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Knowledge Networks and Markets: A Typology of Markets in Explicit Knowledge

25 June 2010

Delegates will find attached a paper on knowledge networks and markets, a horizontal activity of the DSTI, for discussion under item 10 of the draft agenda. Delegates are invited to comment on the document and indicate how TIP could contribute to this work in the context of its work programme for 2011-2012. Written comments are requested by 15 July. Following the TIP meeting, the paper will be revised and presented to the DSTI Committees in the autumn.

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KNOWLEDGE NETWORKS AND MARKETS: A TYPOLOGY OF MARKETS IN EXPLICIT KNOWLEDGE[1]

1. Background

1. Knowledge is, along with capital and labour, an essential factor of economic growth. Well functioning capital and labour markets have long been recognised as necessary for an efficient allocation of resources and for economic growth: but the movement of knowledge throughout the economy has only recently attracted significant, wide-spread attention. Traditional analysis has often viewed knowledge as circulating as embodied in labour and capital and through unintended "spillovers". These are all somewhat inefficient allocation modes, as embodied knowledge circulates according to rules made for the embodying factor – in this case, labour or capital – not for knowledge itself; and spillovers by definition are not controllable, hence not subject to decisions that could optimise them. In addition, spillovers do not allow the investing party to recoup the cost of producing knowledge, hence deterring investment in knowledge in the first place. These inefficient modes of distribution are a consequence of the public good (non rival) nature of knowledge, whose use by one party does not prevent simultaneous use by another party, making it difficult to design and implement mechanisms which provide appropriate incentives to share and circulate knowledge: standard market mechanisms, which require exclusivity of use, don't apply to knowledge in a straightforward way.

2. The mechanisms through which to distribute knowledge across the economy are changing, largely due to the expansion of knowledge production, to the development of information and communication technology which facilitate the storage and circulation of knowledge and to globalisation, which expands the playground for knowledge related activities. The OECD Innovation Strategy calls these mechanisms "knowledge networks and markets" (KNM) which it defines as "arrangements which govern the transfer of various types of knowledge … between independent parties" (OECD, 2010a, 149). KNM take many different forms and may be formal or informal in nature. "KNM are extremely varied: some are essentially based on prices and direct monetary transfers (*i.e.* markets); others are based on structural relations or networks; still others are a mix of the two" (OECD, 2010a, 149).

3. The circulation of knowledge is not new: skilled workers have always been mobile, scientific publications have been available almost since the invention of the printing press. The novelty today is the scale and structure of the circulation of knowledge. Through digitization, the Internet and communities of practice that literally stretch around the globe, more knowledge is produced, is available and used than ever before. As knowledge begets knowledge, building structures – physical and social – through which to circulate knowledge easily and fairly becomes a key factor in both economic and social growth.

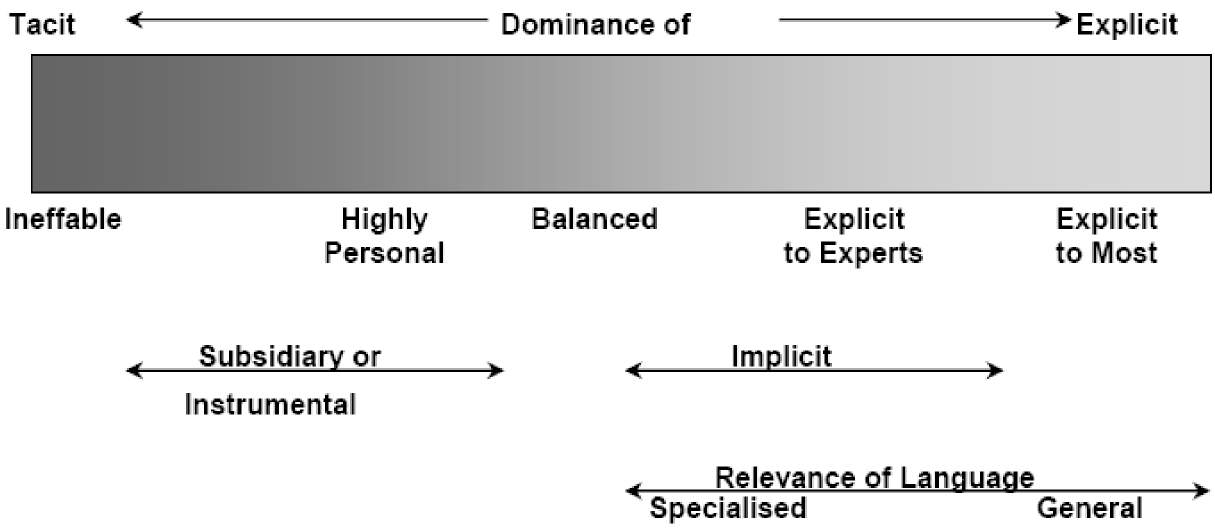
4. This document is a contribution to an effort by the OECD to explore the types, function and effect of KNM on innovation. It relates to two other reports of the same vein which reflected the results of two workshops focussing on the life sciences: Knowledge markets in the life sciences (OECD, 2010b) and

1 This paper draws on a contribution from Richard Gold, Consultant to the Secretariat and extensive comments from the OECD Expert Group on Knowledge Networks and Markets.

