** because of the lack of incentives, and the opportunities for implementing the division of labor and hence achieving adequate levels of specialization (See table 1 for a synthesis of the main arguments).

The public provision of technological knowledge, and especially scientific knowledge has long been regarded as the basic remedy to under-provision. This led to the actual build-up and the systematic implementation of public knowledge commons. The legacy of patronage, such as universities and other public research centers received new endorsement and support (Arrow, 1962; Nelson, 1959).

The key role of the public knowledge commons, based upon the public funding of universities and other public research centers was also **consistent with the top-down view about the generation of technological knowledge**. In **the linear approach** in fact technological knowledge was the eventual result of the application of new scientific discoveries. In the linear model a clear division of labor could be articulated between the role of universities and corporations. **Universities and public research centers** were better equipped to perform scientific research. The eventual application of scientific discoveries for the actual generation of technological knowledge and the introduction of technological innovations was instead assigned to **corporations**.

The **provision of public subsidies to firms** undertaking research and development activities was regarded as a necessary condition to remedy the low appropriability conditions and hence the lack of incentives.

Public procurement was the third basic tool to increase the production of knowledge. The demand for weapons especially was regarded as a major instrument to focus resources and identify research direction and objectives with a broader and general scope for derivative technological applications at the system level and relevant from the viewpoint of the general production of new scientific and technological knowledge. The natural leakage of technological knowledge from the **military sector** - often within the same corporations – was expected to feed the levels of technological opportunity for the rest of the system.

The Arrovian approach was consistent with **the neoclassical views about the exogeneity of technological change**. New scientific discoveries and eventual advances in technological knowledge could not be regarded as the endogenous product of economic decision making, but as **the result of a sphere of human activity that could not be approached with the tools and the instruments of economic analysis**. Actually the Arrovian approach provided good economic foundations to the neoclassical assumptions about exogeneity. The limitations of knowledge as an economic good were such that **economics could not provide basic assistance in understanding the process** by means of which scientific knowledge was produced.

The notion of technological opportunities easily integrated also into the **Schumpeterian legacy** according to which the **large corporation with substantial market power was the appropriate institution** to accelerate the rate of introduction of technological change stemming from new technological opportunities.

Because of the low levels of natural appropriability, **financial markets perform poorly** in providing the necessary amount of external funds to firms undertaking research activities. Financial markets and **specifically banks are most likely to ration the credit to innovation** both because of radical uncertainty and low appropriability. Even when a research project finally generates a new bit of knowledge, the risks that the inventor, and hence the banker who provided the funds, is able to reap the benefits are put at stake by non-appropriability. **Non-appropriability leads to non-fundability** (Stiglitz and Weiss, 1981).

Nelson (1959) stresses **the positive role of large corporations for their higher scope of action across product markets.** High levels of **unpredictability of the results of research activities** and even lower levels of predictability about the specific applications of the new knowledge characterize the production of knowledge. **Large firms can better exploit the results of scientific and technological knowledge by means of diversification strategies** in markets where the knowledge generated happens to command larger rewards.

From this viewpoint the notion of **barriers to mobility**, introduced by Caves and Porter (1977), is especially relevant. **Large corporations, as incumbents in adjacent markets, have much lower barriers to mobility across product markets**.

The foundations of **the well-known Schumpeterian trade-off between static and dynamic efficiency** are laid down in this context. **Monopoly reduces static efficiency,** but makes it possible, via extra profits and **increased ex-post appropriability based on barriers to entry and hence imitation**, the **dynamic efficiency** engendered by the increased amount of knowledge generated and hence the augmented flow of innovations.

KNOWLEDGE AS A PUBLIC GOOD (TABLE 1)	
CHARACTERISTICS	**NON-APPROPRIABILITY** **NON-EXCLUDABILITY** **NON-PREDICTABILITY OF RESULTS AND APPLICATIONS** **NON-RIVALITY IN USE** **NON-DIVISIBILITY** **NON-EXHAUSTIBILITY** **NON-TRADABILITY** **NON-FUNDABILITY**
PROCESSES	**DEDUCTIVE PROCESS** **LINEAR SYSTEM** **TOP-DOWN** **RESEARCH&DEVELOPMENT**
CORPORATE GOVERNANCE	**LARGE CORPORATION** **EX-ANTE BARRIERS TO ENTRY** **INTERNAL FINANCIAL MARKETS**

POLICY DOMAIN	**KNOWLEDGE COMMONS** **PUBLIC PROCUREMENT** **PUBLIC SUBSIDIES** **NARROW SCOPE PATENTS** **NATION STATE**
LIMITATIONS	**POOR INCENTIVES** **LOW TRANSPARENCY** **POOR ALLOCATION** **POOR MONITORING** **POOR DISSEMINATION** **INTERNATIONAL FREERIDING**

The **creation of intellectual property rights was regarded as a complementary institutional set-up**, parallel to the public provision of scientific knowledge and the benign neglect to monopolistic market power.

Patents and copyrights reduce non-excludability and non-appropriability. In a proper institutional design, **intellectual property rights may also favor tradability** and hence lead to higher levels of specialization and division of labor in the technological applications of new scientific discoveries, made possible by the public support. Intellectual property rights can help increasing the incentives to the production of incremental technological knowledge, but only in a broader context shaped by the role of the State (Kingston, 2001).

At this time in fact intellectual property rights are not considered as the major tool to improve the static and dynamic efficiency of the economic system in the production of knowledge. Patents are mainly viewed as an instrument designed to increase the incentives of firms to introduce minor technological innovations.

Public subsidies, public direct participation in the production and demand for knowledge are regarded as the basic instruments to push the introduction of radical technological innovations (Machlup and Penrose, 1950; Alchian and Demsetz, 1973).

3. KNOWLEDGE AS A PROPRIETARY GOOD

The first major shift in the economics of knowledge takes place when the notion of knowledge as a public good is challenged and **knowledge is regarded as a quasi-private good with higher levels of natural appropriability and exclusivity** (Nelson and Winter, 1982). In this new approach, **the distinctions between science and technology are blurred** and the traditional sequence is actually reversed. Scientific knowledge can be considered as the ultimate result of **an inductive process of articulation and codification of knowledge originated in a tacit form and acquired by means of learning processes.**

Here **the work of Polanyi** becomes a basic reference. **The distinction between tacit and codified knowledge** provides in fact the foundation to the new approach to technological knowledge (See table 2 for a synthesis of the main arguments).

Tacit knowledge is the result of learning processes: it is not easy to articulate it and to make it explicit. It cannot be shared and applied outside from its original 'locus' of generation. The eventual articulation makes generalization possible. **The final end-outcome of a bottom-up process of systematization and generalization is the full codification and hence the generation of scientific knowledge.**

Scientific knowledge follows technological knowledge rather than preceding it. **Knowledge emerges out of the inductive process of abstraction and generalization rather than from the deductive process of application of general ideas to specific circumstances.**

Because **technological knowledge is now viewed as the sticky joint product of internal learning**, it cannot spill freely in the air: **appropriability is de-facto secured by high levels of stickiness in routines and procedures**.

Relevant **absorption costs for potential users** should be taken into account and qualified **interactions between producers and users of new knowledge are necessary** for technological knowledge to be actually transferred from one organization to another. **The explicit and intentional assistance of original knowledge holders to perspective users is relevant**, if not necessary.: **the notinvented- here syndrome** is much more effective than assumed in the public good tradition (Mansfield, Schwartz, Wagner, 1981; Von Hippel, 1988; Harabi, 1995).

The theory of the firm is deeply affected by the new approach. The **accumulation of competence, technological and organizational knowledge** and the eventual **introduction of technological and organizational innovations** are now considered the essential role of the firm. **The firm does not coincide with the production function and cannot be reduced to a production function.** From this viewpoint **the firm precedes the production function**: the technology is in fact the result of the accumulation of knowledge and its application to a specific economic activity.

Edith Penrose marks an important contribution to implementing this approach with the identification of the sequence of **developing new knowledge as a resource**, **conceiving of new services** which it could deliver **and imagining new productive opportunities**. In so doing Penrose provides **a direct link between the notion of learning and the emergence of novelty within firms** (Penrose, 1959).

The resource-based theory of the firm focuses the attention on the characteristics of the process of accumulation of competence, the generation of technological knowledge and the introduction of technological and organizational innovations, not only as key factors to **understanding the firm, but also as the system**.

In this context **the firm is the primary, if not the single, actor in the production of knowledge for the whole economic system.** The firm is viewed as the privileged locus where technological and organizational knowledge is generated by means of **the integration of learning processes and formal research and development activities**. **Firms, especially large corporations, are considered, in this approach, primarily as a depository and a generator of competence and eventually knowledge (Chandler, 1990).**

The new growth theory builds upon **the new appreciation of de-facto appropriability arguing that the economic rents of knowledge can be substantially appropriated**, at least to such an extent that **firms can fund correct levels of research and development expenditures.**

According to much new theorizing, the characteristics of knowledge are no longer regarded as conducive to market failure. **Markets are able to allocate viable amounts of resources to fund the generation of knowledge.** The optimum however cannot be identified by market forces (Romer, 1986; Aghion and Tirole, 1994).

On a parallel and complementary ground, **evolutionary theory stresses** not only the role of the firms as the locus of accumulation and generation of technological knowledge, but also **the market place as the proper selection mechanism**. The selection in the market place among **competing bits of knowledge and related innovations** that impinge upon them **makes it possible to fully endogenize the rate and the direction of technological knowledge. The supply of knowledge and its selection can be considered as two different and yet related steps.**

In this context, **intellectual property rights play an important role** to create the institutional conditions to secure appropriability and hence to increase the levels of incentives to fund research activities by firms. **Intellectual property rights, if properly designed, may also favour tradability and hence lead to higher levels of specialization and division of labour.**

Trade in knowledge is now regarded as a major opportunity to achieving **the well known advantages of market coordination in terms of division of labour, specialization and selection**. A huge literature explores the evidence about **the growing flows of trade in patents and licences both in international and domestic markets** (Geroski, 1995; Arora, Fosfuri and Gambardella, 2001).

The new approach is also fed by **growing concern about the limitations in the governance of the model based upon the knowledge as a public good.** In that context, in fact, such issues as the criteria for the allocation of resources, the methodology for the correct monitoring of their use and the assessment of their results were missing. **The case for 'government failure'** is now applied to science policy as well: the risks of government failure **in selecting, conducting and funding research activities** are now regarded as non trivial (Buchanan, 1965).

Fundamental questions were left without an answer and even worse without a methodological clue to address them. How should the levels of public funds to scientific activities be fixed? **How should they be distributed among universities and scientific disciplines?** How should they be delivered? How the results of the public funding should be assessed? (Kealey, 1996). The dissemination of the results of the scientific research were left to publications in scientific journals and the hiring of PhDs from the business community with **little understanding of the problems of scientific dissemination and of the serious limitations to the spontaneous communication of the new scientific discoveries to the community of potential users**.

The perverse effects of international free riding have been much emphasized. The international uncontrolled leakage and spillover of technological knowledge would benefit the technological strategy of laggard countries based upon fast imitation and re-engineering. A closer look to the working of the public commons and the actual need to put under scrutiny the productivity of the resources invested in the public knowledge commons, both at the system and the single units level, is advocated.

The general reversal of policy emphasis –which gained consensus in the 90s- from the role of public policy to the privatization of public provision inspired by the swing from the presumption that governments cam do everything that markets do and more besides to the **new presumption of market efficiency, associated with rational expectations, together with the new theory about knowledge as a proprietary quasi-private good** provided theoretical support to a new - problematic- understanding upon the role of public research.

As a consequence, **a wave of privatizations has been taking place**: **Universities have been pushed to enter the markets for knowledge and knowledge outsourcing**. The new enclosures substitute the knowledge commons. Public research centers and Universities were **solicited to patent their discoveries** and often forced to **enter the markets for the technological outsourcing of large corporations**. The conditions for the effective appropriation of knowledge are enforced both at the firm level and in public organizations: **the mobility of human capital is more and more regarded as a sensitive issue** (Geuna, 1999: Geuna, Salter and Steinmueller, 2003). **Academic patenting and scientific entrepreneurship have been praised as new effective tools** to stimulate the distribution of knowledge and to increase the incentives to its production. Much analysis has been carried out on **the regional aspects of the interplay between the research system and the business community**: geographical distance has proved a relevant factor in this context (Feldman, 1994 and 1999; Audretsch andStephan, 1996; Audretsch and Feldman, 1996; Geuna, 1999).

The large corporation firm and its evolution into the global corporation emerge as the most appropriate tool to **foster the levels of access to scientific knowledge** and the rate of accumulation of technological knowledge by means of the **capability to combine the selection of a few sites worldwide for the location of research facilities** with a **portfolio of production and commercial activities scattered in the global economy**. The global corporation is able, at the same time, to generate and disseminate technological knowledge by means of **the powerful internal markets, into which the international transfer of technological knowledge can take place** with reduced risks of dissipation and opportunistic behaviour. Enhanced internal tradability favours the division of labour and makes it possible to reap the benefit of specialization (Cantwell and Iammarino, 2003)

Special attention is paid to the opportunities provided by financial market as an institution for the exchange of property rights of new innovative companies. The role of IPO (Initial Public Offerings) as a way to convey financial resources into new ventures and at the same time to assess and select the choices of venture capital receives much attention (Gompers and Lerner, 2003). **This evolution of financial markets marks a major shift with respect to the traditional emphasis on the limits of financial markets**. **In the previous approach the stock exchange did not play a role** and only credit was considered. Bankers were supposed to be reluctant in providing credit to risky ventures based on research activities and innovation.

