Institutions, Property Rights and Markets - The case of Knowledge Markets

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Abstract: The purpose of this paper is to consider the basic questions relative to the creation and organization of markets for knowledge. The paper is organized as follows. We will first explain what means for us an intuitionalist approach of markets, and the key questions relative to the social construction of markets. On that basis, we will consider the specific problems posed by the creation of markets for knowledge. We will insist on three points: the importance of the “singularity” of each “products”, and of the complementarities between knowledge units, and knowledge transactions; the specific problems of evaluation of knowledge items; the importance to consider the systems of institutions implied by the commoditization of knowledge. In a last section we will try to illustrate these points by considering two historical cases: The emergence of a market for technology in the United States in the nineteenth century and the formation of a new “knowledge market regime” since the 1980’s.

Key-Words: Innovation, knowledge, market, institutions.

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Introduction

To characterize our economies as “knowledge economies” is now a commonplace. We will not discuss here the precise meaning, and the pertinence of such a view. The growing importance of scientific and technological knowledge for economic activity is certainly not a novelty; it is a distinguishing feature of industrialized economies since, at least, more than two centuries (Kuznets, 1969). And yet, we can observe since twenty or thirty years some profound changes in the structure and organization of scientific and technological activities, and more globally of “innovation systems”, characterized, in particular by the growing importance of intellectual property rights and markets for technology\(^2\). The extension of the “commoditization” of knowledge and the development of markets for technological and scientific knowledge, and, more generally, for new products or technology directly derived from scientific activities, is, in our view, one of the key features of these transformations. It is also one aspect of a more general tendency to extend markets relationships in various domains, including other knowledge activities.

We know that knowledge as a commodity has particular properties, as compared to the usual economic representation of commodities and markets. These specificities raise many questions as regard the conditions that permit the creation of markets relationships, the consequences of the development of such relationships for the evolution of an activity, and the precise nature of what we call a “market”. The case of knowledge markets shows particularly how the “commoditization” of an activity involves not just the creation of a market, but also a complex process of formation of a multiform institutional system, framing “products”, markets, as well as production structures.

We will here just suggest some first reflections on those questions. We shall proceed as follows: in a first section, we try to clarify what means for us an intutionalist approach of markets. Then, we will treat the particularity of scientific and technological knowledge markets. In a last section, we will consider, as an illustration, two historical experiences: The emergence of a market for technology in the United States in the nineteenth century, and the development of new forms of commoditization of knowledge, since the beginning of the 1980’s.

1. Institutions and markets: some preliminary perspectives\(^3\)

1.1 The institutional arrangements supporting market transactions

We need first to define what is understood by market transaction or market exchange. It is useful

\(^2\) See, in particular, Arora and Gambardella (1994; 1998); Arora et al. (2001; 2006).

\(^3\) On what follows, see Coriat and Weinstein (2004, 2005).
to take Commons (1934) as a point of departure: a transaction is above all ‘a legal transfer of ownership’, and not, as in the standard vision of exchange, the physical transfer of goods. The transfer arising from the exchange (or transaction) only bears on objects because it bears on rights. This is also the reason why it is carried out under terms defined via negotiation between the parties. The rules framing the definition of the object of exchange, the negotiating conditions, the terms of the rights transfer all constitute the institutional basis of the transaction. A market transaction is a specific type of transaction, which is characterized by the parties’ equality of position and equality of desire. This form is defined in contrast to other kinds of transactions, which are based on the subordination of one contracting party to the other. In Commons’ terminology, these would be ‘managerial transactions’ (Commons 1934).

In accordance with an institutional perspective, the realization of exchange and trade is based on specific formal and informal rules, or, following Aoki, (2001 : 78), on a “market governance” system, through a “multiplicity of trade governance institutions”.

The new institutionalism emphasizes two points:

A perfect definition of property rights on all the goods, accepted and respected by the agents, is the first condition for the realization of market transactions⁴.

Along with the set of property rights defined for different types of goods, is required a series of provisions taken to guarantee the enforcement of the system. The neo-institutionalist perspective places heavy emphasis on the problem of the parties’ respect of their commitments, which is supposed to be ensured by what Aoki calls a ‘contract enforcing mechanism’. These modes of governance may take highly diverse forms with regard to the nature of the rules imposed on the parties, the sanctions systems and the agents taking part.

Thus a series of institutional arrangements, related to the definition and the enforcement of the property rights are the basic ingredients of market economies. The enforcement of property rights (and more generally of institutional rules) is considered as the main problem. These analysis are certainly useful, and they grasp some important dimensions of market systems, but they also miss some key points. There is one missing dimension, which is, in our view, fundamental, more particularly as regard knowledge markets: the definition and construction of the ‘objects’ exchanged.

The first logical step in the creation of a market, or for the realisation of market transaction is indeed the definition and delimitation of the entity which will be the object of a transaction, and the specification of rights on this entity. The standard economic analysis of markets, including the developments of the new microeconomics, implicitly considers that the object exchanged is perfectly defined (even if some party can have an imperfect information on it). In most of the transactions proper

⁴ « For this institution (the market) to evolve and function, property rights to economic assets need to be clearly defined and enforced » (Aoki, 2001 : 171)
to the complex economies we live in, however, the definition of the object of exchange is not self-evident, and is not given: it must be constructed. This construction may become one of the major issues of the transaction, as Chamberlin (1953) saw quite well: the product, like the price, is an economic variable.

Furthermore, on numerous markets, the exchange does not concern well-defined products but rather, ‘bundles’ of rights and obligations which are often imperfectly specified. Such is the case, for example, with service transactions. That is why, it is more appropriate to consider that the construction of market transactions are based on the definition of rights (and commitments), concerning the actions of the parties involved in the transaction, rather than on strict property rights, on specific products\(^5\). The construction of the ‘object’ of exchange, and of systems of rights, becomes essential with the creation of new markets, linked to the emergence of new activities, the radical transformation of the organization of transactions, based on new technologies (And more particularly telecommunication and information technologies) or to the commoditization of activities previously carried out in other forms.

That dimension is of particular relevance when considering the conditions of “commoditization” of knowledge. That commoditization will be based on a certain way of defining and delineating ‘items’ which will be appropriated to begin with and then exchanged. It also involves the consideration of the very diverse “objects” in which knowledge can be embodied, as we will see later on. The definition of these items will depend on the characteristics of the overall process of knowledge production – the research activity – on the systems of rules governing scientific as well as technological activities, and of the behaviors and strategies of actors. Besides, the construction of specific objects and the definition of property rights are not sufficient to ensure a smooth running of transactions. It remains to consider how are organized and regulated the interactions between the different agents involved in market transactions. That dimension has been quite completely ignored by the standard economic theorization on markets and competition. And yet, it is certainly a critical challenge to any theory of markets. It implies, beyond the analysis of the institutional basis of transactions, to consider the structure of markets as such.

1.2 From transactions to markets

Thus, one of the central issues of an institutional (or “institutional-organizational”) approach of markets is to analyze the different organizational arrangements upon which the market process are based, the determinants of this arrangements, and their effects on the market process and their outcomes. These organizations should also be considered as institutions as they consist - recalls Aoki - in “humanly devised constraints”.

\(^5\) “What is exchanged on a market is not, as economists often suppose, physical entities, but rights to carry out certain actions”, Coase (1992).
The NIE school literature offer a particular perspective to that question, by considering how alternative ways of coordination of the agents (or alternative modes of governance) emerged. Some modes of governance can be seen as alternative to market coordination (hierarchy), but others as different forms of market governance (the “hybrid” forms).

But the contractual approaches take into account only some limited aspects of markets characteristics; and, by focusing on bilateral transactions, do not really consider markets as such. The distinction between (market) transactions (or “economic exchange”, Harvey and Randle, 2002) and markets is indeed essential. Following Commons\(^6\), it is useful to treat the transaction, and for us here, the “bargaining transaction” as the primary unit of analysis\(^7\). As explain before, the realization of any such transaction imply a more or less sophisticated institutional background, but it does not presuppose the existence of a well-defined and organized market (Harvey and Randle, 2002).

To speak of a market is in itself a problem: it means first that it is possible to aggregate different transactions, and treat them as elements of a same set, or a same ‘field’; it also involve the idea of the existence of a durable structure which is more than the amalgamation of transactions, entailing a more or less continuous process of interdependent transactions, between various and changing agents. If each bargaining transaction can be seen as a temporary relation (as opposed to a “managerial” transaction), a market is a long lasting structure, which exists beyond the identity of the parties, who continuously enter it and leave it, and beyond the specific characteristics of each transaction. In that perspective the market is, as the firm, an institution.