Collaborative mechanisms for intellectual property management (2010c). This document maps out the conceptual and policy issues raised by those KNM that function through price and direct monetary transfer or equivalent, arms-length, usually isolated, non-market transaction. It leaves aside other forms of KNM, particularly those that involve collaboration or long-term relationships. The study is structured as follows. Section 2 sets out the broad context in which KNM are emerging and the main features of knowledge circulation. Section 3 submits a typology of KNM and gives a detailed description of those KNM that function through the market and arms-length, isolated transactions. Section 4 addresses the impact of these KNM on innovation. Section 5 reviews the policy challenges that KNM raise. Section 6 concludes.

2. Knowledge flows and innovation

5. Knowledge is far from homogeneous: some knowledge is (relatively) easy to package and hand over to another person with little extra effort by the acquiring person. Other knowledge is so engrained in our ways of being and doing that another person can only access it by learning from a person who embodies it in his or her actions, skills and habits. Kenneth Grant (2007), relying on the foundational work of Michael Polanyi (1958, 1959), illustrates the spectrum of knowledge in the following figure:



6. While all forms of knowledge are required in science and innovation – the research habits of scientists, the assumptions they bring to their research, the scientific language in which results are communicated, etc. – KNM deal principally with the circulation of implicit and explicit knowledge which lie on the right half of the above knowledge spectrum. Through a combination of training, participation in communities of practice, personal interaction, and access to knowledge set out in publications, patents and other material, scientists and other actors use, combine, develop and improve knowledge. The role of KNM is to facilitate the use of these forms of knowledge in a way that takes into account the nature of the knowledge, incentives to invest in knowledge creation and dissemination, and the needs of national and international communities.

7. No knowledge is truly explicit in the sense that it can be absorbed and used by any person without some background in the field. This is particularly true of scientific or academic knowledge that requires capacity in the language, fundamental concepts and starting assumptions of the discipline. Some knowledge requires much specialised knowledge and is held by a small set of scientists while other knowledge requires an intimate understanding of a conceptual framework held by a very few. That is, knowledge contains different combinations of explicit and implicit knowledge and thus falls along various parts of the above spectrum.

8. One way to quantify how much of a particular unit of knowledge is implicit and how much is explicit is its level of 'stickiness' (von Hippel, 1994). The greater amount of implicit knowledge – and hence the greater amount of effort and cost for another actor to access it – the more sticky that unit of knowledge is. While all knowledge is, to some degree, 'sticky', the costs that one must expend in order to use it varies depending on how much extra one must learn to be able to fully use the unit of knowledge (von Hippel, 1994, 430). As KNM provide a set of mechanisms designed to facilitate the circulation of knowledge among independent parties, their form and structure will depend on the nature and 'stickiness' of the knowledge in need of circulation. Thus, just as with the underlying knowledge they seek to circulate, KNM lie on a spectrum from those units of knowledge that can circulate without much extra effort – generally through the market or market-like structures – and those that can only circulate when individuals and organisations are brought into close contact – for example, collaborative research initiatives.

9. This study deals with units of knowledge that lie on the explicit, or non-sticky, side of the spectrum. Those units of knowledge are captured in various forms that include peer-reviewed articles, patent applications and shared databases and are the most susceptible to trading through market and arms-length mechanisms. That is, this study focuses on that sub-set of knowledge that is explicit and that can be traded separately without significant interaction between those providing and those accessing the knowledge. While some of what follows applies to other types of knowledge, this study will not elaborate upon those forms of knowledge. This is not because other knowledge is less important – it constitutes, in fact, the bulk of knowledge necessary to create innovation – but because explicit knowledge is both deserving of a separate analysis and engages in particular KNM based on the market or non-commercial but still arms-length interactions between actors.

An Economic Understanding of Explicit Knowledge

10. Knowledge is characterised as "non rival", in the sense that the use of one piece of knowledge does not prevent the simultaneous use of the same piece by another party. This applies of course to disembodied knowledge, due to its intangible nature. This can be formulated also as the fact that the marginal cost of implementing a piece of knowledge is zero: once an invention is there is no need to invent it again (although there may be a need to adapt it to the circumstances). That applies for instance to information circulating on the Internet.