The **case for credit rationing emerged as a major problem to fund innovation activities**. In turn, **targeted credit rationing in financial markets stressed the role of internal financial markets** and extra profits to fund internally research activities that bankers could not properly fund because of the lack of instruments able to generate and assess the necessary information on the risks and the eventual payoff of investments in research activities (Stiglitz and Weiss, 1981).

The new emphasis on the working of financial markets as an effective and efficient tool to provide funds to innovative undertaking leads to a new assessment about the role of **scientific entrepreneurship**. Scientific entrepreneurship grows into a fully-fledged new viable mechanism to incentive, generate and disseminate technological knowledge in economic systems (**Etzkowitz, 2002**).

The role of new science-based firms as converters of technological opportunities, available in science rich environments, such as Universities and large corporations, into actual market experiments is now better recognized. The **dynamics of spin-off from research laboratories and the supply of funds and managerial competence by venture capitalists** are now regarded as complementary tools for the eventual creation of new science-based firms. Next to the size of firms, new attention is given to their age.

The complementarity between new and small and large firms is now advocated: small startups are seen as the best way for new technologies to enter the market place. **Eventual mergers and takeover by larger firms will lead to the integration and dissemination of the new technologies into larger corporations. Scientific capitalism** is based upon **scientific entrepreneurship**, effective intellectual property rights systems, academic patenting, venture capitalism, initial public offering and financial institutions, including dedicated stock exchange systems (Nasdaq) where the new ventures can be assessed and possibly recombined with existing companies, by means of mergers and acquisitions. Technological knowledge can flow within the economic system embedded in new companies. But, once again, the trade-off between static and dynamic efficiency emerges.

KNOWLEDGE AS A PROPRIETARY GOOD (TABLE 2)	
CHARACTERISTICS	**-FROM TACIT TO CODIFIED** **-STICKINESS** **-LIMITED APPROPRIABILITY** **-MODULAR DIVISIBILITY** **-FUNDABILITY BY PRIVATE EQUITY** **-LIMITED TRADABILITY**
PROCESSES	**INDUCTIVE PROCESS** **BOTTOM-UP** **LEARNING** **SPILLOVER AS A FREE GOOD**
CORPORATE GOVERNANCE	**-GLOBAL COMPANIES** **-FINANCIAL MARKETS:VENTURE CAPITAL + IPO+ M&A** **-KNOWLEDGE OUTSOURCING** **-MARKETS FOR KNOWLEDGE** **-UNIVERSITY AS A KNOWLEDGE SERVICES SUPPLIER**

POLICY	**-PRIVATIZATION OF THE KNOWLEDGE COMMONS** **-STRONG&BROAD IPR**
DOMAIN	**GLOBAL MARKETS**
LIMITATIONS	**-KNOWLEDGE TRADE-OFF** **-EXCLUSION** **-CONCENTRATION**

4. KNOWLEDGE AS A COLLECTIVE AND COMPLEX DYNAMIC PROCESS.

4.1. THE DISCOVERY OF THE KNOWLEDGE TRADE-OFF

The new approach is based upon the **re-discovery through the 90s of external knowledge as an essential intermediary input in the production process of new knowledge**.

The discovery of external knowledge, available not only by means of transactions in the **markets for knowledge**, but also by means of **technological interactions**, marks a new important step in the debate. **External knowledge is an important input in the production process of new knowledge**.

This major progress is made when the special character of **knowledge as a non-exhaustible good that is at the same time an output and an input into the production of other knowledge is grasped and retained at the core of the analysis**. Here the derivation from the Arrovian notions of the non-excludability and non-divisibility of knowledge is clear (Griliches, 1992; David, 1993; Cooke, 2002).

The core of the new analysis is now centered upon the **exploration and identification of the conditions into which external knowledge**, as an essential input in the production of new knowledge and new technologies, **is effectively disseminated in the economic system**.

This line of enquiry contributes the **founding of the systems of innovation approach**, where **the production of knowledge is viewed as the result of both knowledge transactions and the cooperative interactions, mainly rooted in regional space, of agents undertaking complementary research activities.**

The focus is now more and more centered upon **the analysis of the mechanisms of governance of the broad array of knowledge interactions among agents**, including coordinated division of labor and market transactions, and **their effects in terms of generation and dissemination of new knowledge**.

An **array of specific institutional arrangements emerges eventually as indispensable** conditions that are **necessary for the trade of such a idiosyncratic and heterogeneous good** to take place in order to handle the difficulties in understanding and using the differentiated set of new knowledge modules supplied in the markets place (Menard, 2000; Guilhon, 2004).

Regional economic contributes significantly the new approach highlighting effectively **the role of geographic space in the distribution and circulation of knowledge and at the same time regional analysis is deeply affected by the new understanding of knowledge as a way to understand the role of geographic space (Feldman, 1994).**

Here in the economics of knowledge **the issues of externalities on the demand side** become relevant and evident. The generation of technological knowledge is now characterized by relevant end actually necessary **externalities, both technical and pecuniary**. The notion of **user-interdependence** makes its foray into the scene **when agents value the levels of usage of other agents of certain goods** (Von Hippel, 1988).

As far as scientific and technological knowledge is concerned, **interdependence among users, hence on the demand side, is very strong**. The actual chances of **generating a new relevant bit of knowledge for each agent depend upon the levels of accumulation of skills and competence, education and access to information of the other agents in the community.** The evidence especially in new information and communication technologies confirms that **proximity matters in assessing the rates of introduction of innovation** (Foray, 2004).

An important contribution to understanding the role of external knowledge is provided by **an extension and implementation of the approach based upon learning processes**. The competence and experience that is necessary to innovate is acquired **not only in the repeated usage of a given set of capital goods and intermediary products and in the production of well-identified products**.

Also **the experience accumulated in marketing and interacting with a well-defined set of consumers and competitors in a limited range of products, is necessary** in order to generate new knowledge and eventually introduce new products. **Interactions between users and producers are a primary source of tacit knowledge about the actual needs and preferences of customers** (Lundvall, 1985). No successful product innovation can be effectively and successfully introduced without some **dedicated competence about the market place**. **The distance, in the product space, from the products being traditionally delivered to the market place,** can be considered a strong factor of increasing innovation costs and decreasing efficiency in the generation of innovations.

The amount of external technological knowledge, available in a given context, industrial, technological or regional, **and its conditions of accessibility and proximity**, becomes an important endowment, as well as the conditions of access to it and the characteristics of the relational set-up.

The issues of the distribution of knowledge become central in the debate and the notion of an actual knowledge trade-off is articulated. **Uncontrolled leakage and low appropriability regimes reduce incentives, but may not necessarily lead to under-provision. Low appropriability engenders technological externalities and spillovers that are the prime factor in increasing the efficiency of generation of new knowledge, at the system level**: the growth of efficiency can compensate for lower inputs (Griliches, 1992).

The advantages of the intellectual property rights regime, in terms of increased incentives to the market provision of technological knowledge, **are now balanced by the costs in terms of delayed usage and incremental enrichment.** The vertical and horizontal effects of indivisibility display their powerful effects in terms of cumulability.

Indivisibility of knowledge translates into the **basic cumulative complementarity among bits of knowledge**. **Complementarity and cumulability in turn imply that new bits of knowledge can be better introduced building upon other bits already acquired, both in the same specific context and in other adjacent ones. The access exclusion from the knowledge already acquired reduces the prospect for new acquisitions** and in any event has a strong social cost in terms of duplication expenses (O' Donoghue, 2001).

The costs of exclusion associated to intellectual property rights, as a consequence, should be taken into account. **Monopolistic control of relevant bits of knowledge,** provided both ex-ante and ex-post by patents and barriers to entry in the products markets respectively, **can prevent not only its uncontrolled leakage** and hence its **dissemination** but also **further recombination**, at least for a relevant stretch of time (Arrow, 1969; David, 1993).

Intellectual property rights are now questioned as it seems evident that too strong a regime of protection mayhave positive effects in terms of increased incentives to the generation of knowledge, but **has clearly negativeeffects in terms of delayed and slower circulation and distribution of the new knowledge available**(Mazzoleni and Nelson, 1998). Murmann (2003) provides **a fascinating account of the perverse effects of the patenting strategy** pursued by Bayer on the technological development of competitors. **The duration of exclusive property rights assigned by patents and the conditions for their renewal**, become a central issue for the possible negative drawbacks in slowing the rate of generation of new knowledge, **especially when general purpose knowledge with a wide scope of applications is concerned** (Scotchmer, 2004).

The breadth of patents is also questioned: when the breadth is large, the protection is not specific and the negative effects in terms of foreclosure can easily exceed the advantages in terms of increased incentives. **A narrow definition of the scope of application of intellectual property rights is thus recommended** (Scotchmer, 2004).

The understanding of the knowledge trade-off contributes **the parallel development of a systemic approach** to the understanding of the economics of technological change. In this approach **the characteristics of the regional, industrial, professional and national systems** play a major role in determining the rate and the direction of technological change. **Technological knowledge is endogenous to the system into which each agent is rooted.**

4. 2. LOCALIZED TECHNOLOGICAL KNOWLEDGE

Technological knowledge is now viewed as **the outcome of the localized interactions of a variety of learning and heterogeneous agents**, able to learn and to establish network relations, although in a limited range of activities, rooted **in a limited technical and product space** where each firm has accumulated competence by means of process of learning by doing and by using (Atkinson and Stiglitz, 1969; David, 1975; Antonelli, 1999, 2001) (See table 2 for a synthesis of the main arguments).

The retrieval of the Austrian tradition, as articulated by Hayek (1945) about the **dispersion of knowledge** and **the complementarity of the bits of knowledge** possessed by each agent as a key characteristic of economic systems, even in static conditions where technological change is not considered, contributes this line of analysis.

Technological knowledge is now viewed as dispersed and fragmented into a variety of specific and idiosyncratic applications and contexts.

Yet **the variety of agents and of their competence is crucial for generating new knowledge**. This view **contrasts sharply the centralized and top-down understanding of knowledge** built around the Arrovian tradition.

Firms are viewed as creative agents, who are not limited to adjusting prices to quantities and vice versa. **They are also able to learn and change their technology, as well as their strategies**. **When actual market conditions do not match the** plans and irreversibility and limited knowledge make sheer technical substitution expensive, firms are induced to introduce technological innovations. **The generation of new technological knowledge is activated.**

The search for new knowledge takes place locally in the close surroundings of the existing activities bounded by relevant switching costs: the tacit knowledge accumulated by means of learning process **is eventually valorized and articulated both internally and externally by means of network relations.** More generally the generation of new technological knowledge is the result of **four specific activities**: a) **learning, b) socialization, c) recombination and d) research and development**, where both general the process and **each activity is localized by the effects of bounded rationality and proximity.**

These activities are complementary and none can be disposed of. A limited substitution can take place among them. **In the localized technological knowledge approach**, firms generate new knowledge relying on **both external and internal knowledge as complementary inputs**. Essential inputs of tacit, codified, internal and external knowledge **all enter into a multiplicative relationship within the knowledge production function**. External knowledge is strictly necessary to generate new knowledge both when it concerns the same module of knowledge and **when it belongs to other knowledge modules**: **intra-technological and inter-technological flows of knowledge are both necessary**, in varying levels according to the character of the knowledge being generated whether mainly analytical or synthetic (Laestadius, 1998). In some cases, substitution between the four different knowledge inputs is possible, but only above minimum thresholds2.

Learning agents are scattered in space and each possesses a bit of knowledge. In turn **high levels of potential complementarity characterize such bits of knowledge**. **The localized context of learning and action affect the chances of generating new technological knowledge because of the key role of external knowledge as an in disposable input**. For the same token the similarity and alignment of individual learning processes play an important role in the collective undertaking that leads to the generation of new knowledge: **dynamic coordination becomes a central issue** (Richardson, 1972).

2 This approach differs from that of Nonaka and Takeuchi (1995) also shared by Cowan, Foray and David (2000) according to which **tacit knowledge eventually coverts fully into codified knowledge**. On the opposite it is argued here that tacit knowledge remains an essential and non-disposable input which can be never fully codified.

Because of bounded rationality and switching costs, proximity matters in many different ways. Proximity matters in regional space, as well as in technical, professional and industrial space. Proximity of firms to large research laboratories, and academic centers, is now regarded as a vital condition for the successful introduction of new technologies. Proximity in product space matters as the prime source of information about the tastes of customers and their potential interests. **Proximity matters in the product space** as a factor, which makes the acquisition of information and eventually knowledge easier with respect not only to the habits and preferences of customers but also to the capabilities of competitors and their strategic attitude. **The introduction of product innovations in market niches that are far away from the source of the experience of each firm is put at risk by the lack of specific competence and relevant, additional costs should be recognized** (Boschma, 2005).

Variety is the second key factor in enhancing the chances of generation of new knowledge. **Too much cognitive proximity among learning agents can affect the capability of the system to engender successful innovation**. **Variety of complementary competence** is key in assessing the innovation capabilities both at the firm and the system level (Nooteboom, 2000).

The key distinction between receptivity and absorptive capabilities as distinct from **the strength and intensity of the message** plays a key role in this context. **The topological structure of economic systems** from the viewpoint of **the knowledge communication flows and interaction networks receives much attention**: the structure of the communication channels is analyzed and **the organization of communication flows within the networks** of relations appreciated (Cohen and Levinthal, 1990).