How to justify such a view? Two main approaches are possible. The walrasian view of standard microeconomics defines a market as a (abstract) space where a given product is exchange. On a market, are realized perfectly similar transactions, on identical products. This view presupposes the existence of a strong order that strictly impose the characteristics of any transaction (including the characteristics of the product, or the service), and eliminate the possible singularity of individual transactions. It is in accordance with a vision that supposes a total anonymity of transactions, and no direct relations between sellers and buyers. Such a conception is not only in contradiction with all we can observe in the majority of markets (even when the degree of standardization of product is high), and particularly in a regime of continuous product innovation, it seems logically unable to explain the functioning of markets, as coordinating mechanism, in as much it ignore the concrete conditions of interactions between agents.

If we take transactions as point of departure, and admit the diversity of forms of transactions, and of products; and more than that, if we consider - in line with the vision initiate by Chamberlin\(^8\) - that the

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\(^6\) And others: Harvey and Randle (2002), Callon, 2002; Callon and Muniesa, 2002.

\(^7\) It does not mean that we consider pure bilateral relationships. Commons explain, as we know, that any bargaining transaction involves at least five participants.

\(^8\) See Chamberlin (1953), and, for an analysis along this line, Callon (2002), Callon and Muniesa (2002).
individualization of transactions and products is one of the key variables in the competition game, then the concept of market became much trickier. We think that an institutional view only permit the definition and identification of (organized) markets: there is a market, in as much as a set of particular transactions, and the agents involved in this transactions, are subject to a same system of rules, norms and conventions. It means, in particular, that there exist some social devices, and shared representations and belief allowing the evaluation and comparison of divers’ entities. In that sense, a market cannot be considered as given, it is the result of the interactions between individual and collective agents (including public organizations), aiming at regulating and stabilizing the development of a category of transactions. In other words, it is the result of a process of institutionalization. The collectives procedures, the usual routines and practices, and the formal rules resulting from theses interactions are social compromises between diverging and opposite needs and demands of the agents and are, in many cases, “guaranteed” (at least for a certain period) by a third party to establish the regularities inside which the agents can behave.

A market is not just a “place” or an “arena”, it correspond also to a specific social structure. The constitution of a market goes with the differentiation of separate groups of economic agents (See Harvey and Randles for developments along this line). It is thus inseparable from a process of social division of labour, and from a particular mode of development of the structure of production. There is first, in most case, the separation between sellers and buyers; but there will be also the emergence of intermediaries and others types of agents liable to support the transactions (like, for example, consulting firms or specialized financial institutions), of professional associations, regulatory agencies… The system of these actors, their characteristics and modes of intervention and their relations constitute the market. That dimension is particularly relevant for the understanding of the emergence of new markets.

1.3 Markets as components of social systems of production

Market is a very old institution, but the nature and the characteristics of markets have known profound changes in the course of history. We are mainly concerned here with the understanding of markets in the present-day economies. It means first markets in capitalist economies, where capitalist firms are the dominant actors. Braudel had particularly emphasized the fact that capitalism transform markets and create new forms of markets. He considers that there are “at least two forms of so called market economies” (form “A” and “B”) . The first form concern usual trade, traditional markets on which transactions are “regular, predictable, routine, open to small as well as large merchants” while the other form, on the contrary, is what was called “private markets”, which means a much more closed and “opaque” market, who “substitute to the normal conditions of a collective market individual transactions whose terms are changing arbitrarily according to the respective position of the parties”.

And that it is a basic feature of markets relations: “there can be no market transaction without a process of objectification and singularization” Callon and Muniesa (2005: 1234).

We will come back to that important point later on.
“These are neither the same mechanisms, neither the same agents who are governing these two types of activities, and it is not in the first, but in the second one that the sphere of capitalism take place” (Braudel, 1985). This opposition between two polar forms of markets is important, as regard the reality of the market economy, as well as the conceptualization of markets and economic relationships. Its offer two views concerning markets relations: a first one, in which markets relations are characterized as anonymous and impersonal relations – it has been the central economic vision of “perfect” markets, the ‘walrasian’ market – and a second one that focus on markets, and more generally economic relations as systems of personalized transactions, a view implicitly prevailing in the today contractual microeconomics, as well as in the conceptualization of markets in the new economic sociology. As we will see, it is quite difficult, if not impossible to apply the first view to knowledge markets. It involves some fundamental questions as regard the precise meaning of a market relationship, as opposed to other types of economic relationships.

The “domination” of markets by capitalism has important implications:

(a) The first one is that most markets, if not dominated by firms, are at least mainly structured by firms. Firms are always trying to organized transactions and markets according to their own ends. Following Braudel, it can be interpreted as a tendency to see markets organized much often according to the form “B” instead of the form “A”. This B form is well in accordance with the conception of Chamberlin.

More fundamentally, the strong complementarity and connections between markets and firms is in the heart of our economies. That point has been masked by the post-Coasian view which emphasized the opposition between firm and market; it is yet essential for the understanding of the characteristics of markets (as well as firms) (Azoulay and Weinstein, 2001).

(b) It means also that, with the development of industrial capitalism, the interdependence between markets organization and production became essential, in relation with the radical transformation of production structure boosted by the dynamic of capitalism. Two points are important here: (i) the development of the division of labor and the growing complexity of technologies and systems of production leads to the proliferation of market transaction between firms; and (ii) markets for means of production, and markets for (tangible or intangible) assets are thus at the core of systems of production and innovation. Markets for technology and other types of knowledge markets are mainly of that type. It implies that we have to consider together the structure of markets, and the structure of

11 Fliegstein (2001) explain that « Markets are mainly structured by sellers ». We prefer to says that there are structured by firms: most of markets where firms are buyers, like labour markets, or technology markets in the case of technology sold by individual inventors, are structured by buyers much more than by sellers.

12 However, there can be market regulations directed to impose a market organization more in accordance with the “A form”.

13 Polanyi (1944) notes: “labour, land and money are essential elements for industry; they must also be organised into markets; in fact these markets form an absolutely essential part of the economic system”. The same can be
systems of production; and the co-evolution of the organization of markets and of the organization of firms, and of others types of organizations (like, for example, universities).

In that perspective, it is important to perceive how the process of “commoditization” of a activity means not just the transformation of a given (final) product or service into a commodity, but also the (re)organization of the overall production process and the creation of a system of transactions and markets, and notably of intermediate transactions by vertical disintegration and in some cases by a decomposition of the product or service into separate commodities. That dimension is visible, for example, in the case of privatization and deregulation of public utilities, like electricity or railways. It shows how (i) the definition of the objects of transaction, and by that way, the organization of a system of connected markets, is the result of a social process (in which the State and firms are usually the main actors) and (ii) that process is connected to the structuring of production. This issue is of particular relevance for knowledge markets. The development of knowledge markets is inseparable of the evolution of the definition and delimitation of what types (and form) of knowledge can be an object of property, and thus of market transactions; and of the transformation of the whole system of production of knowledge, including the structure and behavior of firms and of academic institutions, as well as the evolution of non-market forms of interactions between agents.

(c) A market is a particular institution where relations between agents are centered on monetary evaluations and calculations. Agents on markets are calculative agents or, using the terminology proposed by Callon (1998), “calculative agencies”. The procedures, norms and techniques used for the evaluation and determination of the “value” of things are thus central in the functioning of markets. Yet, the capitalism, and even different “varieties of capitalism”, tends to impose their own conceptions, principles and techniques of evaluation. That dimension is of particular relevance in the case of means of production and assets which are nothing else than promise of future outcomes and revenues. It is also essential to recognize that the conditions of evaluation of that type of commodity, the modes of ‘calculation’ and of determination of a ‘price’ and the nature of the devices and institutions involved, are specific.

said, today for knowledge, which has became an essential, if not the most essential ‘means of production’.

Polanyi emphasised also the fact that, whereas, until the end of the eighteenth century, “industrial production […] was a simple appendix to trade”, the development of machinism, with industrial capitalism, “completely transformed the relation of the trader with production”. The need for continuity in industrial production entailed, in particular, regularity in the supply of the means of production, thus ensuring their marketization. In Polanyi’s view, the creation of a market economy imply that labour and land, and more generally means of production became commodities. It is precisely what appends to knowledge.

14 A key question is: “where do transactions come from? Why do they arise where they do?” (Baldwin and Clark, 2002). In other words, we have to consider, how and why a production is divided between separate units, and more than that, between separate firms (or other organizations), having a legal status, and organizing between them markets relationships.