11. Non rivalry is one important reason why knowledge can generate spillovers: once a piece of knowledge satisfies the standard economic return requested by investors, it can still produce further value which accrues to competitors for customers, who can derive further benefit from the knowledge. In terms of social optimum, it is therefore preferable that existing knowledge be used by as many agents as possible. On the other hand knowledge needs to be produced in the first hand, including by private parties, which requires resources to be invested, which in turn requires some private return that most often depends on the ability to exclude users who would not pay some price. On the other, knowledge is needed by others to spur competition and bring down prices. This tension between static efficiency (competition to bring down prices) and dynamic efficiency (in encouraging investment in the creation of new products and services) results in a necessarily imperfect compromise: intellectual property (IP) rights that includes patents, copyrights and sui generis database protection. "A patent system should take account of the interests of all parties: inventors, competitors (actual and potential) and customers" (OECD, 2010a).

12. The knowledge at the centre of this study – explicit and non-sticky knowledge – raises the issue of excluding other parties from using existing knowledge. Means used to assure excludability can be technical (e.g., protection of access by passwords), legal (copyright, patent) or organisational (keeping knowledge secret). Excludability is a key condition for explicit knowledge to have private monetary value. Otherwise, as anybody can freely use it without control, the willingness of users to pay for knowledge significantly shrinks and depends mostly on the ease of knowledge acquisition. The public domain is a

major example of non excludable knowledge. Public domain knowledge can be used free of monetary payment, but of course access to this knowledge could involve some monetary or non monetary costs (for example cost of internet connection; or the time devoted for searching the right information in the middle of mountains of irrelevant information, like a needle in a haystack, etc.)

13. Another economic property of knowledge that differentiates it from physical property is that knowledge grows over time. New knowledge is created based on old stock, new discoveries rely on current level of science, new ideas originate from yesterday's experience. This clearly stems from the fact that knowledge is non rival and that it is virtually impossible to destroy. The fact that knowledge can be cumulated over time gives sense to the notion of knowledge capital. Unlike physical capital, knowledge capital is not depleted when it is used (although its monetary value may change depending on use).

The importance of knowledge flows for innovation and productivity

14. The unique properties of knowledge imply that the notion of "knowledge circulation" is somewhat different from the notion of "circulation of goods". Unlike physical goods, explicit knowledge can circulate and be kept at the same place simultaneously. It means that a unit of explicit knowledge can be shared, between an initial user and a new one. New users of knowledge do not necessarily crowd out existing ones. Hence, knowledge flows or knowledge transfer can also reflect knowledge sharing. In the following, we will in general refer to the notion of "transfer" when the initial knowledge holder agrees not to use the explicit knowledge s/he transferred, and to the notion of "sharing" when the recipient joins the initial owner in the ability to use the explicit knowledge. For instance, when a unit of knowledge (*e.g.,* a novel molecule) subject to a patent right is transferred along with the patent, the originator has transferred that knowledge. Conversely, a database is shared between two parties when both agree to have access to it.

15. The non rivalry of knowledge has a second economic impact. Whereas, with respect to tangible property, the issue is to find the single best place for it and to identify which type of market or administrative mechanism will lead to this allocation, the situation is different with respect to explicit knowledge that can be used in several places simultaneously. The goal here is not to determine the *best* place for a given unit of knowledge, but to determine all the places in which this unit of knowledge can be used efficiently (taking into account all types of direct or indirect costs). In view of this essential difference, it is to be expected that the mechanisms allocating explicit knowledge across the economy will differ deeply from those allocating tangible goods and factors.

16. Explicit knowledge flows arise whenever two separate entities (individuals, universities, companies etc.) engage in transferring or sharing knowledge. These flows are essential both to innovation and to production processes, which all require access to explicit knowledge as an input. Inventions are born out of the combination of existing ideas, data and insights (Weitzman 1998), which are initially separate and need to be put together for new ideas to emerge. Hence easier conditions for explicit knowledge flows will foster innovation. They will allow a better exploitation of complementarities across innovative entities, hence boosting the collective efficiency of the involved innovators. For instance new drugs increasingly result from the joint work of biotech companies (specialised in the identification and analysis of genetic pathways) and pharmaceutical companies (which know more on the effects of drugs on human health). Complex products like airplanes (*e.g.,* the Airbus A380) involve complex structured supply chains made up of hundreds of businesses, each contributing its own innovations. Finally, knowledge flows make possible a broader, more diverse use of existing competences and knowledge, beyond the uses or applications foreseen by the sole proprietor: a skilled biotech expert can apply his/her ingenuity to solving a problem raised by a chemical company and a new material invented for airplanes can find use in bicycles.