The role of communication and transmission of knowledge is more and more appreciated. Communication theory is applied successfully to the analysis of knowledge communication processes. **The density of communication channels and their duration are considered as relevant structural elements of an economic system**.

The role of business interactions is now appreciated from the viewpoint of their communication role.

Prices, of course, are no longer viewed as the single vectors of all relevant information for economic decision making. Next to prices in fact, vital information is transferred and contributes the generation of knowledge by each economic agent. **The communication of bits of knowledge in other words is not considered as obvious and spontaneous,** but on the opposite, it is viewed as the result of **intentional efforts both in terms of connectivity and receptivity. Systems differ with respect to the speed and capillarity of the flows of knowledge communication.** In turn the rate of generation of new knowledge and introduction of new technologies is clearly influenced by the permeability of the system. **Percolation analysis** borrowed from physics and communication theory is introduced in the economics of knowledge so as to provide tools to appreciate the distinctive role of receptivity and connectivity in knowledge communication processes.

According to the acquisitions of the localized approach, the firm cannot be seen as the single actor in the process of generation of new knowledge. The assumptions about the complementarity between internal and external knowledge play a key role in this context. **The variety of firms and learning institutions is most important** in **the generation and circulation of knowledge when the latter is viewed as a collective good, with varying degrees of appropriability, dispersed and fragmented in the economic system**, the result of both top down and bottom up processes, where **learning by doing, learning by using and learning by interacting with suppliers, customers and rivals play an essential role, together with research and development activities** (Antonelli, 1999).

Knowledge is now, more and more, viewed as a collective process activity made possible by the continual efforts of accumulation of the highly differentiated competence and technological knowledge, **based upon localized learning processes** and the eventual introduction of innovations, of **a myriad of heterogeneous and interacting agents rooted in a well defined set of scientific, technical, geographic, economic and commercial circumstances.** The capability to generate knowledge is embedded in a network of qualified relations, limited by **relevant switching costs, bounded rationality and limited information**.

The notion of collective process differs sharply both with respect to the Arrovian tradition of knowledge as a public good and the approach to knowledge as a quasi-private good. **Collective processes in fact are characterized not only by partial appropriability and shared property rights but also by the role of the intentional effort, participation and contribution of each agent.**

Collective knowledge is more than a club good for two important reasons: **first knowledge is an activity, rather than a good,** for the continual efforts of acquisition and implementation it requires and second because of the increasing returns which can take place when and if the **dynamic coordination** of stochastic processes make it possible to **take advantage of potential knowledge complementarities** (Buchanan, 1965; Allen, 1983).

Collective knowledge in other words is a shared activity that can be implemented only by interactive agents that belong to a community of practice and understanding. Collective knowledge pays attention to the consequences of knowledge indivisibility and the role of the complementarity among the localized bits of knowledge possessed by each agent that characterize both the generation and the dissemination of knowledge in the system and value the contribution of external knowledge into the production of new knowledge.

The network structure of knowledge communication networks affects deeply the flows of knowledge communication and hence the actual availability of external knowledge.

There is an array of possible network architectures. **In geodesic networks, i.e. networks where each agent has a direct link to each other agent, communication costs are very high**: the dissemination of new knowledge is hampered by relevant communication costs and by the decay of knowledge spillovers associated with distance and heterogeneity among agents.

Within centered networks based upon many interconnected and hence competitive hubs, knowledge is disseminated far better than in fragmented networks, where only a few links connect scattered clusters or in networks based upon monopolistic hubs able to exert a control upon knowledge flows and to extract rents out of it.

In this context it is clear that **the issue of dynamic coordination of the interdependent activities** of the myriad of complementary learning agents involved and the related **design of network architecture** that shape the flows of communications and the interaction modes, including transactions in the market place, **become most relevant** (Richardson, 1972).

Within knowledge networks localized technological knowledge can be understood as a collective activity characterized by the complementarity between heterogeneous and yet complementary items. **Such complementarity takes place especially between external and internal knowledge** and the **stock of existing knowledge and the flows of new knowledge.** The implications of the indivisibility are reconsidered.

LOCALIZED KNOWLEDGE AS A COLLECTIVE ACTIVITY (TABLE 3)	
FORMS AND CHARACTERISTICS	• **ARTICULABLE** • **DISPERSED & FRAGMENTED** • **MODULAR COMPLEMENTARITY** • **CUMULABILITY** • **COMPLEXITY** • **FUNGIBILITY** • **KNOWLEDGE PATH** • **DEPEDENCE**
PROCESSES	• **INTERACTION BETWEEN INDUCTION AND DEDUCTION** • **COMPLEMENTARITY OF EXTERNAL INTRATECHNOLOGICAL AND INTERTECHNOLOGICAL, INTERNAL, TACIT, CODIFIED KNOWLEDGE** • **RESEARCH** • **LEARNING** • **EXPLORATION** • **COMMUNICATION** • **ABSORPTION** • **RECOMBINATION** • **SOCIALIZATION**

CORPORATE GOVERNANCE	• **KNOWLEDGE NETWORKS** • **EPISTEMIC COMMUNITIES** • **TECHNOLOGICAL DISTRICTS** • **JOINT VENTURES** • **KIBS** • **OUTSOURCING** • **TECHNOLOGICAL PLATFORMS** • **SPONSORED SPIN-OFF** • **PATENT THICKETING** • **VENTURE CAPITALISTS AS KNOWLEDGE PROVIDERS** • **MULTIPLE EXPLOITATION: TO SELL OR TO USE**
PUBLIC POLICY TOWARDS DYNAMIC COORDINATION	• **PUBLIC PROVISION OF FUNGIBLE KNOWLEDGE** • **CREDIBLE ANNOUNCEMENTS ABOUT LONG TERM RESEARCH GOALS** • **INTERFACE AGENCIES** • **KNOWLEDGE AS AN ESSENTIAL FACILITY**

A number of key questions is to be addressed in this context: **whether economic systems are able to generate and implement the perfect network architecture;** whether **spontaneous multitask interaction of heterogeneous agents** active in a variety of markets and embedded in a variety of contexts **can actually lead to the 'perfect' design.**

The difference in the time scale of the flows of knowledge among the agents within the networks of communication channels existing at each point in time and **their duration and the time required for their implementation and incremental construction** becomes a relevant factor in assessing **the emergence of appropriate network structures**.

4.3. KNOWLEDGE AS A PATH DEPENDENT EMERGENT PROPERTY: AN AGENDA FOR A POLICY TOWARDS DYNAMIC COORDINATION

Path dependent complex system dynamics provides a major opportunity to articulate the indeterminacies of the interplay among supply and demand externalities into which traditional economics of knowledge stumbles.

In the localized approach developed so far, **four characteristics of knowledge matter**:

A) at each point in time knowledge is dispersed and fragmented, scattered among a myriad of learning agents;

B) no agent can possess and control all the knowledge available at each point in time; **the complementarity among modules of knowledge possessed by each agent is relevant**: its valorization provides the opportunity to generate new radical advances;

C) proximity among agents is relevant for the complementarity among external and internal knowledge, as well as among the learning efforts of each agent and the modules of knowledge possessed by each agent, to be implemented;

D) finally, and most important, **agents can learn and make intentional efforts to generate new knowledge including intentional strategies**, **based upon procedural rationality, to modify locally, because of switching costs, their position within the knowledge networks**. Such efforts take place when the dynamics of localized technological change exerts its effects and agents need to change their current techniques.

In this context, **the conditions, which characterize the access to external knowledge,** play a key role in explaining the innovation capability of agents within a system.

At each point in time **the topology of agents in the space of knowledge, hence their relative distance and the structure of their relations and interactions are key features of the system**. Accessibility of external knowledge and hence the scope to implement the potential complementarities of the knowledge possessed by each agent **are influenced by the channels and flows of communication in place at each point in time**. So far the typical frame for complex system dynamics is set.

Occasional stimulations -such as the mismatch between plans and actual market conditions and the incentive to introduce localized technological change- **push agents to generate new knowledge**. **In so doing the links in place provide access to external knowledge**. **According to an array of parameters**, such as a) the **existing topology, b)** the **distance** among learning agents, c) the **stock of communication channels in place**, d) their **connectivity**, e) the **receptivity** of co-localized agents and hence f) the **complementarities** of their internal modules of knowledge and the structure of stochastic effects of such relations, **some agents in some regions are more successful than others**. Eventually the process can spread across regions and the full map is finally covered.

Complex system dynamics provides an analytical framework into which our analysis can be accommodated with some qualification. Kauffman (1993) provides a path breaking definition of complexity based upon the **interaction of size and interdependence**, which fits very well in this approach to the economics of knowledge. Kauffman elaborates **a model of complexity** based on two parameters, **N, the number of components comprising a whole, and K, the degree of interdependence among these components.** In this context, **complexity is defined as the number of components of a certain piece of knowledge and the degree of interaction between them**.

In so doing, indeed complexity provides a general context into which **the generation of knowledge can be viewed as a collective process undertaken by a myriad of interacting and complementary agents**. So far knowledge generation shares the characteristics of an emergent property.

With respect to **standard complex system dynamics 3, economic analysis cannot forget two major aspects** that are intrinsic to economics and often bypassed by superficial applications of models drawn from physics.

First, the scope for intentional action of agents matters. Agents are indeed affected by bounded rationality and myopic capabilities, nevertheless **they can act**, albeit locally because of the limits of switching costs and procedural rationality, and **build connections, create communication channels, implement their connectivity, align their receptivity and especially direct their learning efforts towards fields of knowledge practiced by agents** that are localized and yet rich in terms of potential integrations with external pools of knowledge. In so doing agents are expected to try and maximize the expected, although myopically, profitability of their intentional activities4.

3 **The results of this analysis are consistent with complex dynamic system approach.** The latter builds upon five basic elements: I) **individual and hence heterogeneous agents** with specific characteristics are elements of a system and their **action is characterized by systemic interdependence**; II) **the distribution of agents in a multidimensional space** is essential to understanding the dynamic behavior of the system; III) **each agent has access only to local information and local knowledge**, i.e. no agent knows what every other agent knows; IV) agents are embedded within multidimensional topological spaces shaped by **networks of relations**, ranging a variety of interactions, transactions and communication channels that affect locally their behavior; V) **agents are creative, i.e. agents can change the rules of their behavior**. In standard complex dynamic system methodology **the topology of the system into which firms are embedded plays a key role**: it can change but only as the result of stochastic processes but the intentional action of agents is rarely accommodated (Rosser, 2004).

4 See (Barabasi, 2002) for a convincing analysis of the emergence of scale-free networks as the result of the convergence in a hub of qualified relations of the micromobility of agents aware of the opportunities of local commons of collective knowledge.

Second, and most important, market selection is at work. Within a given topology of agents and hence a given density in a map of distances among agents and related structure of communication channels and communication flows, **some agents can happen to align their learning capabilities and direct their communication efforts better than others**, or simply in a more effective way than others, even by chance, if not by mistake**. Such agents will nevertheless experience faster rates of generation of new technological knowledge and hence faster rates of introduction of localized innovations. Market selection will appraise such events**. In both cases the effects of profit maximization do change the course of events as anticipated by the sheer adaptive and stochastic dynamics of complex systems where blind agents are not able to anticipate the course of their actions and the market is never able to select the direction of their actions.

It is clear that the metaphor of stochastic action within a symmetric lattice is not appropriate to account for the intentional activity of economic agents within an economic system: such a behavior can be appropriate to analyze the conduct of ants, but not of human agents that are credited to be creative and able of intentional, albeit myopic, action both with respect to the generation of knowledge and to their location in the space of knowledge (Antonelli, 2003)5.

5 See Hayek (1945:520): "It seems to me that many of the current disputes with regard to both economic theory and economic policy have their common origin in a misconception about the nature of the economic problem of society. This misconception in turn is due to an erroneous transfer to social phenomena of the habits of thought we have developed in dealing with the phenomena of nature".

Path dependence seems in this context the single approach, which can help understanding the dynamics of the process. The approach to path dependence **considers creative agents, that at each point in time, are both learning and capable of intentional action and yet under the constraints of the effects of irreversibility and local externalities**.

The topology of the space exists as much as the array of its characteristics such as the **structure of communication channels** in place, their **connectivity and receptivity**, the **structure of relations and interactions which build upon the connections in place**. Agents however, within such a context, **are both able to generate new knowledge and also to change the topology at each point in time**.

Path dependence provides the framework to understand such **a twin dynamics**, **the dynamics of the generation of new knowledge** and **the dynamics of structural change of the topology within which agents operate**.

The issues of dynamic coordination are clearly central in this context and hence the related key notion of governance. Systems where agents are better able to achieve dynamic coordination are likely to experience faster rates of generation of new technological knowledge and hence faster rates of introduction of technological innovations. **By means of dynamic coordination, missing links among key complementary modules of knowledge can be built, effective alignment of agents towards a common design able to enhance the potential complementarities among the learning agents can be practiced (Richardson, 1998; Amendola and Gaffard, 1988). The role of the State in the provision of inputs for dynamic coordination can now be fully appreciated. The State can play a key role for the emergence of dynamic coordination among the variety of heterogeneous players involved in the generation of knowledge as a collective, complex and path dependent process**.

Specifically **the State can specialize in the direct supply of knowledge, by means of University and Public research centers,** only when it has high levels of fungeability, that is, knowledge with a wide scope of applications in a broad array of activities and high levels of incremental enrichment.