15 See McMeeking and Harvey (2006) for comprehensive developments along these lines, more particularly in relations with the “revolution in Biological Science and Technology”.
(d) Markets must be conceived as components of institutional systems. We can here rely on the comparative institutional analysis approach, and the concept of “Institutional Complementarities” proposed by Aoki (1995, 2001) and used by the “Varities of Capitalism” literature (Hall and Soskice 2001) and the French regulation school (See, for example, Amable 2000, 2003). This literature analyse the institutional framework of an economy as a combination of various institutional “subsystems”. The key point is that the effectiveness, or even the sustainability, of each institution or set of institutions is strongly dependant of the interactions with other institutions\(^{16}\).

In such a perspective:

- The institutional characteristics of a market and its “efficiency” are in general dependant of the characteristics of other markets.

- A market, or a system of markets, is usually dependant of other non-market institutional arrangements.

In other words, the “commoditization” of an activity implies in general the construction of a coherent system of complementary institutions. It means that the existence (or not), of markets transactions in specific activities, the delimitation of the spheres where these transactions are feasible, the characteristics of these transactions, and more generally, the institutional constraints framing the markets, are part of global institutional choices (Choices which can be or not the result of intentional constructions). That point is of particular importance as regard the social organization of science and technology, and the emergence and development of markets for technological and scientific knowledge.

2. The case of markets for scientific and technological knowledge

The specificity of knowledge as a commodity, and the problems resulting of the unavoidable “imperfections” of knowledge markets as been extensively studied by economists. We will first try to identify the specificity of transactions and markets for knowledge. Beyond the traditional vision of economists, we will emphasize the conditions of creation of markets for knowledge and the distinctive features of such markets.

2.1 The specificity of ‘knowledge goods’: some basic issues.

The specific problems relative to the creation of markets for knowledge can be approach along two different lines of thought: the first one, based on the standard approach of market failures, put

\(^{16}\) The concept of complementary institutions is based on multilateral reinforcement mechanisms between institutional arrangements: each one, by its existence, permits or facilitates the existence of the others. (…) The constraints and possibilities defined by a given institution favor other institutions’ functioning” (Amable 2000).
emphasize on knowledge as public goods, and the question of appropriation; a second one, more in line with evolutionary views, insist on cognitive factors explaining the particular problems of creation, diffusion and use of (technological) knowledge, and on the specificity of knowledge as a factor of production and a productive asset.

The seminal papers of Nelson (1959) and Arrow (1962) remains the basic references for the study of the problems of organization of science and technology, and more particularly for the problems of creating market transactions for knowledge. Confronting the standard microeconomic model with the features of the process of production and circulation of scientific and technological knowledge allows pointing out some of their specificities, and already shows some reasons why knowledge may not be considered as any other commodity.

In this type of approach, the limits of markets as organizational device (the “market failure”) came first from the character of public goods of knowledge. The characterization of knowledge as a ‘public’ good involve many ambiguities, in as much it entailed considerations connected to the conditions in which knowledge can be used (as a final, or an intermediate product), in relation with its intrinsic qualities, and considerations of its social and legal status, and more particularly the conditions of access by different agents, resulting from the material, as well as institutional forms it can take, including its ‘property’ regime.

Following the standard economic approach, (i) knowledge is a “non-rival” good\(^\text{17}\) a type of good for which market is not necessarily the most efficient institutional arrangements\(^\text{18}\), and (ii) there are strong problems of “excludability” and hence of appropriability of knowledge. It is important to distinguish these two dimensions. The first one concern the conditions in which knowledge can be used, and the relations between production and use of knowledge; we will come back later on that question. The second one is mainly a question of institutional choices: what ‘legal status’ will be given to different types of knowledge? The appropriation of knowledge raises two questions: may knowledge, and in particular scientific and technological knowledge, be subject to some individual appropriation, and up to what point may this be? If this is possible, is it socially desirable? This second question has received most attention, with regard to the analyses and discussions especially about patent systems. We are not going to discuss those theses here, except insofar as they are leading us to set the first question: how may a private appropriation of this particular type of goods be realized?

As far as scientific and technical knowledge is concerned, the economic approach as been based, until recently, on the distinction between science and technology. On the one hand, there is fundamental

\(^{17}\)“The same amount of knowledge that is used to make m units of output will serve to make m+1 units, and the same knowledge that is used by n persons (producers), can enable n+1 persons to make the same product”. (Machlup, 1984). This does not necessarily imply that the costs of knowledge transfer or training are non-existent or low. On the contrary, one of the features of technologic knowledge consists precisely in the importance of those costs.

\(^{18}\)That is why there is no “tragedy of the Commons” in the case of knowledge. See Nelson (2004: 462).
knowledge, scientific knowledge produce by basic research, with the characteristics of mere public goods, freely available (and mainly financed on public funds). On the other hand, there are R&D activities, the results of which, technological knowledge and inventions, may be the subject of a private appropriation, and of a commercial valorisation. This appropriation is realized through the implementation of statutory and institutional forms: either through a system of legal protection (patents, copyright...), or through secrecy, which implies the internalisation of the activity of knowledge production by the firms concerned.

However, this view raises many questions

(i) Where does the distinction between fundamental (scientific) knowledge and technological knowledge come from? Moreover, how to justify the opposite status of these two types of knowledge, as regard appropriation? Scientific and technical knowledge are both non-rival goods, and there are no obvious reasons to think that excludability and appropriability are easier for technological knowledge than for science.

Actually, the separation between science and technology has been the result of an historical process resulting in a particular mode of division of labor and a particular institutional arrangement, which include a specific way to ‘qualify’ and classify knowledge. It means that there as been some form of agreement, or “convention” on the nature and qualities of different types of knowledge, and different activities of knowledge production. This arrangement is based on a critical differentiation as regards the “rules of the game” governing these different institutions. It concerns first of all the property regime of diverse types of scientific and technological knowledge. The scientific knowledge produced by academic institutions has the status of a “free good”. The world of “open science” is thus governed by a specific set of rules (publicity and the precedence of discoveries, ensuring the discoverers’ reputation and fame, and on availability: the disclosure and the circulation of a discovery cannot be hindered). The knowledge and other outputs produced by the innovative activity of firms, and in particular produced by their R&D units, are intended for private appropriation by different means, including intellectual property systems (Levin and al., 1987).

There can be diver’s ways for justifying such a system, and more particularly, the fact that scientific knowledge must remain outside the realm of private appropriation and commercial relations. A first argument has been that the results of basic, scientific research and more particularly its practical

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19 See McMeeking and Harvey (2006), for a comprehensive discussion of that issue.
20 Except, maybe, by invoking the importance of the tacit dimension in technological knowledge. The reference to tacit knowledge involve a radical break with the neoclassical view (which tend to assimilate knowledge and information), but the thesis according to which the tacit dimension is more important in technology than in science is, in our view, questionable.
21 The “Frascati Manual” presents a codified form of that type of institutional arrangement.
22 “Free good” does not mean that everybody can effectively use it, but just that the knowledge is freely available for those who have the capabilities, and the complementary assets needed to exploit it. The notion of ‘free’ good must clearly be distinguished from that of ‘public’ good. (see Pavitt, 1998; McMeeking and Harvey, 2006).
payoffs are largely unpredictable, so that it preferable to lets that activity financed by public funding, and governed by the scientists themselves, motivated by the “search of understanding”, rather than by the search of practical applications (Nelson, 2004). Another argument, quite different, insist on the importance of the cumulativeness of scientific knowledge production: the outcomes of basic research are used mainly as inputs for the production of new knowledge (rather than incorporated into products services, or production process), so that the rules of the ‘republic of science’ – the disclosure and free availability of research results – are the best way to insure the continuous production, as well as the ‘certification’ of ‘quality’ of scientific knowledge; while a private appropriation of knowledge results would, on the contrary, discourage the production of new knowledge. It remains that a same argumentation could be advanced as regard technological knowledge, as soon as its production can also presents an important dimension of cumulativeness.

In other respects, much of basic scientific research is oriented towards the resolution of practical problems (Nelson, 2004). Actually, we have to recognize that the differentiation between scientific and technological activities has been in great part a social convention – it does not means that it is a useless device - and that there are important interdependencies and overlapping between them. That aspect is particularly relevant as regards the conditions of commoditization of knowledge: we are confronted to a domain in which the interrelations between public and private activities, between private and open knowledge, and between market and non-market relationships are playing a major role.