17. The circulation of explicit knowledge is also essential to productivity growth, as inventing and manufacturing goods are two distinct activities, which rely on quite different competencies and facilities. Users of inventions can be manufacturing companies with little or no internal capacity to innovate but a strong ability to assemble and market products. Knowledge flows allow companies to specialise in what they do best; it allows inventions to be implemented by actors other than the inventor, who is not necessarily good at manufacturing and marketing products. It facilitates the emergence of companies that specialise in research in industries such as biotech, chemicals or IT. By making inventions available to a broader range of potential manufacturers, knowledge transfers also allow the implementation of an invention at a larger scale, its embodiment in a larger quantity and variety of products. For instance certain specialised electronic devices invented by one company are implemented in many products manufactured and marketed by various companies. This has been especially important in the context of globalisation, with the emergence of global value chains, in which the comparative advantage of countries, either for inventing or for manufacturing, can be better exploited by multinational firms.

18. Explicit knowledge flows generate value which is partly appropriated by those contributing the transferred knowledge through prices or other rewarding mechanisms, and which can partly go to other parties as knowledge spillovers. Their relative importance depends on the mechanisms used to transfer knowledge, which have an uneven capacity to internalize the value of inventions.

Channels of explicit knowledge flows

19. While this study focuses on the circulation of explicit knowledge, it must be recognised that explicit knowledge is frequently transferred or shared either in conjunction with other forms of knowledge (*e.g.,* know-how) or embodied within other economic factors (*e.g.,* in products or through skilled workers). In fact, in view of specific difficulties in knowledge transactions, notably appropriability of the return, sellers might choose a less efficient but safer way of transferring knowledge in an embodied form. When embodied, knowledge is subject to the physical constraints and legal rules applying to its vector rather than that applying to the knowledge itself. For example, the preference of proprietary software or music producers for CDs rather than for digital transmission of a program or song over the internet or the resistance of some experts to codification of their knowledge may be examples of this phenomenon.

20. KNM have important effects on the circulation of knowledge and more broadly on the economic and social organisation of research. Specifically, with respect to the circulation of explicit knowledge, a discussion of KNM raises issues such as the valuation of knowledge, appropriation of this value by the parties involved in the transactions, risk sharing, etc.

Interactive invention: Clusters, industry/university relations, open innovation

21. Many of the modern interactive forms of production of new knowledge, such as innovation clusters or eco-systems for instance, involve a mix of various types of knowledge and of channels through they circulate. An innovation ecosystem can be defined as “a community of independent players that operate inter-dependently, that feed off, compete and collaborate with one another, and that operate within a common climate.” (Barami and Evans 2005) The mobility of skilled labour, informal encounters, participation in business associations, a high density of M&A, out-sourcing and joint research projects are all components of the glue that keep the participants in an eco-system together. Eco-systems are also made of other types of players like venture capitalists, lawyers and so on who ensure the proper economic conditions in which innovation can flourish.

22. The interaction between the various channels is also striking in university/industry linkages (OECD 2003). Over the past decades universities and public research organisations have been pressed by governments to commercialise more of their research, to ensure that society makes the best of discoveries

and inventions resulting from public funding. The major vehicles for these activities with respect to explicit knowledge include the following: licensing of IPR, contractual research and the creation of spinoffs. All of these are examples of KNM that are used either individually or in combination with other KNM that focus on implicit knowledge.

23. Open innovation has become an integral part of the innovation strategy and of business model of many companies in recent years (Chesbrough 2003). Innovation is increasingly based on explicit knowledge created outside the boundaries of the company and co-operation has become an important way of tapping into outside knowledge resources in order to generate new ideas and bring them quickly to the market (the “outside-in” approach). At the same time, companies may spin out technologies and knowledge that they have developed internally but that are outside their core business and thus better developed and commercialised by others (the “inside-out” approach). Hence open innovation influences both the demand and the supply side for explicit knowledge. The main motives for joining forces for companies is to seize new business opportunities, to share risks, to pool complementary resources and to realise synergies. Companies recognise open innovation as a strategic tool through which to explore new growth opportunities at a lower risk. Open technology sourcing offers companies higher flexibility and responsiveness without necessarily incurring huge costs. Open innovation is more about increasing R&D options than about replacing existing ones. External technological collaborations are complementary to internal R&D investments. An OECD study of 59 companies in a dozen countries found that almost three-quarters of them devoted the bulk of their R&D budget – 80% or more – to in-house R&D activities. At the same time most companies are actively involved in open innovation practices: 51% of the companies allocate up to 5% of their R&D budgets to research in other companies, while 31% allocate more than 10% outside (OECD 2008).