Second the State can favor the activity of interface bodies that have the specific mission to increase the dissemination of scientific knowledge and its communication to potential users. This role is especially important when codified knowledge generated in scientific bodies can feed the generation of technological knowledge by means of recombination within firms.

The announcement of important, long-term programs of scientific and technological research where a broad array of public agencies is involved is a third major line of activity. Here credible announcements can favor the alignment of the research activities of a myriad of firms and hence the emergence of complementarity and interoperability.

Finally, the State can favor the reduction of the exclusivity associated with intellectual property rights especially when knowledge cumulability matters and hence the chances to generate new technological knowledge depend heavily upon the access condition to pre-existing knowledge. The public implementation of the access conditions to such knowledge, viewed as an essential facility, is key to achieving dynamic efficiency in the generation of new knowledge.

The implications of the notion of knowledge as a path dependent, complex and collective process pave the way to a brand new approach to public research policy, well distinct from the role of generalized supplier of knowledge as a public good and the role of enforcement of exclusive intellectual property rights associated with the notion of knowledge as a quasi-private good.

5. CONCLUSION

Major changes have occurred in the economic understanding of knowledge in the second part of the XX century. **Knowledge has first been regarded as a typical public good** that markets and profitseeking agents could not produce in the appropriate quantities and with the appropriate characteristics. **These theoretical ingredients paved the way, through the 60s and 70s**, to **the build- up of the infrastructure for the public provision of knowledge**.

Consensus on the analysis of the public good character of knowledge has first been contrasted and eventually substituted by the new argument about **the quasi-private nature of technological knowledge**. The privatization of the knowledge commons and the **new reliance on the markets for knowledge, as a private good, emerges as the second model of governance, since the early 8os and through the 90s**. Intellectual property rights and **the new organization of financial markets** based on the direct access of new high-tech companies to the stock exchange become important tools for the governance of technological knowledge.

The identification of the central role of external knowledge in the production of new knowledge marks the third step. The 're-discovery' of the knowledge trade-off, towards the end of the century, **stressed the key role of its dissemination and highlighted the limitations of intellectual property rights**. Eventually a view of knowledge as collective and path dependent complex process has emerged: it is based upon **a deeper analysis of the interaction of the generation and distribution of knowledge, the appreciation of the role of the variety of learning and creative agents, the understanding of their complementarity and systemic interdependence,** in a context where prices do not and cannot convey all the relevant information. **This third approach has made possible to grasp the relevance of path dependence and dynamic coordination within complex system dynamics.**

The appreciation of the different forms and characteristics of knowledge makes it possible a closer analysis of the role of knowledge interactions and transactions as aspects of a broader governance problem **which includes strategic behavior at the firm level, the evolution of specific institution and policy interventions. This debate has important consequences on the analysis,** the design and the implementation and of the institutional architectures best suited to favor the generation and distribution of knowledge.

BEIJING FORUM 2011

"Reconciling Tradition and Modernity: the role of universities"

(Keynote Speech, November 4th, 2011)

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The theme underlying much of the discussion at this year's Forum will be the tension between "modernization" and "tradition" in the development of the modern world over the last two hundred years. This tension is still present in our contemporary world. It is a firm fact of modern history as many elements of the changes during those centuries may be thought to express this conflict of opposites. Furthermore, these terms are a discursive tool which has been and still is used to give value (positive or negative) to the opposing phenomena. The prospectus for this meeting of the Forum has urged us to rebalance our understanding of modernity and tradition with a view to preparing "The Harmony of Civilizations".

It is not my purpose here to summarize the arguments and debates of theorists and academics since, at least, the time of Max Weber and his discussion of the significance of an opposition between traditional authority and modern rational-legal authority. The panels at this Forum will provide examples and analysis. My objective is to argue for the paramount importance of universities around the world in the task of reducing the tensions between "modernization" and "tradition". Before I get to a closer examination of the role of universities in this, however, I need to provide some contextual observations.

First, it would be absurd to imagine that one could extinguish the tension between the historic and socio-economic forces that these two terms are taken to represent. The prospectus for this Forum does not suggest such an outcome. Indeed, sociologists remind us that every social organisation is simultaneously a field of competition and co-operation. This idea is scalable to the relationships within global human society. Indeed, a great deal of the dynamism of societies is driven by competition, while a great deal of their success in converting competition's ambitions into stable progress derives from people's capacity to co-operate. The issue before us is, therefore, essentially one of how to mitigate the negative consequences of a competition which this Forum has chosen to label as "modernisation" against "tradition".

My second observation is that these words "modernisation", "tradition" and, indeed, "harmony" represent each a cluster of meaning. The difference between them is generally clear to us. Nonetheless, each word refers to a complex phenomenon whose implication, in the case of the first two at least, has commonly been biased towards one particular interpretation by the uses to which the term has been put. In short, a strong element

of assumed value has been added to the definition. Thus, in the opposition between modernity and tradition each has a positive or negative meaning according to whether one welcomes or rejects it. In reality, neither phenomenon can be completely described in this way, neither is wholly beneficial or wholly harmful.

This bias was there from the beginning in the eighteenth-century European Enlightenment. Its modernity expressed notions of the nature of knowledge, the social order and the legitimacy of political, legal and social authority that were fundamentally different from those represented by tradition. The Enlightenment asserted the universality of truths rooted in the laws of Nature, discoverable and verifiable by the use of human Reason; it asserted that human society should be organised on the basis of such universal truths; it asserted the primacy of the individual in the purpose and legitimacy of social organisation; and it asserted that the individual was possessed of rights which were also universal and natural. Such claims were the antithesis of a view that saw social order rooted in custom, inherited position, local difference, long-established rules of collective solidarity, and a religious explanation of the purpose of society and the relationships between human beings in it. The opposition between the two was seen to be absolute.

The struggles of the French Revolution firmly attached the notion of good and ill to the clash. The revolutionaries classed those who opposed their attempt to reorganise society on universal individualist principles as wicked and using tradition to uphold a system for their selfish advantage. These opponents in turn saw them as wicked and self-interested promoters of purely mechanical principles. Each side accused the other of promoting social instability, poverty, darkness and death.

This is the source of the moral sense of profound good or ill attached subsequently to "modernisation" and "tradition", even though these terms have been used for developments and objects of different nature in a changing world. Only at moments of great conflict does the absolute antipathy between the terms emerge; more usually there is a nuanced sense of advantages and disadvantages in change. Nonetheless, we have inherited a deeply-rooted predisposition to see modernisation in a positive light. The exceptional improvements in the human condition (capable eventually of being extended on a global basis), which have been brought by scientific discovery and technological invention over the last two centuries, have appeared to verify the Enlightenment's claim to universal principles for human as well as other natural organisation, discoverable by human reason. The damaging by-products of modernisation (especially where it has been appropriated to serve purposes of power and exploitation) have always generated dissent and resistance, but I think that they have not, in western minds at least, diminished the pre-disposition that I have described.

Globalisation (our contemporary word for modernisation) brings into new focus these issues of meaning, of the balance between competition and co-operation, and of the value judgement about change. It does so because of the compression of the world and its consequences: the inrush of elsewhere into our own environments, the transformations of knowledge, the appearance of new political and economic geographies, and the tendency to homogenisation in culture and in individual and collective identity. Rather than modernisation and tradition, it is perhaps easier to say that this is the issue of the relative values of the universal and of the particular or local. A new urgency has been given to the problematic relationship between universality and difference.

The theme of this Forum, thus, poses a number of central questions. How do we understand complex phenomena? How do we chase out myth and bias from our evaluation of the world about us? How do we mitigate absolutes in claims to legitimacy or to worth? On what basis do we verify what is beneficial and what is negative in the alternatives present in our time? How do we understand the relationship between the changes that accelerate the future and the rooted forms and values of the present?

It is this that brings me to the role of universities. These questions belong to their core business. Universities have, I think, three basic functions. First, they constitute new knowledge either by research which literally discovers new phenomena or properties which were previously unknown or else by finding new meaning or new content or new applications in existing knowledge. Second, they subject the knowledge which we have inherited to tests which identify its assumptions and verify its reasonable solidity. Using a term drawn from the current language of public finance, we might call this "stress-testing" the truths and certainties which come from our predecessors, including recent ones. Third, universities transmit this knowledge to future generations and to their contemporary society. They teach it to students who will go out into the world; they publish it; they provide advice to governments and others on the basis of it; they contribute to the creation of new products and new enterprises in the economy.

That is the common project of all universities and of all academics in those universities. Although the appropriate procedures and objects differ between the sciences, social sciences and humanities and between disciplines within them, all academics are engaged in basically the same process.

They are using their faculties of reason in order to scrutinize data and, freeing themselves from prior assumptions as far as possible, to establish patterns in the evidence and thus to provide meaning. These tests are themselves based upon agreed procedures of investigation and evidence.

Four things are essential: the neutrality of the investigator; the absence of a pre-determined outcome; a transparency of method and evidence so that the conclusions may be tested by others; and, finally, a lively and free debate about these conclusions and their meaning. This is the essence of critical enquiry. It provides the guarantee to society that the knowledge offered by universities is accurate or, rather, as close to truth as can be managed at the time.

Indeed, universities are very much engaged in the society in which they find themselves. They contribute towards it in the ways that I identified as their third function. They remain rightly responsive to its needs. Recently, my colleague Geoffrey Boulton and I have argued that governments almost everywhere have developed a distorted view of what universities should do.[1] I do not intend to cover that ground again here. My proposition today is that it is to universities that we should look for guidance when challenged by the great dilemmas of modernity, such as the one presented to this Forum. We should do so because it is there that we are most likely to find conclusions that are deeply thought-out, based on evidence, and devoid of the taint of value judgement.

Of course, there is one clear limit to the clarifying power of universities. In an important sense knowledge is quite unstable, despite the fact that, for example, many complicated scientific discoveries can be demonstrated by repetition to be beyond doubt. The fact is that scientific knowledge in particular (but most other branches also) is an edifice built upon some basic assumptions. From time to time, these can be radically subverted. We need only think of the recent challenge to the Einstein principles of modern Physics by neutrinos travelling apparently faster than light and by the discovery of "dark energy". Such uncertainty is even more likely in areas where evidence is more enigmatic and measurement less sure, such as the question posed to this Forum.

I said earlier that the issue before us is the relationship between universality and difference. Universities contain powerful reflection on both of these and that is another reason to value and learn from the whole range of their activity. I hope that I am not misrepresenting the sciences if I say that they are concerned with the mysteries of the natural and physical world of which we are part and that they are so on the premise of the universality of physical phenomena. This is reflected in their quest for a "theory of everything".

The humanities and social sciences, however, are about another sort of complexity characterised by difference. They are concerned with understanding what humans as individuals and social beings have in common and how they differ. These disciplines gather the thinking, learning, and explanation of what binds and what separates human beings. This work is devoted to issues essential to stability, good order, creativity and inspiration in society.

The humanities in particular are concerned with what it means to be human. They seek it in the stories, the ideas, the words that help us make sense of our lives and the world we live in and of how we have created it and are created by it. These stories, words and ideas give voice to feeling and artistic shape to experience, exploring issues of morality and value. The humanities seek to understand and make accessible that extraordinary intensity and complexity of beauty by which human beings specify themselves in the merging of thought, emotion and expression. They provide understanding of why and how we express differently our common characteristics of humanity, as well as how we differ as individuals, groups and cultures. In an important sense, all this is about identity and about how identity is protected by cultural difference.

In conclusion, it might have been more honest of me to declare at the beginning rather than at the end of this talk that I do not know the recipe for the "Harmony of Civilizations". I have some opinions, but that is not the same thing. What I do think that I know is the following.

First, as well as being mostly irreversible, globalisation brings immense benefits. At the same time, the rapid growth of global immediacy and the virtual proximity of once distant populations make competition and destructive conflict potentially more dangerous.

Second, difference is necessary. It is necessary as a corrective to the global. It is necessary because it is an intimate element of what makes us humans and it is thus at the heart of creativity without which the energy of global benefit would falter. It is necessary because the maintenance of identity is one of the bases of stable and healthy societies.

Third, it is of paramount importance to develop understanding. We need to understand the nature of the dynamic of globalisation and of the interaction between universality and difference. Without that understanding we shall not identify and be able to reduce dangers that may arise. We need also to understand what is valid in our own cultures and what is simply prejudice or archaism. Finally, we need to understand the mentalities and assumptions of other civilisations if we are to avoid unnecessary conflict with them. Understanding enables respect for as well as realism about others which are a necessary basis of co-operation.

Fourth, universities are crucial in all this. Their core activities include the search for understanding and the creation of appropriate and reliable knowledge. Universities are themselves part of a global system of knowledge. They bridge cultures through trans-border education and the international movement of staff and students which promote practical understanding. Furthermore, they teach the young people who will come to lead our societies and should instil in them the understandings needed here.

Finally, the harmony of civilisations is not achieved overnight. It is young people who create the future but it is education at all levels which provides them with the tools to do so. One thing is certain: ignorance is the surest route to panic, hatred, and devastation.