For the present, let us add two remarks:

- There can be alternative forms of circulation (and of “transactions”, using the meaning given to that term by Commons) of knowledge, linked to specific institutions, modes of production, modes of appropriation and control, and incentives systems. With also divers forms given to (codified) knowledge (patent, publication, but also databases, software, research tools…). These forms are not given, they have to be constructed. It is what can be observed more particularly when a new field of research is emerging, like, for example, in biology and bio-informatics.

- The delimitation of the type of knowledge, which can be appropriate through patent, or another intellectual property system, or any system of rules combined with different forms given to “knowledge goods”, is a basic institutional choice, essential for the conditions of “marketization” of knowledge. It has been, since the beginning of the 1980’s, the object of important, if not radical, transformations. It means that the qualification and classification of knowledge goods, the definition of their property regimes, the delimitation of the realm of ‘scientific’ activities and products, are today particularly uncertain and open. It is in that context that the construction of knowledge markets has to be analyzed.

(ii) The possibility of transactions and markets for technological knowledge (or of valorization of knowledge assets) is based first on the possibility of a private appropriation of knowledge, itself
implying excludability. It is the merit of the first approaches of the economics of knowledge to have emphasized that problem. It shows precisely that a market (and other institutional arrangements) has to be constructed, and that the first step is to create the institutional conditions for appropriation, and the feasible forms of appropriation. It remains to consider how it can be done.

Intellectual property rights have been of course considered as the main means to assure the appropriation of knowledge. The institution of such rights can be seen as one particular application of the general principles of private property rights, as a means to increase the incentives to produce and accumulate wealth. As we will see later on, recent history shows how the creation of patent law actually had led to a development of technological transactions, even if the patent system has not been created mainly for that purpose.

However, the general reference to property rights gives only a very partial view of knowledge markets, on several accounts:

The precise definition and characteristics of these rights can have strong effects on the characteristics of markets. In particular, the mode and the degree of “fragmentation” of a body of knowledge are important as regard the conditions of innovation. As previously explained, before to consider the definition and enforcement of (property) rights, we have to consider how are created the “objects” of transactions. In fact, the definition of rights (right to appropriate, right to use; right to transfer…) and the construction of the objects of transaction is the same things.

Transactions based on patent (or copyrights) are one particular form of knowledge transactions, transactions on existing codified knowledge. Patent (for example) implies to give to knowledge a specific form. It means first that the conditions of codification have in itself an effect on the definition of the good. To patent does not means the codification of a given piece of knowledge, it involved the construction of a specific object.

In other respects, there are means of appropriation others than codified property rights: knowledge, and particularly tacit knowledge, is not a strict public goods, in as much the producer of knowledge (an individual, tam or organization) can have some form of a “natural” de-facto appropriation, due to the specificity and contextual character of knowledge. The first form of knowledge is not a codified form: it the knowledge possessed by (incorporated in) an individual or a group; it can be seen as a “private knowledge”. That form can be also the object of markets transactions, through various channels: research contracts, business service activities, labor markets, firm’s acquisition…

The property right backgrounds contribute just to the definition of what can be an object of market transaction (and possibly, who can conclude such transactions), it remains to see how, on such a backgrounds, a market can emerge.
2.2 Beyond the standard view: some questions about knowledge transactions and markets.

Let us now consider more precisely some specific characteristics of transactions and markets for technological or scientific knowledge. The “new” microeconomics as well as sociological literature on markets has put emphasis on the fact that market coordination is not just a question of price determination, but also of quality. In other words, the “mechanism” of market, the interactions between the parties involved, had to solve two main problems: the definition of the object exchanged, or, more generally, of the characteristics of a transaction, and the determination of a “price”, or a more complex system of payment. Following the approach set out in the precedent section, in order to grasp all the issues involved by the process of creation of knowledge markets, we will proceed as follows: we will first consider how ‘knowledge products’ and transactions on knowledge can be created, and the forms they can take; then the consideration of markets for knowledge will lead us to focus on some key specificities of this markets, and on the problem of evaluation.

The constitution of knowledge as commodity, and the creation of knowledge transactions

In the case of knowledge particularly the ‘product’ and the characteristics of a transaction cannot be considered as given, they have to be constructed. It means that we have first to consider the ‘objects’ in which knowledge can be embodied, and the economic and social ‘status’ given to these objects, which include, in particular all the system of rights and obligations governing the conditions of ‘transfer’ of these objects, but also their conditions of use and production. As we will see, the nature of these objects can be very divers, as well as these systems of rights. Technological and scientific knowledge can take many forms, can be embodied in divers tangible or intangible goods, and be subjects to diversified systems of rights. Transactions on knowledge can concern existing knowledge or knowledge still to be developed. In that respect, not all knowledge transactions can be reduce to the transfer of an object, to a simple exchange relationships, in the usual meaning of this term.23

In order to grasp these issues, it is useful, following McMeeking and Harvey (2006), to take the process of knowledge production as point of departure. Knowledge is first a continuous activity, not a ‘product’ or an ‘asset’. In the course of this process, divers types of objects are produced, these objects are, in the first instance, components of the research process, they include publications and working papers, blueprints, but also technical devices and research tools, observations and databases, modes of formalization and modeling, including computer modeling; software’s; and new capabilities of individual researcher, or teams… . The research activity is “production of knowledge by means of knowledge”. At the same time, some of them will also be used outside the research activity, in other

23 The Antitrust Guidelines for the Licensing of Intellectual Property of the U.S. Department of Justice distinguish, for example: markets for ‘goods’, markets for ‘technology’ (markets for “intellectual property that is licensed”) and markets for ‘innovation’ (Including, for example, agreements for the development of new technologies that will be exchanged, or jointly owned, by the parties: R&D contracts, technological collaborations, etc.). (See Arora et al. (2001:5).
fields, and, particularly, as inputs for innovative activities, the conception and production of new products and manufacturing process, or new services. Thus, diverse types of “outputs” are emerging during a research or inventive activity, which can be subjected to various modes of transmission, appropriation and use (McMeeking and Harvey, 2006). A process of commoditization could be based on this outputs, but what is more important, he will also act upon the form given to them, and the rights governing their dissemination and use, and by that way, it will shape the organization on functioning of the knowledge production system.

Actually, the creation of knowledge markets has to be grasped as a component of a larger process of institutionalization. When a new scientific and technological field emerges – for example bioinformatics – the characteristics of activities and of the divers research ‘objects’ are not precisely established, the modes of division of labor, as well as the modes or relationships between people, and the conditions of circulation of information and knowledge between them, remains mainly informal, inside a limited circle of specialists. Progressively, the structure of the new field, and the rules and norms governing its functioning will take shape. In this process, new special scientific and technological fields could be defined, standard modes of exploration, formalization and modeling will be designed, as well as key research objects, and, in many cases, new organizations and new professions will emerge.

At the same time, the scientific, economic and eventually legal status of these objects will have to be defined, and collectives’ procedures, usual practices and modes of interactions are established. It involves more particularly the definition of the conditions in which they can be used, their conditions of access, appropriation, and diffusion, and consequently what can be, and what cannot be subject to market transactions, and, more generally, to divers forms of contractual relations. One of the key issue of that process of institutionalization is precisely the division between ‘open’ and private knowledge; it being understood that ‘openness’ and ‘privatization’ can take divers forms, and that ‘hybrid’ forms are possible, like, for example, when a knowledge product (such as a software or a database) remains free for some uses, but subjects to an agreement and possibly to monetary obligations for others. The process of institutionalization is, as explained before, the result of the interactions between individual and collective agents, and of the behaviour of these actors, and more particularly, in the present case, of academic institutions and firms. For example, both the changes in the intellectual property system and the way the players - the universities, research centers, the researchers themselves, and the business firms - have been utilizing this system, have been central determinants of the development of knowledge markets since the beginning of the eighteen’s, and their forms.

The standard economic conception on that issue, has been until recently based on a quite strict division between open science and of technology, and between academic and business organization, subject, as explained before, to specific systems of rules. It was supposed to involve a clear separation between scientific knowledge (and discoveries), subject to an obligation of (free) disclosure - and thus
no possibility of commoditization – and technological knowledge (and inventions) for which a private appropriation by means of the intellectual property system was possible. Thus, markets for patents and licenses were considered as the main, if not the only forms of knowledge markets. This is, of course, a very important dimension, but we need to go beyond that vision. It gives certainly a too simple view of the relations between “pure” science on one side and applied scientific and technological research on the other side, and, above all, it is called into questions by the transformations of the overall scientific and innovations systems in advances countries, and more particularly in the U.S., since more than twenty years.