24. KNM provide soft infrastructures and instruments that facilitate the development of innovation clusters, open innovation strategies and the commercialization of university inventions. While other tools are needed to support this effort in terms of access to capital, the mobility of labour, and so on, KNM are critical to implementing open innovation.

The changing scale and channels of knowledge flows

25. Knowledge transfers are driven by supply and demand forces. Supply is made of explicit knowledge that is made available by the person holding them to uses by others. Companies engage in transfers for a verity of reasons. Some, for example, look for ways to generate additional revenue from in-house innovations, especially when the technology has future potential but is not part of the firm’s core strategy. The inventor can expect that a unit of knowledge would produce further value if used elsewhere, and part of this supplementary value could be appropriated by the current holder, either in return for a monetary benefit (selling rights) or as an indirect benefit (*e.g.,* the use of an invention developed by a third party using that unit of knowledge). Universities and firms specialised in doing research are major suppliers of new explicit knowledge that they produce but do not, themselves, put into practice. There are also unused or underused knowledge protected by patents held by large companies (“Rembrandts in the attic”), although the scale of this is debated.

26. On the demand side, there are important needs for explicit knowledge that cannot be satisfied just by internally produced knowledge. A firm might need knowledge that falls outside its internal capabilities (e.g., basic knowledge, that industrial firms usually do not produce internally; or a unit of explicit knowledge in a complementary field, etc.). Firms also need to acquire much external knowledge when they start a new research line, in a field in which they have little experience. Increased competitive pressure tends to accelerate innovation and to require firms to more frequently introduce new products on the market. This can be facilitated through the use of existing explicit knowledge offered by others instead of attempting to develop that knowledge in-house. Other firms, which specialise in manufacturing and

marketing but not research and development, may wish to purchase existing explicit knowledge from those actors that develop new products.

27. Two underlying trends heighten the importance of new mechanisms through which to circulate explicit knowledge: globalisation and ICT. Globalisation has reinforced the competitive pressure on firms, now confronted with competitors from around the world. As a result, speed matters ever more: the ability to introduce products on the market as rapidly as possible, integrating the latest technology into one's product line, and responding to the changing needs of customers all demand flexibility and speed. Using external sources of knowledge allows actors to both 'parallelise' the research process (using already available off-the-shelf inventions rather than inventing in-house) and tap the best knowledge sources (instead of creating in-house second-rate imitations). While increasing the pressure on firms, globalisation also makes it easier for them to access the best knowledge sources, wherever they are situated, by reducing many of the costs –monetary or institutional- associated with distance.

28. ICT is another driver of change in the circulation of explicit knowledge. The internet has reduced informational costs. As knowledge can often be represented as information (*e.g.,* databases, models), this translates directly into cost reductions in the cost of transferring knowledge. Thanks to the Internet, one-to-many and many-to-many communication is now easier than ever before. ICTs are increasingly essential as a tool in most research fields (*e.g.,* grid computing in genomic research or virtual simulations to conceptualise and test products before they are built) and the way science is organised. Computing and computer science have increasing impacts on other sciences in terms of new modelling and simulation techniques, expanding the range of *in silico* experimental research. The physical and life sciences increasingly rely on computer science to reduce the time to develop new scientific insights and expand the scope of enquiry. Faster exchange and transfer of research results is enabled. The participative web is democratizing science and could allow a greater community to participate in research, scientific activities (*e.g.,* amateur science) and foster more open access.

29. More generally, across all industries, developments in the codification and standardization of R&D processes have increased the ability to segment and disperse R&D activities in different locations. Rapidly improving connectivity and the development of platform technologies/standards have facilitated the management of dispersed innovative activities within firms and networks of innovation involving external partners, even external partners globally. In a context of globalisation, innovation activities are becoming more distributed, involving more separate, more diverse entities. This new organisation of innovation has many advantages that make it potentially more efficient than the alternative, more centralised, model. These include the following: it is more able to mobilise large and widespread resources for innovation; it can boost competition among alternative innovation roads; and it can reduce some of the bureaucratic costs associated with centralised R&D. However, in order to be sustainable, distributed innovation requires a stronger glue that allows for dense knowledge flows between actors. KNM focussed on the circulation of explicit knowledge can play a role here.

Market failures and hampering factors

30. Because explicit knowledge is subject to high uncertainty and, as explained above, non-rival, it has economic properties that differ from those of tangible products and assets. These properties can result in market failure or higher transaction costs.