[1] Geoffrey Boulton & Colin Lucas, *What are universities for?* (LERU, 2008); translated in *Chinese Science Bulletin* (March 2011).

http://www.atem.org.au/publications/occasional-papers/what-are-universities-for-

What are universities for?
Geoffrey Boulton and Colin Lucas

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1. "*A University is a place … whither students come from every quarter for every kind of knowledge; … a place for the communication and circulation of thought, by means of personal intercourse. … It is the place to which a thousand schools make contributions; in which the intellect may safely range and speculate. It is a place where inquiry is pushed forward, … discoveries verified and perfected, and … error exposed, by the collision of mind with mind, and knowledge with knowledge. … Mutual education, in a large sense of the word, is one of the great and incessant occupations of human society. … One generation forms another. … We must consult the living man and listen to his living voice, … by familiar intercourse … to adjust together the claims and relations of their respective subjects of investigation. Thus is created a pure and clear atmosphere of thought, which the student also breathes.*" So wrote John Henry Newman in *The Idea of a University* in 1852.**1**

2. Some 40 years earlier, in 1810, Wilhelm von Humboldt wrote a memorandum**2** that led to the creation of the University of Berlin. He envisaged a university based on three principles: unity of research and teaching, freedom of teaching and academic self-governance. The first was critical both of research divorced from teaching, undertaken by private scholars or in separate research institutes, without the stimulation of sharing those investigations with young minds, and of higher education divorced from original enquiry. The second, *Freiheit der Lehre und des Lernens*, was that professors should be free to teach in accordance with their studiously and rationally based convictions. The third principle, of academic self-government, only implicit in Humboldt's memo but increasingly apparent as an integral component of his vision, was meant to protect academic work from the distortions of government control.

3. The perceptions of Newman and Humboldt have dominated western thinking about the functions of universities. They are represented to different extents and in different ways in the objectives and structures of the comprehensive research universities of Europe. They are sometimes considered to be antithetical, implying that the ethos of specialised research is in tension with the liberal education of an informed and critical citizen. That may simply be a reflection of the openness to contradiction that is part of the genius of the university. For our part, we see them as complementary and the western comprehensive university to be in many ways the fusion of the two. Thus, Newman's "discoveries verified and perfected and error exposed by the collision of mind with mind, and knowledge with knowledge" is a powerful basis for Humboldt's search for new knowledge through research. Equally, to consult "the living man and listen to his living voice" emphasises the virtue of tuition by researchers who, with first-hand rather than second-hand knowledge, are best able to penetrate with their students the complex tangle in which true knowledge often lies.

6. If we may borrow a phrase from the founders of the American Philosophical Society**3**, universities are concerned to create and transmit "useful knowledge". Inescapably, the definition of useful knowledge is relative: it is partly what is practically useful; it is partly what serves the broadest purpose of rendering the human condition and the world we live in coherent to us; and it is also partly the preparation of what we do not yet know to be useful knowledge.

8. It is important to remember that whatever policy-driven demands are placed on universities and whatever the desire to mandate particular outcomes, the space of university endeavour is essentially one where discoveries cannot be determined in advance and where the consequences of the encounter between minds, between a mind, a problem and evidence, and between the minds of successive different generations are profoundly and marvellously unpredictable. They are the very conditions of creativity.

9. These enduring elements of success explain why, in the world of globalisation, universities are now regarded as crucial national assets. Governments worldwide see them as vital sources of new knowledge and innovative thinking, as providers of skilled personnel and credible credentials, as contributors to innovation, as attractors of international talent and business investment into a region, as agents of social justice and mobility, and as contributors to social and cultural vitality.

10. It is not surprising therefore that universities have moved from the periphery to the centre of government agendas. Governments around the world have invested heavily in universities and made demands upon them about objectives and even the processes used to attain them. The European Union serves as an example: it has promoted a "modernisation agenda" for university reform "as a core condition for the success of the broader Lisbon Strategy**4** to make the European Union "the most dynamic and competitive knowledge-based economy in the world"**5**. The European Commission has defined the role of universities as to exploit the so-called "knowledge triangle of research, education and innovation"**6**, and has set about creating its own university, the European Institute of Innovation and Technology, to demonstrate how these objectives should be addressed.

12. This policy preoccupation with the immediate challenges of a world in transition has led to a growing tendency to see universities as sources of highly specific benefits. This means in particular that they are (or should be) sources of marketable commodities for their customers, be they students, business or the state. There are injunctions to redesign or repackage and sell their products in response to shifting consumer priorities and to the immedi- ate gratification of the marketplace.

13. Indeed, what is striking is that the realisation of the importance of universities in the context of globalisation has brought governments of most of the major economies (other than the USA where other mechanisms operate**7**) to seek to regulate and stimulate universities in order to make them instruments of social and economic public policy. Broadly speaking, public policy sees universities as vectors of the contemporary skilling of an increasing segment of the population and as providers of innovation that can be translated into advantage in a fast changing global economic

environment. This involves the use of regulation and incentives (especially financial) to obtain forms of behaviour in universities that provide outcomes defined as desirable within this short-term frame of reference.

14. Public policy implies the engagement of universities in the contemporary concerns and objectives of their societies. We recognise that as both necessary and welcome. Public policy acknowledges the potential for the creativity of universities to benefit the economy. We recognise the validity of that premise. However, the contention of this paper is that such public policy needs to be moderated by a better understanding of the broader function of universities. We believe that the general attitudes that underlie such government policies are based on some serious misunderstandings. It is crucial that the true role of universities in modern societies and the relationships between means and ends are understood before mechanisms to promote change are put in place. Indeed, there is a danger that the current approach to universities is undermining the very processes that are the source of those benefits so cherished by government. It may staunch the universities' capacities to look beyond today's concerns in order to prepare the thoughts and the ideas that the future will need. Ultimately, they would be left as universities only in name.

15. Increasingly, discussions about the organisation of research and indeed of the university system across Europe have become dominated by analyses of the ways in which they can best fulfil an immediate economic function**8**. But we should pause to consider whether both the end and the means to achieve it have been correctly identified.

18. Nonetheless, we argue that these outcomes are the by-products of a policy constructed on flawed premises. Many governments have adopted a simplistic reductionism in their perception of the connection between universities and globalisation. Globalisation is certainly the child of the breathtaking scientific and technological advances that have created the developments in communication whose rapidity and universality have astonished the vast majority of people who do not understand the technology. Whether globalisation is the creation of this technology or simply another version of the globalising tendency of nineteenth- century imperialisms hardly matters. What policy makers have seen is the power of technological innovation and the threat of world economic reordering that it poses. They have made a cursory connection between technology and science and then between science and the obvious place where public money is spent on it – universities. It is on this basis that policies of investing in university science with a particularly public benefit in view have emerged.

22. Nonetheless, the contention of this paper is that the current emphasis of public policy about universities in Europe and elsewhere is far from capturing the essential reality of their function in society. Research universities in particular must be wary of simply accepting the premises of that policy as a whole truth. They must have a clear sense of their own about what they stand for and what their purpose is. They should not be rushed by a combination of inducements, urgency and regulation into accepting an identity proffered them from their ambient world, but they must engage with it to define a commonly accepted purpose. Even accepting the European Commission's knowledge triangle of education – research – innovation, universities need to provide their own answers to the questions: What sort of education? What sort of research? And how do universities contribute to innovation, previously believed to be the exclusive domain of private industry?

23. The phrase “useful knowledge” tends to imply the immediately applicable. But today’s preoccupations are inevitably myopic, often ephemeral, giving little thought for tomorrow. The ideas, thoughts and technologies that tomorrow will need or that will forge tomorrow, are hid from us, and foresight exercises have had a lamentable record of success in attempting to predict them. Just as the breathtaking pace of scientific, technological and societal innovation has changed and is changing the way we live, in an unpredictable way, so will it in the future. The universities in their creative, freethinking mode are a vital resource for that future and an insurance against it. The policies being increasingly pressed upon them implicitly assume a knowable future or a static societal or economic frame. As Drew Faust has said, in her inaugural address as President of Harvard**10**: “A university is not about results in the next quarter; it is not even about who a student has become by graduation. It is about learning that moulds a lifetime; learning that transmits the heritage of millennia; learning that shapes the future”.

25. Notwithstanding these lessons from the recent past, much current thinking about universities implies a predominant concern that they should gear themselves only to immediate demands. We argue that in research, in teaching and in learning it is not only important that universities address and train for current needs, but equally important that they develop the thinking and the mental and conceptual skills and habits that equip their graduates to adapt to change and even steer it if circumstances permit. Uncertainty about future relevance in the spectrum of research or of curricula is such that a Darwinian adaptive model is the most appropriate; where both range across the whole landscape of human understanding and experience, embodied not only in the natural sciences and technology but also in the arts, humanities and social sciences.

26. The key to retaining the flexibility to exploit the unexpected lies in a fundamental understanding of the nature of phenomena. Such understanding continuously resynthesis specific knowledge in the form of general understanding that is broadly applicable, such that a complex narrative in one generation can be replaced by a simpler one in succeeding generations. Basic research that compresses and generalises understanding in this way invigorates teaching that probes the limits of understanding. Together, they are the fuel for the university engine. Such generic understanding also represents a fundamental “transferable skill” which can be applied to a much wider range of circumstances and phenomena than any catalogue of specific knowledge. It is a vital investment in the future.

27. We concur with the view that universities’ fundamental contribution to society lies in creating and passing on “useful knowledge”, and engaging with society in its application, but argue that the definition of utility is often too narrowly drawn. As is evident from the argument so far, we do not concur with the increasing assumption that useful knowledge is only that immediate knowledge which forms the basis for the technologies and skills believed to be crucial for economic success. Useful knowledge, and the skills that go with it, are derivative from a deeper capability that is insufficiently credited by government, and often relinquished for shallower perceptions of utility by the very academics who should most cherish it. It is a capability deeply embedded in the fundamental role that universities have in creating new knowledge and transmitting it to successive generations together with the knowledge which has been accumulated by predecessors and which in each generation is subjected to renewed tests of verification.

29. Let us therefore examine how university contributions to society are achieved through their historic roles in education and research, and how they should best respond to current priorities for outreach, in contributing to innovation, and in public and international engagement. They are by no means all the roles that universities do or could play, but are the major parts of their current effort and the focus of current debate.

30. There is, or should be, in university education, a concern not only with what is learned, but also with how it is learned. Too much pedagogy is concerned solely with the transfer of information. Even an education directed towards immediate vocational ends is less than it could be, and graduates are left with less potential than they might have, if it fails to engage the student in grappling with uncertainty, with deep underlying issues and with context. Generation by generation universities serve to make students think. They do so by feeding and training their instinct to understand and seek meaning. It is a process whereby young people, and those of more mature years who increasingly join them as students, are taught to question interpretations that are given to them, to reduce the chaos of information to the order of an analytical argument. They are taught to seek out what is relevant to the resolution of a problem; they learn progressively to identify problems for themselves and to resolve them by rational argument supported by evidence; and they learn not to be dismayed by complexity but to be capable and daring in unravelling it. They learn to seek the true meaning of things: to distinguish between the true and the merely seemingly true, to verify for themselves what is stable in that very unstable compound that often passes for knowledge. These are deeply personal, private goods, but they are also public goods. They are the qualities which every society needs in its citizens. That is even more the case in our European societies since our culture believes that fair and open societies, which can resolve legitimate competition between individuals and groups and harmonise legitimate differences, are only maintained by participatory democracy. It is universities that produce these citizens, or at least enough of them to leaven and lead society generation by generation.

31. Moreover, and once again, many of the qualities prized by government - entrepreneurship, managerial capacity, leadership, vision, teamwork, adaptability and the effective application of specific technical skills - are not primary features, but are derived from the more fundamental qualities explored in the previous paragraph. It is these qualities that policy and university management should seek to reinvigorate. The more recently advocated functions of universities are only part of a wider project which contains their essence. That capability which leads to economically significant outcomes is derivative from a deeper creativity. It has been misguidedly made to stand as a proxy for useful knowledge; but universities should read their function more widely and more intelligently.

36. Successful research, whether in the sciences, humanities or social sciences, depends upon a culture and individual attitudes that value curiosity, scepticism, serendipity, creativity and genius. They are values that are crucial to the university educational process at its most profound, and are most readily acquired in an environment of free-ranging speculation and research that is permeated by them. Their transfer into society by graduates who embody them is an essential contribution to an innovative culture and a spirit of informed civic responsibility.

37. Not only does its research create the frame for a university’s educational role, but universities have also proved to be highly cost effective settings for basic research in particular. The reasons may lie in their non-hierarchical nature, the pervasive presence of the irreverent young, whose minds are not so full of the means of refutation that original ideas are denied entry, and the highly competitive nature of most funding for university research, in contrast to specialist research institutes, where the peace and quiet to focus on a mission, undistracted by teaching or other

responsibilities, and with relatively assured funding, may be a questionable blessing**12**. By the same token, the excitable and dynamic nature of universities suits them much less well to the pursuit of longterm, strategic research objectives. This university inclination towards basic research, which seeks to explore the fundamentals of phenomena, also chimes well with their educational role, in stimulating the flexible modes of thought and creativity that are adaptable to a wide range of circumstances, and the deeply personal ownership of the basis for lifelong learning.

38. Universities, particularly comprehensive universities, are unique amongst human institutions in the range of knowledge they encompass. As a consequence, they have the potential rapidly to restructure and recombine their skills in novel ways to address both the many trans-disciplinary issues that are becoming increasingly important, and also to explore new, unexpected avenues of understanding. As the pace of unanticipated discovery and the urgency of demand increase, this capacity is increasingly vital, although universities have not exploited it as decisively as they should. Although much has been made of the need to develop and maintain critical mass in research, the *critical diversity* required to confront challenges as they arise or to create novel combinations of researchers to address evolving trans-disciplinary demands is often more important. And electronic networks are no substitute for diverse and dynamic communities of place.