To a better understanding of what can be knowledge transactions and markets is useful to consider the main types of outcomes of the research and inventive activities. They can take three basic forms:

- “Codified” knowledge embedded in various things: working papers, publications, blueprints, patents, and others like databases, models or software programs, formalized method of experimentation…
- New knowledge and capabilities embodied in individuals and teams, resulting from the learning effects of the activity.
- Devices, research tools, prototypes, and other tangible products.

They lead to different ways to create transactions on knowledge (McMeeking and Harvey, 2006; Arora et al. 2001):

(i) Transactions on existing ‘items’ or packages of constituted knowledge. It include Market for technology as defined by the U.S. Department of Justice (markets for “intellectual property that is licensed”), or selling of know-how.

(ii) Transactions on entities incorporating not only constituted and constructed knowledge, but also capacities to create new knowledge, or the planned creation of new knowledge. It covers markets for ‘innovation’ (For example, agreements for the development of new technologies that will be exchanged, or jointly owned, by the parties). Moreover, it is crucial to consider here markets for knowledge and capabilities embedded in individuals and firms, that is labour markets and markets for services with an important dimension of scientific and technical capabilities and expertise, on one side, and markets for high-tech firms (mergers and acquisitions) on the other side.

(iii) Transactions on tangible products.

In each case, the definitions of transactions will have to involve the specification of the precise

25 McMeeking and Harvey (2006:18) gives other examples, coming mainly from Biology and Bioinformatics.
objects concerned, and the specification of rights and commitments of the parties. That operation could be, in the case of knowledge, particularly complex. Let us emphasize some points:

- The delimitation of the object of transaction is crucial. In the first case, for example, it will depend first on the rules and usual practices governing intellectual property (Patent or copyright) in as much it is supposed to establish what type of knowledge can be covered by patent or copyright, the extent of the protection, who can patent, and in what conditions. Thus, the precise characteristics of intellectual property systems are evidently of great importance, as we will see later on. However, the behavior of actors, the way they are using this systems is essential as well. The institutional rules governing intellectual property (and other domains of economic law) are always ‘incomplete’ and imperfect – and changing - they leave a great deal of autonomy (and uncertainty) to actors. It concern in particular the way they can divide a body of knowledge in separate items, eventually covered by separate patents. That aspect, as we will see, is of particular importance, as regard the conditions and the problems of functioning of markets for technology.

Similar questions can concern transactions on knowledge embedded in high-tech firms: in case of an acquisition, for example, what exactly is acquired? In what extent is it possible to ‘buy’ the knowledge and capabilities of a firm? It will depends on various factors, including the legal status of the firm, the diverse contracts in which it is engaged, and notably the characteristics of labor contracts, the form of its assets, and the conditions in which the firm really ‘control’ its intangible assets. Here also a firm had the possibility to divide its assets – and itself – in parts that can be object of diver’s property regimes, and of separate transactions. That possibility will depends of the possible property regimes, of the characteristics of corporate and labor law. Intellectual property rights can favor the disintegration of production, firm specialization and the creation of firms based on the production and property of specific knowledge assets (Merges, 1999). By that way, transactions on firms (and on financial markets) can become a modality of transaction for knowledge, and a way to create a market value of knowledge.

- The definition of the object and form of transactions will depend heavily of the conditions of appropriation, or control, of knowledge. What matters here is, once more, the intellectual property regime, and, more generally, the evolution of the modes of property in capitalist economies. However, we have to go beyond the usual, general consideration on property. If it is true that, as explained by the new institutionalism, there can be no markets without well defined and enforced property rights, what does it means in the case of knowledge? What doe it means to be “in possession” of an item, or a bundle of knowledge? It is important to remark that there exist transactions involving non patentable knowledge (Arora et al. : 6), but a knowledge which is, in some way, control by a firm, or an individual. That question is particularly complex when one consider the possession of knowledge by a firm, and that is precisely what is relevant, as regard the analysis of markets for knowledge. Beyond the legal dimension, we need to consider the conditions
in which a firm can effectively control knowledge (and how it can use it), and in what conditions knowledge can be qualified as a (strategic) asset. It is clearly today one of the key question concerning the economy of the firm in a ‘knowledge-based’ economy. It means also that we have to question the exact nature of intellectual ‘property’ rights.

- Many transactions on knowledge can be considered as being a matter of « futures » markets, as explained by Arora et al. (2001: 5). There are transactions involved in the creation of new knowledge, covering mainly commitments in futures actions. The importance of that type of type of transaction results from the first characteristic of knowledge: as explained before, it must be treated first as a process. Most transactions have to be considered as part of a social, collective process of knowledge production. That type of transaction raise specific problems, linked to uncertainty and asymmetries of information, implying the search of specific forms of organization, interactions and contracts between the parties involved. We find here forms of interactions and coordination that have been sometimes defined as “hybrid” forms, which mean economic forms that are “neither market nor hierarchy”, and which are characterized by strong personalized relations between parties (As opposed to the supposed anonymous and impersonal character of market relationships). These types of transactions are clearly, as regard ‘markets’ for technology and knowledge, the rule rather than the exception. It means that we have to wonder what exact meaning we are giving to the notions of ‘market’, or ‘market transaction’ (Or ‘bargaining transaction’, following Commons’ terminology), and what it means to speak of a ‘commoditization’ of an activity or a product. It is useful here to go back to the reflections of Fernand Braudel, previously set out.

The specificity of knowledge markets: the “singularity” of products and the complementarities between transactions.

Let us consider here the market for new technological knowledge, or the market for “invention”. As regard the object of exchange, the first point to notice is the total singularity of each “product”. Each item of knowledge, more particularly when patented, is, by the mere existence of patent law, unique. As we know the first effect of patenting, the creation of a private property right is not to generate a market, but to create a monopoly.

The singularity of the product goes with the singularity of each transaction. The selling of a licence is negotiated with each buyer. It can take divers forms, depending to the precise rights given to the buyer. This aspect has strong implication for the question of the fixing of a price. Before to come to

26 And the transformation of the firm in today’s capitalism, towards “post-Chandlerian” forms (Lamoreaux et al. 2002).

27 That question is, of course, not specific to markets for knowledge. We can observe today, in economics, a general tendency to consider the (bilateral) contract as the archetypal form of economic relation, which, with the trend towards the individualisation of transactions, can make the notion of markets particularly difficult to grasp.
that point, it is useful to consider what can be a market in the present case.

It is clear that the standard conception of a market has no meaning here (Unless to consider that there is one market for each piece of knowledge). Even a Chamberlinian view is not appropriate: different patents are not close substitutes (apart from very specific cases). On the contrary, what seem important for the organization of transactions are the complementarities between knowledge units, and the interdependence among users (Antonelli, 2002). Theses complementarities are of two types: (i) the complementarities resulting from the fact that the conception and production of a product needs the combination of different rights held by different agents, so that some coordination between rightholders is needed (Merges, 1996, 2000) and (ii) a “vertical” complementarity between an inventor and developers of following improvement or applications (Scochmer, 1991, 2004). This type of relation is essential for the dynamic of innovation and knowledge creation, more particularly in “cumulative” technologies. We have thus, a very peculiar “architecture” of transactions, which leads to specific problems of coordination. These problems have been extensively discussed in the intellectual property rights literature, under the expression of the “anti-commons” in this situation it seems that it is not the imperfection of private property rights that leads to coordination failure (as in the standard property right theory), but, on the contrary the strengthening and extension of (private) intellectual property rights, in as much as it leads to a dramatically rise of transaction cost, and discourage innovation. That problem is all the more important when the production of knowledge is tightly cumulative and knowledge is divided in a large number of items, subject to separate rights. That’s precisely the characteristic that seems to predominate today, because of the increasing complexity of technologies, the multiplicity of knowledge inputs, due to the increasing division of labor by disintegration of production, and the evolution of IPR rules and the IPR strategies of firms.

To overcome these coordination problems, specific institutional arrangements are needed. If we leave out the question of the fundamental choice of a property regime, and consider the case where a (private) IPR regime prevails, different transactional arrangements have been implemented. For example:

- Public rules: compulsory licensing

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28 There is also another key point: a same knowledge can have, and will have in many cases, various very different possible uses, and in particular commercial (as an input for innovation) and non-commercial uses (as an input for research). Moreover, there is, generally, a great uncertainty as regards the possible applications of new knowledge, and the possible (immediate) economic outcomes of its uses. It seems to be an important problem for biotech research. More on that point later on. All these problems are particularly relevant, in as much knowledge is a non-rival good, which can be used simultaneously for multiple uses and by multiple institutions. It implies the possibility to have, for a same item of knowledge, and in a same field, a multiplicity of forms of transactions, including monetary and non-monetary transactions.