31. Knowledge increases its value to society when it circulates and is put to use on a larger scale by more parties. At the same time, its value to its inventor may be decreased – but not uniformly as some knowledge, e.g., that embodied in standards, may increase in value with use – as the inventor may lose control and hence derive a lower reward from its use. This provides a weaker incentive to produce the knowledge in the first place. KNM have an important role in mediating this tension between static and

dynamic efficiency: "Efficient KNM reduce the cost of accessing knowledge for their participants; they must strengthen, or at least not weaken, the conditions and incentives for producing new knowledge in a co-operative or distributed context" (OECD, 2010a, 152). KNM should not, obviously, be confused with intellectual property rights or other legal measures that provide exclusivity. KNM operate as practices and norms that take for granted functioning intellectual property systems, competition law and other general policy. What they offer, however, is a set of flexible formal and informal mechanisms that facilitate the voluntary circulation of knowledge for the mutual benefit of knowledge creators, users and consumers.

32. Any market or arms-length transaction involving explicit knowledge, especially (but not only) if of a commercial nature, will involve an assessment of the value of that knowledge. Both the knowledge supplier and acquirer require this information to determine whether the transaction is worthwhile. How detailed and precise the valuation needs to be will obviously depend on context and whether the transaction is commercial or otherwise. The economic value of an asset can be roughly defined as the sum of revenues (or non monetary reward) it can be expected to generate, discounted by time and risk. The value of explicit knowledge is, in general, difficult to assess before a product or service incorporating that knowledge is actually placed on the market. Even in such cases, the particular contribution of the one unit of knowledge may be difficult to disaggregate from the total value of the product, making valuation difficult. This uncertainty in value is a source of risk that may limit the willingness of risk-adverse actors to engage in transactions based on that knowledge. While there exist various methods available to place a value on certain forms of knowledge – particularly, those subject to intellectual property rights – none of these is currently seen as highly reliable. Further, some of these methods rely on private information (e.g., market forecasts) that are not reliably shared, making the valuations estimate difficult to be shared between prospective suppliers and acquirers.

33. As a general rule, the value of a unit of explicit knowledge is better known to suppliers than to acquirers, at least where the supplier has access to implicit knowledge about the merits and limitations of the knowledge, and required complementary research needed to bring out the value of the knowledge. This information asymmetry (akin to a 'lemons' market' situation) might deter market demand for explicit knowledge: potential acquirers may believe that only low value knowledge is being supplied (on the argument that if it were valuable it would have been kept private). Certain institutions, such as the patent system, may help to mitigate this asymmetry, as they facilitate the sharing of information between actors as they provide some guarantee to the supplier that disclosing the knowledge will not undermine its ability to consent to the transfer or sharing of the knowledge. Hence suppliers will more easily allow prospective buyers to test the knowledge prior to deciding to acquire it. However such a legal framework does not apply in all cases, not only because much explicit knowledge is neither patented nor patentable, but that the extra costs of patenting and enforcing patents over certain knowledge may render the transaction unappealing to the acquirer.

34. Search costs are high, as knowledge production and use are highly differentiated across the many parties involved. Identifying a partner, supplier or acquirer often requires significant effort and cost that may deter search in the first place. The internet has gone a long way in reducing those cost (*e.g.,* databases are accessible online which register available technology and specific needs, so that matching is easier). A survey by the OECD, the EPO and University of Tokyo found that 24% of European companies and 53% of Japanese companies holding patents could not license out those patents despite their willingness to do so; the main reason for this, they stated, being the difficulty of identifying a partner (failure in the search). Other reasons, such as inadequacy of the technology, contract drafting cost or difficulty to agree on price were ranked much lower than inability to identify a partner. This difficulty does not seem related to lack of experience: this problem was reported more often by those actors having experience licensing out patents than for those companies which do not – 45% against 19% for European firms, 78% against 42% for Japanese firms. (Zuniga and Guellec 2009).

3. Knowledge networks and markets

35. In view of the plethora and diversity of existing KNM that operate to transfer or share explicit knowledge through either market or arms-length transactions, it is necessary to establish a typology of such KNM in order to better understand them and to identify specific policy concerns to which they may be sensitive.

Market and arms-length KNM can be characterised along three main dimensions.

1. Their purpose

36. The first distinctive character among KNM is the purpose for which they are established. One can identify three main alternative (but not completely exclusive) purposes as follows:

- *To circulate (share, trade) existing explicit knowledge subject to existing legal rights of exclusion (e.g, intellectual property)*. In the case of patents, knowledge is, in most cases, publicly available no later than 18 months after filing. Nevertheless, patent laws provide that this knowledge cannot be used or traded without the patent holder's consent. While publicly accessible knowledge subject to copyright or database can be freely used by others, knowledge contained in databases may be subject to exclusion through either technological keys or copyright or database laws that prevent entry into the database itself. In either the case of patents or protected databases containing non-public information, the knowledge is, from a practical point of view, not in a usable form without the consent of the intellectual property holder. KNM can operate to provide this consent to those wishing to acquire and use the knowledge.