Innovation

39. We referred earlier to the stress currently laid on the role of universities as engines of innovation and economic development, and the drive to shift university behaviour in order to give prominence or priority to these issues. The crucial question is whether and to what extent this is true and appropriate. By implication, the European Commission believes that it is, given the equality of treatment afforded to education, research and innovation in their socalled "knowledge triangle" in its recent communication**4**, and the way in which this is to be embedded in the European Institute of Innovation and Technology (EIT) as a putative exemplar of a world-class university for the modern world. We have no doubt that universities have a fundamental contribution to make to the innovation process, but it is important to understand what that contribution is, and not to assume, as many increasingly do, that universities are direct drivers of innovation, and that this could be their primary rationale.

40. Universities can and do contribute to the innovation process, but not as its drivers. Innovation is dominantly a process of business engagement with markets, in which universities can only play a minor active role. They do however contribute to the fertility of the environment that innovation needs if it is to flourish. University commercialisation activities themselves, the creation of spin-out and start-up companies and licensing of intellectual property, do not, even in the USA, where university commercialisation is best developed, directly contribute significantly to GNP. These activities have a different role. They help to create an environment sympathetic to and supportive of innovation, and particularly where they are associated with internationally competitive research and excellent graduates, they create a hubbub of creativity that attracts research-intensive companies and investment into a region, and help catalyse innovation in indigenous businesses. The bedrock for this potential remains however the university's commitment to education in the deepest sense, and its exploration at and beyond the limits of human understanding. A recent study of the role of higher education in meeting international business demands**13** concludes that it is "the quality of staff at all levels that is the most important determinant of business competitiveness". To which we would retort that the individual qualities embodied in university graduates, developed through the classical educational processes summarised in paragraph 30, and leavened by appropriate technical skills, are crucial contributions from universities.

41. There is much debate about "innovation systems"; how they should be structured and the role of universities in them. The notion of a single, durable and generically applicable innovation system is a seductive concept for policy makers, but misconceived. A recent LERU report**14** gave examples of the great diversity of ways in which universities contribute to innovation processes, which vary according to the nature of the regional economy, the business sector involved and the nature of the university. Indeed it is clear that multiple innovation systems operate concurrently in the same region and that the mosaic of innovation changes through time. Innovation systems might best be defined as an "ecology"**15**, in which interactions between different actors produce emergent behaviour that is highly adaptive to circumstance and opportunity.

42. If this is a good description of reality, it warns against generic governmental or European Commission interventions that take a prescriptive view of innovation processes or structures. A key principle is that it is autonomy of action by an institution that is aware of regional priorities that gives an institution the greatest potential to contribute, not only to market innovation, but also to innovation in cultural and social spheres. The key processes are those that stimulate interaction. It is a matter of concern that the principle of developing enabling processes that can support a wide variety of activities is often not recognised by funders of research at national and European levels, who frequently propose to reinvent and prescribe knowledge transfer structures at levels far removed from the research base. This risks increasing the constraints on universities' efforts to use intellectual property and capability creatively, and, at worst, stopping successful initiatives in their tracks**16**.

43. It is erroneous to think of innovation, as some of these interventions implicitly do, as a supply-driven process, fuelled by inventions, often created in universities, and particularly in science and technology. Although few would admit it, this can be the only rationale for some governmental policies of recent years. In practise, although attention must be given to the quality of supply of excellent education, excellent research and responsiveness to business needs, this of itself is not enough. Where demand is weak, excellent supply has rarely been sufficient to stimulate it. Governmental intervention has often been a powerful stimulus for demand, with government use of public procurement of research products from companies as a particularly potent device for stimulating the growth of knowledge-intensive companies and increasing private investment in R&D.**14** It is also the case that as the service sector becomes pre-dominant in developed economies, knowledge-intensive growth depends on a much wider range of inspiration than just science and technology, and in which the arts and humanities are playing an increasing role**17**.

51. There is an implicit notion that the understanding they confer is less important than that loosely termed "science", although natural scientists themselves rarely take that view. Research in the humanities and social sciences is concerned with issues that are essential to stability, good order, creativity and inspiration in society. In these disciplines are gathered the thinking, learning, and explanation of what binds and what separates human beings. They seek not only to understand and make accessible that extraordinary intensity and complexity of beauty by which humans specify themselves in the merging of thought, emotion and expression – a high enough mission by any standard. More important for our purpose, they provide understanding of why and how we express differently our common characteristics of being, as well as how we differ as individuals, groups and cultures. History – and none more so than recent and contemporary history – demonstrates how supremely important the dissemination of that understanding is to stable and healthy societies. Globalisation, especially in its effects of instantly accessible worldwide information, and

increasingly mobile populations, has created political complexity by bringing once distant cultural assumptions into close proximity, and makes this an ever more pressing necessity. It would be absurdly naive to argue that an understanding society (another form of "knowledge society") would be devoid of divisive competition and destructive conflict. At the same time, though, ignorance is the surest route to panic, hatred, and devastation.

52. Research in the arts, humanities and social sciences is a core resource and stimulus for cultural performance, exhibition and maintenance of the historic environment, and is increasingly embedded in the norms of popular culture. It promotes historical understanding of our own and other cultures, religions and societies. It fosters public debate and engagement with the complexities of modern life, especially those which involve conflicting moralities, traditions and beliefs. Through its humane values, it provides crucial support for civic virtues and open, accessible government, on which civilised society depends. Its societal and humane focus addresses major current social, cultural, ethical and economic challenges, including the impact of scientific and medical advances, the management of international relations, development and security, and the effects of globalisation and migration. It contributes decisively to today's recognition that modern society depends on the whole range and interconnectedness of knowledge rather than on a few academic disciplines. It makes an increasingly effective practical contribution, together with other disciplines, to the creation of public policy.

54. We wrote at the beginning of this essay of "the openness to contradiction that is part of the genius of the university". One of those contradictions derives from the relative freedom and autonomy of academics, and the lack of inhibition of its students; which are the source both of the university's greatest strength and its greatest weakness. On the one hand it generates a hubbub of creativity and entrepreneurial initiatives that stimulate diverse and sometimes towering intellectual achievement. On the other, it can be the source of profound resistance to managed change or the orchestration of joint efforts in response to changing societal needs. A central dilemma for university governance is therefore how to retain the sense of ownership of the university enterprise by its members, which creates the setting for their creativity to range freely, whilst implementing the structural changes that are inevitably needed from time to time if a university is to remain a creative force for future generations.

55. Managing such a university is not like managing industrial production in response to market demand. There is a core of the university operation that requires efficient top-down management, such as the framework for teaching, the structures of research support, technology transfer and professional services. But the crucial attribute, for both students and academics, is a culture of individual freedom, creativity and serendipity. It provides the frame for new insights and understanding; gives free rein to the enthusiasms and commitment that lead to public engagement; and for the space to create new enterprises that as they mature can be absorbed into the formal operation of the university, and so change its shape and direction. A current danger in many countries stems from the financial benefits that come to a university through research funding mechanisms. These can be such powerful drivers of behaviour and corporate motivation that top-down mechanisms are driving some institutions close to becoming strongly managed research institutes, squeezing out diversity of function and undermining teaching and learning.

62. Universities are not just supermarkets for a variety of public and private goods that are currently in demand, and whose value is defined by their perceived aggregate financial value. We assert that they have a deeper, fundamental role that permits them to adapt and respond to the changing

values and needs of successive generations, and from which the outputs cherished by governments are but secondary derivatives. To define the university enterprise by these specific outputs, and to fund it only through metrics that measure them, is to misunderstand the nature of the enterprise and its potential to deliver social benefit. These issues of function and purpose are important, and need to be explicit. They must be part of the frame for the animated debate taking place in Europe that generates headlines such as "creating an innovative Europe"**19**, "delivering on the modernisation agenda for universities"**20**, and "the future of European universities: renaissance or decay?"**21**.

63. The second point is that the instinct to understand, to find meaning, to map oneself and one's actions and the world, is essentially human. In our view, this is one of the principal definitions of humanity, even if one were to reduce it simply to primordial angst. Knowledge is a human attribute, quite distinct from, say, the tool-making skills of the New Caledonian crow or the communication skills of the chimpanzee. Therefore, those parts of the university and its research which deal with the human being as an individual or as a collectivity (that is, the humanities and the social sciences) are as important as science and technology and are as central to the well-being of society.

THINK

References

Abecker, A. (Ed.) (2002), *Geschäftsprozeßorientiertes Wissensmanagement*, Berlin, Springer.
Abram, S. (1997) ,Post information age positioning for special librarians: is knowledge management the answer?' *Information Outlook*, 1(6), 18-25.
Ackoff, R.L. (1981), *Creating the Corporate Future*, New York, Wiley.
Ahl, V. and Allen, T.F.H. (1996), *Hierarchy Theory*, New York, Columbia University Press.
Alexander, G. (2000), 'Information-based tools for building community and sustainability#, *Futures*, Vol. 32, No. 3, pp.317-337.
Allenby, B. (2000), 'Industrial Ecology, Information and Sustainablity', *Foresight*, Vol. 2, No. 2, pp. 163-171.
Anderson, P., Arrow, K. and Pines, D. (eds.) (1988), *The Economy as an Evolving Complex System*, Redwood City, California, Addison-Wesley
Argyris, C. and Schön, D. (1999), *Die lernende Organisation*, Stuttgart, Klett-Cotta.
Argyris, C. and Schön, D. A. (1996), *Organizational Learning II,* Reading, Mass. Addison-Wesley.
Arshinov, V. and Fuchs, C. (Eds.) (2003), *Emergence, Causality, Self-Organisation,* Moscow. Russian Academy of Sciences.
Arthur, W. B., Durlauf, S. and Lane, A. (Hrsg.) (1997), *The Economy as an Evolving Complex System II,* Reading, Mass. Addison-Wesley
Bach, V. (Ed.) (1999), *Business Knowledge Management,* Berlin, Springer.
Banathy, B.H. (1996), *Designing Social Systems in a Changing World*, New York, NY. Plenum.
Bateson, G. (2000), *Steps to an Ecology of Mind*, University of Chicago Press
Baumgartner, P. (1993), *Der Hintergrund des Wissens. Vorarbeiten zu einer Kritik der programmierbaren Vernunft,* Klagenfurt. Kärntner Druck.
Baurdrillard, J. (1983), *Simulations*, New York, Semiotext(e).
Beck, U. (1986), *Risikogesellschaft. Auf dem Weg in eine andere Moderne,* Frankfurt am Main, Suhrkamp.
Beck, U. (1992), 'Modern Society as a Risk Society', in Stehr, N. and Ericson, R. V. (eds.) (1992), *The Culture and Power of Knowledge,* Berlin/New York. de Gruyter, pp.199-214.
Beck, U. (Hrsg.) (1999), *Schöne neue Arbeitswelt. Vision: Bürgergesellschaft,* Frankfurt am Main/New York, Campus.
Beer, S. (1994), *Beyond Dispute; The Invention of Team Syntegrity*, New York, Wiley.
Bell, D. (1971), 'The Post-industrial-Society: The Evolution of an Idea', *Survey*, Vol. 17, 2, 102-168.
Bell, D. (1973), *The Coming of Post-industrial Society*, Basic Books, New York
Best, S. and Kellner, D. (1997), *The Postmodern Turn,* New York/London, Guilford Press.
Bhagwati J.N. (1976), *The Brain Drain and Taxation - Theory and Empirical Analysis*, North-Holland Publishing Co., Amsterdam.
Böcher, W. (1996), *Selbstorganisation. Verantwortung. Gesellschaft. Von subatomaren Strukturen zu politischen Zukunftsvisionen,* Opladen, Westdeutscher Verlag
Boisot, M. (1998), *Knowledge Assets: Securing Competitive Advantage in the Information Economy*, New York, Oxford University Press.
Borghoff, U. (ed.) (1999), *Information Technology for Knowledge Management*, Berlin, Springer.
Bornemann, M. (2002), *Anwendungsorientiertes Wissensmanagement*, Wiesbaden, Deutscher Universitätsverlag.