29 See, for example; Heller and Eisenberg (1998), for the case of biomedical research.

30 It has also, negative effects on market efficiency, according to standard view of markets competition (Shapiro, 2000). See also, Nelson (2004:464).

31 The proliferation of gene fragment patents is a good example.
- Private arrangement, through “collective rights organizations” (Merges, 1996, 2001), likes “patent pools”\(^ {32}\) or the ASCAP\(^ {33}\).

It seems possible to speak of markets of scientific and technological knowledge (or of markets for technology, a common terminology\(^ {34}\)), in as much as we are confronted with a category of transactions that are subjects to specific rules, (the legal system governing IPR, and other public or private arrangements), to specific systems of control and regulation, and to specific “rules of thumb” and modes of behaviour. We have also a set of transactions where are playing specific categories of agents (eventually changing) in a more or less stable configuration.

The evolution of the rules governing intellectual property rights and the way agents, and more particularly firms, are using the IPR system will give to the market (and to the innovation system) its morphology. In this particular case, we can see clearly how institutions (the IPR system) are resources used strategically – unequally - by agents. The configuration of the market will be the result of these strategies.

_Evaluation: the value and ‘price’ of knowledge._

Remains the trickiest problem: how an evaluation of the «product»\(^ {35}\) can be achieved on a knowledge market? On which basis a ‘price’ can be determined? It is clearly hard to imagine a determination of a price by the confrontation between supply and demand (we cannot even define a “quantity” exchanged). That problem results first of the unique character of each knowledge good, but also of the complementarities between technologies (for users) and of the non-rival character of the product: the value for the buyer depends on the other buyer’s behavior, and on the conditions of access to other technologies, knowledge and capabilities. However, the main problem is uncertainty, and the specific problems of evaluation of intangible assets.

Arrow (1962) made of uncertainty one of the main problems for innovative activities, and as one of the main cause of market failure. Uncertainty is actually present on any market. What is important is the precise nature of the uncertainty involved in an economic exchange, and the procedures and devices by which it is managed. We will just suggest here some lines of thought.

a) The uncertainty is mainly concerned with the “quality”, the precise properties and

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\(^ {32}\) A patent pools is an arrangement in which is created an entity that can licenses the patents of many firms to third parties as a package.

\(^ {33}\) American Society of Composers, Authors, and Publishers.

\(^ {34}\) One possible definition: markets for «intellectual property that is licensed and its close substitutes, i.e. the technologies of goods that are close enough substitutes significantly to constrain the exercise of market power with respect to the intellectual property that is licensed” (U.S. Department of Justice, 1995; quoted by Arora et al., 2001). A more general definition could be “a market for technology refers to transactions for the use, diffusion and creation of technology” (Arora et al., 2001).

\(^ {35}\) A private evaluation, which is, as we know, very different from the social value of an invention or a scientific knowledge.
potentialities of an invention or a new knowledge, and its potential uses. It is a radical uncertainty and, in most cases, more than uncertainty in the usual sense: there is what we have call an “indetermination of the use value” (Weinstein, 1991). The determination of the possible uses of a new knowledge will generally be the outcome of a long, collective, learning process linked with the diffusion of knowledge (and ranking with the production of complementary knowledge). This aspect is related to the unique and specific characteristic of each piece of knowledge (and each research project), as well as to the importance, the complexity and uncertainty of the interrelations between producers and users of knowledge. Of particular importance here is the fact that a scientific or technological knowledge is usually, at the same time, an input for the production of a final product, and an input for the production of new knowledge.

In such a case, we have to consider how will emerge some common representation about the way to evaluate a knowledge, and the procedures implemented in order to produce such evaluations. What is important here is to consider the modes of evaluation specific to economic relations and market transactions, as compared to other fields of activities, and more precisely to the “republic of science”. It means to identify the institutions involved in the process of evaluation, institutions made of rules and conventions, and of specific agents or organizations, like intermediaries, experts or consulting firms. One point that deserves a particular attention is the relations between the scientific and economic fields, and the growing interactions between them. It means that the institutions of science (and their specific modes of evaluation) are susceptible to play a part in market evaluations. We will give an illustration of that point later on. We have here an example of the importance of institutional complementarities, and how market relationships can be dependant of other institutions.

b) The economic evaluation of knowledge is connected to the specific status of knowledge in a capitalist economy: knowledge is an asset. The growing importance of knowledge as a strategic asset can be precisely considered as the basic characteristic of a so-called “knowledge-based” economy. To consider knowledge as an asset means that knowledge has to be regarded as “a useful thing or quality” and “a single item of property” (Winter, 1987)\textsuperscript{36}, and as a source of income. That last feature is clearly critical: as for any other type of asset (and as financial asset), a knowledge asset is a “promise of future earnings”, and the “fundamental” economic value of a knowledge asset is not a question of “utility” (individual or social), it is just the discounted value of the future incomes expected from its productive uses. The value of a knowledge asset derives from the expected market value of the goods produced with it. Of course, the problems of uncertainty and “indetermination” regarding the possible uses remains, but the spectrum of the relevant uses can become much narrower. The key issues concern the conditions in which knowledge can be a source of income. It will depend of the overall structure of

\textsuperscript{36} It is useful to extend the definition, by considering as asset an item that is controlled by an agent, by a legal device (a property right) or by other means. One of the key questions regarding knowledge assets, particularly in a “knowledge-based economy” is precisely to determine the different ways by which different types of assets can be controlled (Granstrand, 2000; Azoulay and Weinstein, 2001). That question is linked to the problem of appropriability of innovations (Levin et al. 1987).
production and innovation systems. In some cases there can be a direct link between one item of knowledge (for example a patent, or a small number of patents) and a product, like in the pharmaceutical industry. Then, technical and market uncertainty as regard the final product is the main problem. In others cases the links between knowledge and final products will be more complex, and another source of uncertainty.

   c) We can apply to knowledge markets what Karpik (2002) says about “quality markets”: they are organized with “external arrangements” that include “judgment and commitment devices” (des “dispositifs de jugement et de promesse”). These devices will be based mainly on the intervention of intermediaries and experts (like, for example in patent pools, where valuations are made by technology specialist (Merger, 2001), and in some cases on evaluation procedures more akin to the ones of the world of science, through the role of publications and the mobilization of “star scientist”, used in a way as “quality signals”.

   The ideal form of evaluation of an asset is, in a market economy, the evaluation through a secondary market. Moreover, such a market allows increasing the liquidity of the asset. This property is of particular importance when the yield of the asset will be obtained only in a relatively distant future, and with a great uncertainty. Could it be possible to imagine such a device for knowledge assets? As we will see later on, the functioning of some financial markets – more precisely of the NASDAQ – for firms specialized in the production of knowledge, could be interpreted in this way.

   Again, it appears that the transformation of knowledge into commodity involve multidimensional institutional changes. Let us try now to see how history can illustrate this view.

3. The construction of markets for technological knowledge: Two examples

   We will consider here briefly two historical cases.

   3.1 The emergence and decline of a market for technology in the United States in the nineteenth century

   Following Lamoreaux and Sokoloff, we can analyze how a specific institutional evolution had contributes to the development of a market of patented inventions. In that story, it is not a surprise to find that the role of US patent system and of some of its specific features – as compared to the British system - has been essential. Two points are important.

   First, the US patent system has been “directed at stimulating inventive activity”, by diver’s ways:

   [37 Lamoreaux and Sokoloff, 1999, 2001; Khan and Sokoloff, 2001.]
low registration fees; reservation for only the “first and true” inventor (in the all world) and the attribution of an exclusive property right. The creation of an examination system (by trained experts), replacing the previous simple registration system (in 1836,) has contribute to the reduction of the uncertainty concerning the “value” of the patent (Lamoreaux and Sokoloff, 2001: 39).

Secondly, the patent system favored individual inventors: patentees must be an individual; firms could not receive patents directly for inventions developed inside the firm.