- To c*irculate (share, trade) existing explicit knowledge*. Rather than focus on providing consent to use knowledge (in the case of patents) or databases containing knowledge (in the case of copyright and database protection), KNMs can also consist of the infrastructure through which to exchange knowledge, whether that knowledge is subject to intellectual property rights or not. This infrastructure includes online markets, wikis and other mechanism that help knowledge suppliers identify knowledge acquirers and vice versa.

- To *jointly produce new explicit knowledge*. KNM in the form of bilateral or multilateral contracts can facilitate knowledge production aimed at introducing new technology or software into the market or in assembling a new database. These contracts must specify both the inputs (who contributes what, under which conditions) and the expected output of the joint project (sharing benefits and establishing terms of use). These contracts are often complex, reflecting the difficulty in valuing inputs, the uncertainty of outputs and the difficulty in monitoring contributions (*e.g.,* the intensity of efforts).

2. The supply side: incentives to participate

37. Why do actors chose to share or transfer knowledge? The answer to this question is particularly important in respect of KNM as understanding participants' incentives will be critical to designing and implementing an appropriate mechanism. Incentives to contribute knowledge are intimately tied with the economic model of the supplier: commercial entities will seek a commercial reward (direct or indirect) as a result of participation, while government funded entities will follow, directly or indirectly, a goal related to public interest. Some of the reasons for businesses, individuals or universities to participate in a KNM include the following:

- *Monetary reward:* explicit knowledge suppliers are compensated for their contributions either by those acquiring the knowledge or by managers of the KNM (who want to encourage participation in the mechanism).

- *Reciprocity in access*: contributors obtain access to other parties' explicit knowledge. For instance, in the BioBrick Foundation, a genetic databank, contributors obtain free access to the entire databank.

- *Reputation, contact:* KNM provide a means of establishing contact with potential partners, provide a showcase through which to demonstrate personal or business skills to a broad audience, thus enhancing one's status within one's community. Lerner and Tirole (2004) suggest that this is a prime motivation for involvement in open source communities.

- *Public interest:* serving public interest is a motive for government agencies, government funded actors and various communities.

- *Validation:* KNM provide a means to validate knowledge through a peer-review like mechanism. With the large variety of people looking at the knowledge, flaws, holes and limitations can be more easily revealed.

3. The demand side: Conditions of access

38. The expected result of KNM is facilitation of access to explicit knowledge. Access is not, however, always unconditional. Based on a review of existing KNM using market or arms-length mechanisms to circulate explicit knowledge, one can identify three models of conditional access as follows:

- *Access is restricted to selected members* ("club"). That is typically the case in exclusive and non-exclusive licensing and for certain knowledge sharing internet-based arrangements (*e.g.,* www.sermo.com, a fee-based internet market restricted to doctors and registered nurses).

- *Access is open to all but requires payment*. That is the case of many KNM which qualify as marketplaces and auctions (*e.g.,* ICAP Ocean Tomo) as their interest is to attract as many potential buyers as possible, and to charge them.

- *Access is open to all and it is free (with or without conditions)*. Certain internet-based KNM aimed at sharing explicit knowledge are free, such as Wikipedia. Other KNM may be free but require knowledge acquirers not to encumber that knowledge with intellectual property that blocks others from accessing the original knowledge (*e.g.,* BioBricks) or require acquirers to contribute back any new explicit knowledge developed as a result of access (*e.g.,* Cambia's BiOS).

39. Certain KNM are based on mixed models; they impose differentiated types of access conditions on the explicit knowledge that depend on the purpose of the acquisition and identify of the acquirer. Access can thus be open and free for certain transactions, open and subject to fees for others, and other transactions can be restricted to a specified type of users.

40. Apart from the three dimensions outlined above, existing KNM using market and arms-length mechanisms differ with respect a large number of other criteria. Two are of particular importance from an economic perspective: the nature and interaction of participants and the KNM's governance structure.

41. Participants can include (not necessarily exclusive of one another): individuals (volunteers or remunerated), universities, government bodies, various types of businesses (start-ups, established firms) and community organisations. Some KNM are a mix of these categories, such as customer innovation networks which involve both customers (individuals or firms) and the firm producing the improved product, or such as public-private partnerships.

42. The *governance* of a KNM can be left to:

- Participants themselves: Certain KNM have been set up by participants, with the aim of facilitating access to the explicit knowledge they need or that they wish to disseminate (*e.g.,* patent pools managed by one of the participants or a hired management firm).

- A separate entity: Certain KNM result from the initiative of entrepreneurs, sometimes social entrepreneurs, who have identified an opportunity to develop markets to facilitate knowledge exchanges (*e.g.,* most IP marketplaces, some knowledge sharing platforms).