Bourdieu, P. (1986), *Distinction. A Social Critique of the Judgement of Taste*, London, Routledge
Bouthillier, F. and Shearer, K. (2002), 'Understanding knowledge management and information management: the need for an empirical perspective',*Information Research* 8(1), paper no. 141
Brier, S. (2003), 'The Cybersemiotic model of communication', *TripleC*, Vol. 1, No. 1.
Brier, S. (1999), 'The Relation between the Semiotic and the Informational Research Programs in the Quest for a Unified Theory of Information, Cognition and Communication' in Schmitz, W. (Ed.) (2003), *Sign Processes in Complex Systems,* Dresden. Thelem. CD-ROM.
Brier, S. (1996), 'Cybersemiotics: A New Interdisciplinary Development Applied to the Problems of Knowledge Organization and Document Retrieval in Information Science', *Journal of Documentation*, Vol. 52, No. 3, pp. 296-344.
Brown, J. S./Collins, A./Duguid, P. (1989), 'Situated cognition and the culture of learning', *Educational Researcher* 18:1, 32-42. 1989.
Bühl, A. (1997), *Die virtuelle Gesellschaft: Ökonomie, Politik und Kultur im Zeichen des Cyberspace*, Opladen/Wiesbaden, Westdeutscher Verlag.
Bühl, W. L. (1991), ,Politische Grenzen der Autopoiese sozialer Systeme', in Fischer, H. R. (Ed.) (1993), Autopoiesis. Eine Theorie im Brennpunkt der Kritik, Heidelberg, Carl-Auer-Systeme. pp. 201-226
Bürgel, H. D. (Ed.) (1998), *Wissensmanagement*, Berlin, Springer.
Butts, R. E. and Brown, J. R. (Ed.) (1993), *Constructivism and Science,* Dordrecht/Boston, Kluwer
Capurro, R., Fleissner, P. and Hofkirchner, W. (1997), 'Is a Unified Theory of Information Feasible?' *Informatik Forum*, 1/1997, pp. 36-45.
Castells, M. (1996), *The Rise of the Network Society. The Information Age: Economy, Society and Culture*, Vol. I. Cambridge, Mass./Oxford. Blackwell
Checkland, P. (1981), *Systems Thinking*, Systems Practice. New York. Wiley
Choo, C. W. (1998), *The Knowing Organization: How Organizations Use Information to Construct Meaning, Create Knowledge, and Make Decisions,* New York, Oxford University Press.
Coyle, D. (1997), *The Weightless World. Strategies for Managing the Digital Economy*, Oxford, Capstone Publishing.
Dahrendorf, R. (1997), *After 1989: Morals, Revolution, and Civil Society*, Basingstoke, Macmillian.
Davenport, T. and Prusak, L. (1998), *Working Knowledge: how Organizations Manage what they Know*, Cambridge, MA: Harvard Business School Press.
Deppe, J. (1992), *Quality Circle und Lernstatt*, Wiesbaden, Gabler.
Drucker, P. (1994), *Post-Capitalist Society*, New York, Harper Business.
Drucker, P. (1969), *The Age of Discontinuity. Guidelines for our Changing Society*, New York, Harper and Row.
Dunsire, A. (1996), 'Tipping the Balance. Autopoiesis and Governance', *Administration and Society*, 28 (3), pp. 299-334.
Durkheim, E. (1972), 'Sociology of Knowledge', in Giddens, A. (ed.) (1972), *Emilie Durkheim; Selected Writings*, Cambridge, CUP, pp.250-268.
Elias, N. (1971), 'Sociology of Knowledge. New Perspectives', *Sociology*, 5(2+3), pp.149-168+355-370.
Etzioni, A. (1971), *The Active Society*, New York, Free Press.
Etzioni, A. (1991), *A Responsible Society: Collected Essays on Guiding Deliberate Social Change*, San Francisco, Jossey-Bass.
Faulstich, W. (2000), *Grundwissen Medien*, München, Fink.

Fenzl, N., P. Fleissner, W. Hofkirchner, R. Jahn and G. Stockinger (1996), 'On the Genesis of Information Structures, A View that is neither Reductionist nor Holistic' in Kornwachs, K., and K. Jacoby (eds.)., *Information, New Questions to a Multidisciplinary Concept*, Berlin, pp.271–283
Fenzl, N., /Hofkirchner, W. and Stockinger, G. (Eds.) (1998), *Information und Selbstorganisation. Annäherungen an eine vereinheitlichte Theorie der Information*, Vienna/Innsbruck, Studienverlag
Feyerabend, P. (1975), *Against Method*, New York, Humanities Press.
Fischer, F and Hajer, M. A. (1999), *Living with Nature*, New York, Oxford University Press.
Fiske, J. (1996), *Media Matters. Everyday Culture and Political Change*, Minneapolis/London, University of Minnesota Press.
Fleissner, P. and Hofkirchner, W. (1996), ,Emergent Information' *BioSystems* 2-3(38)/1996, pp. 243-248
Foerster, H. v. and Zopf, G.W. (Eds.) (1962), *Principles of Self-Organization,* New York, Pergamon
Foerster, H. von (2003), *Understanding Understanding. Essays on Cybernetics and Cognition,* New York/London, Springer.
Forrest, S. (Ed) (1991), *Emergent Computation,* Cambridge, Mass. MIT Press
Foucault, M. (1972), *The Archeology of Knowledge,* London, Tavistock Publications.
Freeman, C. and Soete, L. (1994), *Work for all or Mass Unemployment; Computerised Technical Change into the 21st Century*, London/New York, Pinter
Fuchs, C. (2002), 'Software Engineeting and the Production of Surplus Value', *Cultural Logic*, Vol. 4 (2002), No. 3.
Fuchs, C. (2003), 'Co-operation and Social Self-Organisation, *Triple C* (Cognition, Communication, Co-operation), Vol. 1 (2003), No. 1.
Fuchs, C. (2003d), 'Structuration Theory and Social Self-Organisation', *Systemic Practice and Action Research*, Vol. 16 (2003), No. 2. pp. 133-167
Fuchs, C. and Hofkirchner, W. (2003a), *Studienbuch Informatik und Gesellschaft,* Norderstedt. Libri.
Fuller, S. (1992), 'Knowledge as Product and Property', in Stehr N. Ericson R V (eds.), *The Culture and Power of Knowledge. Inquiries into Contemporary Societies,* de Gruyter, Berlin/New York
Fuller, S. (2002), *Knowledge Management Foundations*, Boston, Butterworth-Heinemann.
Gibbons, M. (1994), *The New Production of Knowledge: the Dynamics of Science and Research in Contemporary Societies*, Sage, London
Giddens, A. (1981), *A Contemporary Critique of Historical Materialism. Vol. 1: Power, Property and the State*, London/Basingstoke, Macmillan
Giddens, A. (1985), *A Contemporary Critique of Historical Materialism. Vol. 2: The Nation-State and Violence,* Cambridge. Polity Press
Giddens, A. (1990), *Consequences of Modernity*, Cambridge, Polity Press
Glaser W.A. (1978), *The Brain Drain: Emigration and Return*, Oxford, Pergamon Press
Glotz, P. (2001), *Die beschleunigte Gesellschaft. Kulturkämpfe im digitalen Kapitalismus.* Berlin. Rowohlt.
Götz, K. (ed.) (2002), *Wissensmanagement. Zwischen Wissen und Nichtwissen*, München, Hampp.
Gross, P. (1984), *Die Multioptionsgesellschaft,* Frankfurt/Main. Suhrkamp.
Hamlyn, D. W. (1970), *The Theory of Knowledge*, London, Macmillan.
Haraway, D. (1999), 'Situated Knowledges: the Science Question in Feminism and the Privilege of Partial Perspective' in Biagioli, Mario (Ed.) (1999), *The Science Studies Reader*, New York/London, Routledge. pp. 172-188.
Harding, S. (1996), *The Science Question in Feminism*, Ithaca, Cornell University Press.
Harvey, D. (1990), *The Condition of Postmodernity*, Oxford, Blackwell.

Hayek, F. A. (1949), *Individualism and Economic Order*, London, Routledge & Kegan.
Held, D., McGrew, A., Goldblatt, D. and Perraton, J. (1999), *Global Transformations*, Cambridge/Oxford, Polity.
Hilty, L. M. (2002), 'Sustainable Development and Information Technology', *Environmental Impact Assessment Review*, Vol. 22, No. 5, pp. 445-447
Hofkirchner, W. (1998a), 'Emergence and the Logic of Explanation. An Argument for the Unity of Science', *Acta Polytechnica Scandinavica*, Mathematics, Computing and Management in Engineering Series 91, 23-30
Hofkirchner, W. (1999b), 'Cognitive Sciences in the Perspective of a Unified Theory of Information' in Allen, J. K., Hall, M. L. W., Wilby, J. (Eds.), Proceedings of the 43rd Annual Conference of ISSS (The International Society for the Systems Sciences), ISBN 09664183-2-8 (CD-ROM)
Hofkirchner, W. (2001), 'The Hidden Ontology: Real World Evolutionary Systems Concept as Key to Information Science', *Emergence* 3/3, 2001, pp. 22-41.
Hofkirchner, W. (2002b), 'The Status of Biosemiotics' SEED Vol. 2/No. 3, 2002, pp. 4–15
Jantsch, Erich (1979/1992), *Die Selbstorganisation des Universums. Vom Urknall zum menschlichen Geist*, München/Wien. Hanser
Jessop, B. (2002), *The Future of the Capitalist State*, Cambridge, Polity.
Jurisica, I. (2000) 'Systematic Knowledge Management and Knowledge Discovery', *Bulletin of the American Society for Information Science*, Vol. 27, No. 1.
Kauffman, S. (1993), *The Origins of Order*. Oxford. Oxford University Press
Kenney, M. (1997) 'Value Creation in the Late Twentieth Century: The Rise of the Knowledge Worker' in Davis/Hirschl/Stack (1997), pp 87-102.
Klauninger, B. (2002) 'Causality and Emergence' in Trappl, R. (Ed.) (2002) *Cybernetics and Systems 2002*. Vienna. Austrian Society for Cybernetic Studies. pp 193-196.
Knorr C. K. (1999), *Epistemic Cultures. How Sciences Make Knowledge,* London, HUP
Krugman, P. (1996) *The Self-Organizing Economy*. Malden, Mass./Oxford. Blackwell
Kuhn, Thomas (1962) *The Structure of Scientific Revolutions*. Chicago. University of Chicago Press.
Kukla, André (2000) *Social constructivism and the philosophy of science*. London. Routledge.
Lane, R. E. (1966) 'The Decline of Politics and Ideology in a Knowledgeable Society', *American Sociological Review* 31, pp. 649-662.
Lash, S. (2000), ,Die Informationsgesellschaft', in Pongs (2000).
Laszlo, E. (1991) *The Age of Bifurcation*. Philadelphia. Gordon and Breach.
Leggewie, C. (1996) Die multikulturelle Gesellschaft »Kulturelle Vielfalt statt kulturelle Einfalt«. In: Pongs (1996), pp. 147-168.
Lévy, P. (1997), *Collective Intelligence: Mankind's Emerging World in Cyberspace*, Cambridge, Mass. Perseus Books.
Lévy, P. (1998), *Becoming Virtual. Reality in the Digital Age*, New York, Plenum Trade.
Lévy, P. (2001), *Cyberculture*, Minneapolis, University of Minneapolis Press.
Leydesdorff, L. (1993), 'Is Society a Self-Organizing System?' *Journal for Social and Evolutionary Systems* 16 (1993). pp 331-349
Liebowitz, J. (ed.) (1997), *Knowledge management and its integrative elements*, Boca Raton, CRC Press.
Lipietz, A. (1992) *Towards a New Economic Order. Postfordism, Ecology and Democracy*. Cambridge/Oxford. Polity Press/Blackwell Publishers

Longino, H. E. (1990) *Science as Social Knowledge. Values and Objectivity in Scientific Inquiry*. Princeton, NJ. Princeton University Press.
Luhmann, N. (1975), ‚Systemtheorie, Evolutionstheorie und Kommunikationstheorie', in *Soziologische Aufklärung 2.* Opladen: Westdeutscher Verlag, pp. 193-203
Luhmann, N. (1984), *Soziale Systeme – Grundriss einer allgemeinen Theorie* Frankfurt.
Luhmann, N. (1997), *Die Gesellschaft der Gesellschaft* , 2 vol, Frankfurt
Luhmann, Niklas (1990) *Die Wissenschaft der Gesellschaft*. Frankfurt/Main. Suhrkamp.
Luhmann, Niklas (1998) *Die Gesellschaft der Gesellschaft*. Frankfurt/Main. Suhrkamp.
Lyotard, J.-F. (1984), *The Postmodern Condition*, University of Minnesota Press, Minneapolis.
Machlup, F. (1962), *The production and distribution of knowledge*, Princeton Univ. Press, Princeton.
Mannheim, K. (1952), *Essays on the Sociology of Knowledge*, Routledge, London.
Mansell, R. and Wehn, U. (Eds.) (1998), *Knowledge societies: information technology for sustainable development*, Report for the United Nations Commission on Science and Technology for Development. New York. Oxford University.
Martensson, M. (2000), 'A critical review of knowledge management as a management tool', *Journal of Knowledge Management*, 4, 204-216.
Mayntz, Renate (2000), ‚Die dynamische Gesellschaft', in Pongs (2000), pp. 219-239.
McQuail, D. (1987) *Mass Communication Theory*. Beverly Hills/Newsbury Park. Sage.
Meja, V. and Stehr, N. (1999), *The Sociology of Knowledge*, 2 Volumes, Cheltenham/Northampton. Edgar Elgar.
Merton, R. K. (1945) *Social Theory and Social Structure*. New York. Free Press.
Mingers, J. (2001) 'Can Social Systems Be Autopoietic?' *Warwick Business School Research Papers*, No. 346
Mitchell, K D. (2000) ‚Knowledge management: the next big thing', *Public Manager*, 29 (2), 57-60.
Myers, P. S. (1996) *Knowledge Management and Organizational Design*. Boston. Buttersworth-Heinemann.
Nicolis, G. and Prigogine, I. (1989), *Exploring Complexity*, New York, Freeman
Nonaka, I. and Takeuchi, H. (1995) *The knowledge creating company: how Japanese companies create the dynamics of innovation*. New York: Oxford University Press.
Nonaka, Ikujiro/Takeuchi, Hirotaka (1995) *The knowledge-creating company*. New York/Oxford. Oxford University Press. Offe, C. (1984) *Arbeitsgesellschaft*. Frankfurt/New York. Campus.
Oluic-Vukovic, V. (2001) ‚From information to knowledge: some reflections on the origin of the current shifting towards knowledge processing and further perspective', *Journal of the American Society for Information Science and Technology*, 52, 54-61.
Perkin, H. (1990) *The Rise of Professional Society*. Routledge
Polanyi, M. (1962) *Personal knowledge*. Chicago, IL.: University of the Chicago Press.
Pongs, A. (1996) *In welcher Gesellschaft leben wir eigentlich? Band 1*. München. Dilemma.
Pongs, A. (2000) *In welcher Gesellschaft leben wir eigentlich? Band 2*. München. Dilemma.
Pöppel, E. (2000) ‚Drei Welten des Wissens. Koordinaten einer Wissenswelt', in Moor et al. (2000), p. 21-39.
Popper, K. (1981) *Objective Knowledge*. Oxford. Oxford University Press.
Quinn, J. (1992) *Intelligent enterpriese. A knowledge and service based paradigm for industry*. New York. Free Press.