The result has been the development of a market consisting mainly in transactions between individual inventors and firms, with the emergence of a class of professional inventors\textsuperscript{38}. The increasing number of patents and the increasing percentage of patents assigned (from 1870 to 1911) attest the development of the market, in relation with a fast technological change, proper to the late 19\textsuperscript{th} century. However, from 1870 to 1911, the percentage of assignments “to groups that include patentee” decrease, while the percentage of assignments to Company increase (Lamoreaux and Sokoloff, 1999). It can be interpreted as a movement of specialization at research and invention by patentees:

“The ability to trade property rights in technological information, based on the patent law and other institutions contributing to this market, encouraged greater specialization at inventive activity for the inventor” (ibid. p. 9).

One of the crucial features of this new technology market has been the emergence and key role of specialized intermediaries\textsuperscript{39}. The expansion of the market leads to the need of intermediaries able to provide information about businessmen and firms, at the national level, about the supply of technologies and the technological needs of firms, able to appreciate the value of an invention, and able to help for the financing of innovation. It means specialized intermediaries mainly lawyers and “patent agents”. Their role has been increasing\textsuperscript{40}.

Thus, the “market for technology” in the19th-Century United States took a specific configuration: a market for patents, favoured by the characteristics of the patent system, and structured around three categories of actors: specialized individual inventors, firms and specialized intermediaries. Another key point is that technology transactions, in that context, take apparently the form of “arms-length transactions”\textsuperscript{41}. The constitution of that market seems in accordance with the standard economic

\textsuperscript{38} Lamoreaux and Sokoloff (2001), consider the existence of two types of inventors: in the first type, the inventors tends to retain the control of their inventions, there remains outside the market, while the inventors of the second type are those who where oriented towards the market, and the commercialization of their inventions.

\textsuperscript{39} Lamoreaux and Sokoloff, (2002)

\textsuperscript{40} “By the”mid-1840’s, for example, a number of national patent agencies had begun to publish periodicals (such as \textit{Scientific American}) that printed complete lists of patents issued, provided news about the latest technological developments, featured articles about how inventors could profit from their ideas, and provided extensive space for classified advertisements placed by patent agents and lawyers soliciting clients, inventors seeking partners with capital to invest, and patentees hoping to sell or lease rights to their technologies.” (Lamoreaux and Sokoloff, 2001:40)

\textsuperscript{41} That observation, made by Lamoreaux and Sokoloff, (2001), seems in contradiction with the common view
view: the definition and enforcement of well specified property rights permits the formation of a market, and the development of the division of labor and specialization. But, the evolution of US capitalism will progressively erode that system.

First, early in the twentieth century appear “a trend towards long-term attachments between highly productive inventors and particular firms” (Khan and Sokoloff, 2001), which means a form of relation quite different from a “standard” market relation (More in accordance with the type B market analyzed by Braudel). This trend continues during the greatest part of the twentieth century. But, the more important evolution concern the industrial structure: the evolution towards a system dominated by the large corporation where innovation is based mainly on in-house R&D, and a relative decline of the individual inventor, and of the market for technology.

This evolution is part of a global transformation of industrial structures, and of the conditions of production and diffusion of scientific and technological knowledge, coupled with a transition from a “Schumpeter mark I” to a “Schumpeter mark II” innovation regime:

(i) The institutionalization and professionalization of innovation and R&D (Noble, 1977; Mowery and Rosenberg, 1998), based on two key structural evolutions:

(ii) The emergence and growing domination of the large integrated corporation: the “Chandlerian” Firm. It means that an increasing fraction of the production of technological knowledge has been realized inside the firm: the “visible hand” has substituted for the market coordination.

(iii) The development of scientific institutions, which means the production and diffusion of scientific knowledge by non-market institutions, and non-market forms of coordination.

3.2 The end of the twentieth century: towards a new knowledge market regime?

The capitalist economies, and first the US economy experience profound transformations since the beginning of the eighteen’s. This evolution combine different dimensions, and notably, a profound transformation of firm’s structure and strategies (See, for example, Lamoreaux et al. 2003; Sturgeon, 2002; Langlois, 2003, Berger, 2005). It can be summarize in two key dimensions: (i) the transformation of the structures of production, connected to profound technological changes, towards a so called “knowledge-based economy”, and (ii) the rising importance of financial institutions, and financial markets, “the rebirth of financial capitalism” (Baker and Smith, 1998). It also include, a rising importance of markets relationships, by different ways: vertical disintegration of firms, privatization of public utilities, and the creation of markets for new type of services, which include the extension of the
“commoditization” of knowledge and the development of divers forms of markets transactions for technological and scientific knowledge, as explained before. In some sense we can see that evolution as a revenge of the markets on the “visible hand”42.

We will try here only a first assessment of the specific features of the new forms of scientific and technological knowledge transactions and markets, and their links with the overall transformations of the institutional bases of capitalism. These transformations affect three connected fields: intellectual property; the structure and behaviour of firms and scientific organizations, and –last but not least – the finance institutions and markets.

A new intellectual property regime

A first key factor of this new “techno-science” regime lies in some crucial institutional changes regarding intellectual property rights in the USA, the formation of a “new regime of intellectual property rights”43. It has different dimensions concerning:

(i) Who can patent? : The “Bayh-Dole Act” permits non-profit research organization to patent and commercialize technologies developed with public funds (1980). This new regulation will boost patenting by universities, and will contribute to a more global evolution of their behavior and strategies, towards a growing importance of market-oriented research activities.

(ii) The increase in patent protection (The effects of the creation of the CAFC44, and of the “doctrine of equivalent”).

(iii) The extension of what is patentable: scientific discoveries involving living matter (The “Chakrabarty Ruling” granting a patent on a genetically-modified organism, 1980); research tools; software, business methods…

These two changes, combined with the growing importance of competition by innovation, will deeply contribute to give to the “knowledge-based” economy a specific orientation where the control and appropriation of knowledge, through intellectual property, became a central strategic tool as an instrument of rent-seeking.

The transformations of firms and scientific institutions

The second dimension is relative to the transformations of the industrial and scientific systems. First, the general evolution of industrial structure and firm’s organization towards a “post-Chandlerian” system is, as we know, characterized by the development of externalization and vertical disintegration by firms. This evolution has certainly different cause, one of them is the increasing complexity of

42 It does not mean a decline of the large corporation, but transformations of their forms and strategies.
44 Court of Appeals of the Federal Circuit, created in 1982, in order to unify patent doctrine.
technologies, leading to an increasing specialization and division of labor, more particularly in knowledge production, and to a growing importance of knowledge transactions between firms (and between firms and other types of organizations). It means that, on one side, a firm can exploit his knowledge and capabilities assets, not only by incorporating them into products or services, but by directly selling (or licensing) them to other firms. And, on the other side, a firm can, and, very often, is obliged to resort to external knowledge and capabilities in order to fulfill its objectives. Overall, we observe, in the new capitalism, a growing importance of knowledge as strategic asset, which has strong implications as regards firm’s governance and organization (Rajan and Zingales, 2000), as well as inter-firm relations, and inter-firm markets. Thus, the conditions of organization of knowledge transaction became more and more important, and a key component of the new industrial system.

Another central dimension of this system has been the emergence of new types of firms: knowledge-intensive firms, including firms specialized in the production of knowledge (Notably in Biotech). These firms, are more particularly start-up companies, often promoted by (and on) the financial markets (Orsi, 2001; Coriat, Orsi and Weinstein, 2003, Antonelli and Teubal, 2006). These firms are, as we know, very important components of innovation systems, but, what is more directly important as regards our subject, is that these firms are also a central element of a new form of knowledge commoditization, in connection with the Venture-Capital system, as observed by Antonelli and Teubal (2006): the creation of such knowledge-intensive start-up companies, with the support of Venture-Capitalist, realize a “bundling of knowledge with other complementary goods” (managerial capabilities, business services and financial assets) (Ibid.: 15), and the transactions on these firms, notably through financial transactions, became a major form of knowledge transaction.

The transformation of scientific institutions, universities and public research centers, giving a major part to market-oriented activities is also central for the new regime. It express itself in the “invention of the entrepreneurial university” (Etzkowitz, 2002), and the emergence of a scientific entrepreneurship, based upon venture capitalism. These transformations and their implications as regard the overall properties, behavior and effectiveness of academic institutions would deserve a specific study. We will just note that the universities are thus engaged in market-like relations in mainly two ways: (i) direct contractual relations with firms, and (ii) scientific entrepreneurship, the creation of knowledge-intensive start-up by researchers, support by their institution.

The role of Finance

The third key dimension of the new system is the critical role of finance. As explained before, the “rebirth of financial capitalism” is one the most important, if not the most important trait of the transformations of our economies since the 1980’s. The connections between finance and the development of knowledge markets are essential to appreciate the characters of the new regime.

Actually the acquisition of a firm is nowadays one of the usual ways to acquire knowledge and
capabilities. The overall transformations of financial systems, including the developments of financial markets, and the emergence or increasing activity of new financial actors (And notably, LBO and Venture Capitalists), combine with the new forms of firm’s behavior and a tendency to incessant restructuring, have boost operations of mergers, acquisitions, takeovers, … The reasons and logics behind these operations are complex, but in some cases there are oriented towards acquisition of specific knowledge and capabilities. As explained before, the acquisition of a firm means the acquisition of a bundle of assets, including strategic knowledge assets. This type of knowledge transaction can be important between large existing corporations, but it is also crucial as regard the new small knowledge-intensive and knowledge producing firms, specialized in R&D. Financial markets are in the heart of this new mode of (knowledge) transactions. The ease of access to Stock Exchanges, and more particularly for new high-tech firms is then a central issue. As explain by Antonelli and Teubal (2006), the acquisition of small knowledge intensive companies either before or after their initial public offering, is an important form of acquisition of technologies, a substitute to internal knowledge production, or R&D outsourcing. Specific conditions of financing for these firms are the condition of viability of this system. The combination of Venture-Capital and specific financial markets has been the main answer, at least in the US, with the NASDAQ. The precise rules governing these financial markets are of critical importance: the development of venture-capital, in the US, would have been impossible without a key new financial regulation: the new rules for NASDAQ IPO’s (1984), which permit the quotation of firms without “immediate earnings”, but with “high growth potential”, based in particular to the detention of non tangible assets: patents, copyrights and trademarks.

The architecture of the new knowledge market regime

The “commoditization” of knowledge, the constitution of a feasible system of knowledge transactions and markets rest on a complex system of institutional and organizational complementarities. We have just try to give a first evaluation of what seems to us some key dimensions of a new regime, mainly in the US economy. Let us add some points.

(i) The transactions are mainly of three types: standard “technology” transactions, on markets for ‘technology’ (markets for “intellectual property that is licensed”); more complex contractual relations, corresponding to ‘innovation’ transactions, including, for example, R&D outsourcing, agreements for the development of new technologies that will be exchanged, or jointly owned, by the parties. These two modes of transactions are not new; the specificity to the new regime lies in the importance of the third form: knowledge transactions through transactions on firms. This last form is inseparable from the new configurations of industrial and financial systems. It shows the

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45 Thus, we have: “a dedicated market place specialized in knowledge intensive property rights where the shares of new companies can be traded and exchanged. Its innovativeness lies in its internal architecture and on its impact on the economic system at large.” Antonelli and Teubal (2006: 10).

strong interdependence between the conditions of *production*, and *diffusion and exchange* of information and knowledge goods. It remains to explain more precisely the profound reasons, and the implications of the present system.

(ii) The key actors of the new regime are first, as before, firms and scientific institutions. But what matters, as we have seen before, are the transformations of these actors, of their modes of organization and governance\(^{47}\), their behavior, and their relations. We have here a good example of the *institutional complementarities between firms* (and others organizations) *and markets* forms. The other important fact is the leading role of new actors (or their increasing importance) in the “knowledge field”: new types of small knowledge-intensive firms, and financial actors, and first the VC agents as key specialized intermediaries.

(iii) We have support the idea that the construction of knowledge markets is confronted with two central problems: a problem of coordination resulting from the strong complementarities between knowledge units, and a problem of evaluation of the knowledge assets. The increase in patent deposits, due to the strategic use by firms of the opportunities open by the new IPR regime, and more generally the multiplicity of rights and controls over various pieces of knowledge, make the ‘complementarity question’, and the resulting problem of ‘anti-commons’ particularly critical. As explained before, it leads to the search of specific institutional arrangements for the coordination and regulation of knowledge transactions. The first usual arrangement is in the design of common rights organizations, and notably, patent pools. Patent pools are an old institution; there where very usual at the beginning of the 20\(^{th}\) century, there seems to be very important today, since the end of the 1990s (See Lerner and Tirole, 2007). But the knowledge transactions by way of firm’s acquisition can be seen also as a mean to deal with the needs to control complentary knowledge. The acquisition of a firm assure – by one transaction - the acquisition and control of a collection of complementary pieces of knowledge, required for the realization of some activity. As explained before, a firm, and more particularly a high-tech knowledge-intensive firm, constitutes a bundle of divers and complementary knowledge and capabilities. An important point is that it combines *codified* knowledge, which could be protected by intellectual property rights, and *tacit* individual and collective knowledge, embedded in individuals and teams. A market transaction *on tacit knowledge* is realized by that way. The complementarity between codified and tacit knowledge is here very important, inasmuch it can be a way to assure the effective control of individual and collective capabilities, that is of tacit knowledge which cannot be subject to property rights. It would be the case if the researchers and engineers of the acquired firm could not continue their activities without the access to the complementary codified knowledge (protected by property rights). It contributes to increase the importance of intellectual property rights, as an instrument of

\(^{47}\) The links between the evolutions of the dominant rules of Corporate Governance, and the strategies of firms, as regard R&D and technology, is an important matter. It would need a specific study.
firm’s strategies, but it could also make the problem of anti-commons even more critical.

The evaluation of knowledge assets, condition of the realization of knowledge transactions, seems a particularly difficult question. Let us just note here how the organization of transaction of firms, as bundles of assets, can appear as a solution. First, precisely because of the strong complementarities between the assets (as means of production), it is easier to estimate the value of the bundle of assets (resulting of the future productive used of these assets) that the separate value of each asset, and more particularly of intangible assets. Secondly, through IPO, the financial market could appear as a way to produce a ‘true’ market evaluation of the firm, and, by that way, in the case of knowledge-intensive firm, a true market value of the knowledge assets on which it is based, the liquidity of the financial market providing a form of collective recognition of this evaluation.

Such a view is in accordance with the central place of finance in the new system of production and exchange of scientific and technological knowledge, and the more global domination of financial capitalism. It remains to appreciate what could be the overall properties and outcomes of such a system, which seems dependant of a doubtful assumption of a perfect efficiency of (financial) markets.

**Conclusion**

We have tried, in this paper, to propose some first reflections on the conditions of creation of transactions and markets for knowledge, and the forms they can takes in contemporary capitalism. It raises many questions, concerning the nature and forms of markets relationships, in the today complex capitalist systems, which can be very distant from the usual standard economic view of the market, and relative to the specificities of knowledge and information as commodities, and of the scientific institutions. Let us mention here three issues.

The conditions of construction of knowledge products and services and the definition of (property) rights are the first key issue. There is no ‘natural’ mode of existence of knowledge. The forms given to knowledge and information, including the forms of codification and the delimitation of codified and tacit knowledge, the definition and delimitations of knowledge items, the modes of incorporation of knowledge in tangible and intangible objects are the product of complex social and institutional constructions. One of the most critical dimensions of these constructions is the definition of the condition of access (or exclusion) to different categories of knowledge, that is the definition of system of (property) rights, but also the characters of other economic and social structures which condition the de facto capacities, influence and power of different actors. In that respect, the evolution of the forms of ‘property’, appropriation and control in capitalist economies is a major issue.
The development of “knowledge markets”, and their diverse modalities and modes of functioning can be understood only as part of the global transformation of the social systems of production and innovation. Thus the formation of specific institutional complementarities and the conditions of their evolution and coherence and stability (or, on the contrary, their potential contradictions and shakiness) are key issues. The problem is not mainly to notice these complementarities, but to understand the causes and conditions of their constitution, and to assess their possible evolutions, as well as to explore the possibilities of diverse institutional configurations and their properties.

The last important issue is relative to the conception of a market, and a market economy, we can hold. The supposed ‘markets for knowledge’ (Or ‘market for technology’, ‘market for innovation’...) have specific features, completely different from the usual economic representation of a market. What we can observe are diverse forms of transactions, with diver’s institutional arrangements, which are often close to the “hybrid forms” of the new institutional economy, rather than to strict market transactions. The question is: are there ‘real’ markets for knowledge? And, more fundamentally, what does it means exactly to speak of market relationships, and of markets? The conception of Braudel, that we have previously recalled, suggest that we have to question the ‘nature’ of the market in capitalist economies, in economies dominated by firms, and large corporations. And, following Polanyi, we can support the idea that the development of industrial capitalism, and now of a “knowledge capitalism”, imply the extension of markets relationships, but at the same time completely transforms the relations between production and trade, and by that way transforms the ‘nature’ and forms of ‘markets’.

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