Reich, R. (1991) *The Work of Nations*. New York. Knopf.
Robertson, R. (1992) *Globalization: Global Theory and Global Culture*. London. Sage.
Rollett, H. (2003) *Knowledge Management. Processes and Technologies.* Boston. Kluwer.
Ryle, G. (1949) *Concept of Mind*. New York. Barnes and Noble.
Salthe, S. N. (1993) *Development and Evolution*. Cambridge, MA. MIT Press.
Scheler, M. (1926/1960) *Die Wissensformen und die Gesellschaft*. Bern. Francke.
Scheler, M. (1990) 'The Sociology of Knowledge. Formal and Material Problems', in: Meja, Volker/Stehr, Nico (Eds.) (1990) *Knowledge and Politics. The Sociology of Knowledge Dispute*. London/New York. Routledge. pp. 17-36.
Schütz, A. (1964) The well-informed citizen. In: Collected papers. Vol. II. Studies in social theory. The Hague. Martinus Nijhoff, pp. 120-134.
Sennett, R. (1998) *Der flexible Mensch*. Berlin. Berlin-Verlag.
Simon G. (1995), Géodynamique des migrations internationales dans le monde, PUF, Paris
Sizer, Theodore R. (1992) *Horace's School: Redesigning the American High Schoo*l. Houghton Mifflin Co., Boston, MA.
Smith, D. E. (1990) *The Conceptual Practices of Power. A Feminist Sociology of Knowledge*. Boston. Northeastern University Press.
Stehr N. and Ericson R. V. (1992), *The Culture and Power of Knowledge; Inquiries into Contemporary Societies*, de Gruyter, Berlin/New York.
Stehr, N. (2001) *Wissen und Wirtschaften*. Frankfurt/Main. Suhrkamp.
Stehr, N. (2003) *Wissenspolitik*. Frankfurt/Main. Suhrkamp.
Stein, J. A. et al. (1996), *International Education and Training of Scientists & Engineers and their Employment in European Industry*, PREST Report, published by the European Commission.
Stepin, V. (1999) *Theoretical Knowledge*. Moscow. Progress (In Russian).
Steward, T. (1997), *Intellectual capital. The new wealth of organizations*, New York, Doubleday.
Stockinger, G. (1998), 'The role of variety in the evolution of information society', *World Futures*, Vol 50, p. 715 - 729, Gordon and Breach, Amsterdam
Stockinger, G. (2002), 'The Differentia Specifica of the Social Information Process', in Trappl. R. (Ed.) (2002) *Cybernetics and Systems 2002.* Vienna. Austrian Society for Cybernetic Studies. pp. 185-188.
Sveiby, K. (1997) *The new organizational wealth. Managing and measuring knowledge-based assets*. San Francisco. Berrett-Koehler.
Thompson, J. B. (1995) *The Media and Modernity. A Social Theory of the Media*. Cambridge. Polity.
Tochtermann, K. (2001). 'Greening the Superhighway. Practical Steps to Sustainability in the Information Society', *Foresight*, Vol. 3, No. 2, pp. 113-121.
Toulmin, S. (1972) *Human Understanding*. Oxford. Clarendon.
Ulrich, H./Probst, G. J. B. (Ed.) (1984) *Self-Organization and Management of Social Systems. Insights, Promises, Doubts, and Questions*. Berlin/Heidelberg/New York/Tokyo. Springer.
Vattimo, G. (1994) *The Transparent Society*. Baltimore. Johns Hopkins University Press.
Watzlawick, P. (Ed.) (1984) *The Invented reality : how do we know what we believe we know? Contributions to constructivism*. New York. Norton.
Webster, F. (1995) *Theories of the information society*. Routledge, London.

Weingart, P. and Stehr, N. (2000), *Practising Interdisciplinarity*, University of Toronto Press.
Weisbord, M. (1992) Applied Common Sense. In: Discovering Common Ground. San Francisco. Berrett-Koehler
Welsch, W. (1999), 'Transculturality - the Puzzling Form of Cultures Today', in Featherstone, M. and Lash, S. (Eds.) (1999), *Spaces of Culture: City, Nation, World*. London. Sage. pp. 194-213.
Williams, R. (1974), 'Television and Representation', in: Higgins. John O. (Hrsg.) (2001) *The Raymond Williams Reader*. Oxford/Malden. Blackwell. pp. 179-187
Willke, H. (1995b), *Systemtheorie III: Steuerungstheorie*, Stuttgart/Jena, Fischer.
Willke, H. (1996), *Ironie des Staates. Grundlinien einer Staatstheorie polyzentrischer Gesellschaft*. Frankfurt am Main
Willke, H. (2001), *Systemisches Wissensmanagement*. Stuttgart. Lucius & Lucius.
Zhang, W.-B. (1991) *Synergetic Economics. Time and Change in Nonlinear Economics*. Berlin u.a. Springer.
Zucker, L., Darby, M. & Brewer, M. (1996), *Intellectual Human Capital and the birth of US Biotechnology Enterprises*, NBER Working Paper Series, 1996.

ANTONELLI

References

Aghion, P. and Howitt, P. (1998), *Endogenous growth theory*, Cambridge, The MIT Press.
Alchian, A. and Demsetz, H. (1973), The property rights paradigm, *Journal of Economic History* 33, 16-27.
Allen, R. C. (1983) Collective invention. *Journal of Economic Behaviour and Organization* 4, 1-24.
Amendola, M. and Gaffard, J. L (1988), *The innovative choice. An economic analysis of the dynamics of technology,* Basil Blackwell, Oxford.
Antonelli, C. (1999), *The microdynamics of technological change*, London, Routledge.
Antonelli, C. (2001*), The microeconomics of technological systems,* Oxford University Press, Oxford.
Antonelli, C. (2003), *The economics of innovation, new technologies and structural change*, London, Routledge.
Arora, A., Fosfuri, A. and Gambardella, A. (2001), *Markets for technology*, Cambridge, MIT Press.
Arrow, K. J. (1962), Economic welfare and the allocation of resources for invention, in Nelson, R.R. (ed.) *The rate and direction of inventive activity: Economic and social factors,* Princeton, Princeton University Press for N.B.E.R. pp.609-625.
Arrow, K. J. (1969), Classificatory notes on the production and transmission of technical knowledge*, American Economic Review* 59, 29-35.
Atkinson, A. B. and Stiglitz, J.E. (1969), A new view of technological change, *Economic Journal* 79, 573-578.
Audretsch, D. B. and Feldman, M. (1996), Spillovers and the geography of innovation and production, *American Economic Review* 86, 630-640.
Audretsch, D. B. and Stephan, P. E. (1996), Company-scientist locational links: The case of biotechnology, *American Economic Review* 86, 641-652.
Avimelech, G. and Teubal, M. (2004), Venture capital start-up co-evolution and the emergence and development of Israel's new high tech cluster*, Economics of Innovation and New Technology* 13, 33-60.
Barabasi, A.L. (2002), *Linked. How everything is connected to everything else and what it means for business, science and everyday life*, Plume, New York.
Boschma, R. A. (2005), Proximity and innovation: A critical assessment, *Regional Studies* 39, 61- 74.
Buchanan, J.M. (1965), An economic theory of clubs, *Economica* 34, 1-14.
Cantwell, J. And Iammarino, S. (2003*, Multinational corporations and European regional systems of innovation*, London, Routledge.
Caves, R.E. and Porter, M.E. (1977), From entry barriers to mobility barriers: Conjectural decision and contrived deterrence to new competition, *Quarterly Journal of Economics* 91, 241-261
Chandler, A. D. (1990), *Scale and scope: The dynamics of industrial capitalism*, Cambridge, The Belknap Press.
Cohen, W.M. and Levinthal, D.A. (1990), Absorptive capacity: A new perspective on learning and innovation, *Administrative Science Quarterly* 35, 128-152.
Cooke, P. (2002), *Knowledge economies*, London, Routledge.
Cowan, R., David, P.A. and Foray, D. (2000), The explicit economics of knowledge codification and tacitness, *Industrial and Corporate Change* 9, 211-253.
David, P.A. (1975), *Technical choice innovation and economic growth,* Cambridge University Press, Cambridge.

David, P. A. (1993), Knowledge property and the system dynamics of technological change, in Summers, L. and Shah, S. (eds), *Proceedings of the World Bank Annual Conference on Development Economics.* Washington, The World Bank, pp. 215-248.
Etzkowitz, H. (2002), *MIT and the rise of entrepreneurial science*, London, Routledge.
Feldman, M. P. (1994), *The Geography of Innovation,* Dordrecht, Kluwer Academic Publishers.
Foray, D. (2004), *The economics of knowledge*, The MIT Press, Cambridge
Freeman, C. (1991), Networks of innovators: A synthesis of research issues, *Research Policy* 20, 499-514.
Geroski, P. (1995), Markets for technology, in Stoneman, P. (ed.), *Handbook of the economics of innovation and new technology,* Oxford, Basil Blackwell, pp. 90-131.
Geuna, A. (1999), *The economics of knowledge production*, Cheltenham, Elgar.
Geuna, A., Salter, A. and Steinmueller, W.E. (eds.) (2003), *Science and innovation. Rethinking the rationales for funding and governance*, Cheltenham, Edward Elgar.
Gompers, P. and Lerner, J. (1999), *The venture capital cycle*, Cambridge, The MIT Press.
Griliches, Z. (1992), The search for R&D spillovers, *Scandinavian Journal of Economics* 94, 29- 47.
Guilhon, B. (2004), Markets for knowledge: problems, scope and economic implications, *Economics of Innovation and New Technology* 13, 165-182.
Harabi, N. (1995), Appropriability of technical innovations: An empirical analysis' *Research Policy* 24, 981-992.
Hayek, F. A. (1945), The use of knowledge in society, *American Economic Review* 35, 519-530.
Kauffman, S.A. (1993), *The origins of order. Self-organization and selection in evolution*, Oxford University Press, Oxford.
Kealey, T. (1996), *The Economic Laws of Scientific Research*, London Macmillan Press Ltd.
Kingston, W. (2001), Innovation needs patents reforms, *Research Policy* 30, 403-423.
Laestadius, S. (1998), Technology level, knowledge formation and industrial competence in paper manufacturing, in Eliasson, G. et al. (eds.) *Microfoundations of economic growth*, The University of Michigan Press, Ann Arbour, pp. 212-226.
Lundvall, B.A. (1985), *Product innovation and user-producer interaction*, Aalborg University Press.
Machlup, F. and Penrose, E. (1950), The patent controversy in the nineteenth century, *Journal of Economic History* 10, 1-20.
Mansfield, E., Schwartz, M., and Wagner, S. (1981), Imitation costs and patents: an empirical study, *Economic Journal* 91, 907-918.
Mazzoleni, R. and Nelson, R.R. (1998), The benefits and the costs of strong patent protection: A contribution to the current debate, *Research Policy* 27, 273-284.
Menard, C. (ed.) (2000), *Institutions contracts and organizations. Perspectives from new institutional economics*, Cheltenham, Elgar.
Murmann, P. (2003) *Knowledge and competitive advantage*, Cambridge, Cambridge University Press.
Nelson, R.R. (1959), The simple economics of basic scientific research, *Journal of Political Economy* 67, 297-306.
Nelson, R.R. (ed.) (1993), *National systems of innovation*, Oxford, Oxford University Press.
Nelson, R. R. and Winter S.G. (1982), *An evolutionary theory of economic change*, Cambridge, Harvard University Press,
Nonaka, I. and Takeuchi, H. (1995), *The knowledge-creating company*, Oxford, Oxford University Press.
Nooteboom, B. (2000), *Learning and innovation in organizations and economics*, Oxford, Oxford University Press.

Penrose, E.T. (1959), *The theory of the growth of the firm*, Oxford, Basil Blackwell.
Richardson, G. B. (1972), The organization of industry, *Economic Journal* 82, 883-896.
Richardson, G.B. (1998), *The economics of imperfect knowledge*, Edward Elgar, Cheltenham.
Romer, P.M. (1986), Increasing returns and long-run economic growth, *Journal of Political Economy* 94, 1002-37.
Rosser, Jr J.B. (2004) Complexity in economics, Cheltenham, Edward Elgar.
Scotchmer, S. (2004*), Innovation and incentives*, Cambridge, MIT Press.
Stiglitz, J.E. and Weiss, A. (1981), Credit rationing in markets with imperfect information, *American Economic Review* 71, 912-927.
Von Hippel, E. (1988), *The sources of innovation*, Oxford, Oxford University Press.