A typology of market-oriented and arms-length KNM

43. There exist a wide variety of KNM that apply specifically to explicit knowledge that work either through the market or arms-length interactions through a network. As new KNM emerge and some of the existing KNM fall away, it is not possible to provide any clear classification of KNM in this market/arms-length space. However, a typology of these KNM can help to articulate and focus the analysis of economic and policy issues if classes are designed for the purpose of grouping together KNM which are responsive to similar policy instruments. At a first level, we identify three main categories of KNM, which are based on the first criterion above, the purpose of the arrangement; other criteria intervene at the second level of the classification (sub-categories):

- *Category 1: IP marketplaces.* These include mechanisms to trade existing and identifiable units of explicit knowledge protected by IP rights, usually patents. Their purpose is to facilitate the transfer of IP – and accompanying explicit knowledge if not (as would normally be the case) already in the public domain – by matching potential suppliers and acquirers. These mechanisms include patent auctions, patent pools, patent clearinghouses (*e.g.,* MPEG LA's new diagnostic genetics patenting 'supermarket') as well as exclusive and non-exclusive licensing by firms, universities and public research organisations. Their goal is neither to create knowledge or transfer or share knowledge but to remove legal barriers to using and exploiting explicit knowledge.

- *Category 2: Knowledge exchanges*: These KNM consist of any mechanism through which existing explicit knowledge (as opposed to IP) is transferred or shared. These include databases, expert networks, publications and so on. Exchanges may take place through traditional means (*e.g.,* printed publications) ro through the Internet. Examples include expert networks (*e.g.,* www.sermo.com), data sharing networks (*e.g.,* Sage Bionetworks), social networking sits and blogs.

- *Category3: Incentives for innovation.* These mechanisms provide an incentive for actors to undertake innovation. They rely on a large set of market and non-market incentives such as fee for service, prizes and reputation. For example, research contracts provide a fee to (usually) specialty firms, universities or community organisations to develop explicit knowledge. Other KNM provide a mechanism through which those desiring a particular innovation establish a prize for those who first provide it (*e.g.,* Prize4Life). Finally, open source communities offer acknowledgement and reputation within a community for having innovated.

44. The frontier between these categories is not clear-cut and certain KNM may fall into two or more of the categories: for instance an agreement for doing joint research (category 3) will often include a clause on IP sharing (category 1), may include a clause on data sharing (category 2).

IP marketplaces

45. Transferring IP in the business context can be done either by granting a licence or by selling the IP title. A licence is a contractual arrangement under which the holder of IP promises not to assert it under certain conditions (notably the payment of a royalty). Licensing of IP does not usually require the transfer of explicit knowledge since that knowledge is already publicly available. (This would not be the case, however, if the licence was to knowledge protected by trade-secret or if, in addition to the patent, implicit knowledge were also transferred.) An IP licence does not provide the licensee with the legal right to use the knowledge as others may have conflicting IP or other (*e.g.,* privacy) rights. Licensing agreements are usually negotiated on a bilateral and ad-hoc basis. They are market transactions as they are associated with

monetary flows (direct when there is payment, indirect when there is cross-licensing), but there is no centralised market for licenses. Such a market would require systematic informational and financial linkages between all transactions, with the result that there exists some correlation in individual prices. This piecemeal (decentralized) organisation is a source of transaction costs:

- informational (identifying partners is difficult)
- negotiation costs, including determining value
- aggregation costs (need many patents to use certain particular technologies).

46. In view of these drawbacks, small players are often at a disadvantage vis-à-vis larger ones: informational or negotiation costs are mainly fixed (for each transaction), and decline with experience and size of the party. In addition, the ability to enforce contracts and IP are also subject to economies of scale. Why have not a centralized market emerged? The answer seems to be because of the diversity of trades (patents are not, by definition, identical in nature and value) and of its secretive character (no disclosure of contractual terms). The former limits the potential for economies of scale while the latter prevents the capitalization of any experience beyond single actors. Things are changing, however, as the number of deals increases and as the Internet makes information more broadly available. This sets up the opportunity for more centralized ways of organising these transactions.

47. IP marketplaces include mechanisms that systematise transactions involving IP, notably patents: transfer of title, grant of licenses, aggregating IP, pooling etc. These mechanisms may rely on intermediaries (*e.g.,* patent brokers or pooling agents) or on computerised information systems, or both. Their aim is to create and exploit informational economies of scale, including search, negotiation, price setting and the drafting of contracts. They can accumulate experience and information over time and across cases, translating it into standards and expertise. Depending on characteristics of transaction handled, the economic model etc., various types of IP marketplaces can be identified (a more detailed analysis with many examples is provided in Yanagisawa, *et al.* 2009).

Trading mechanisms

48. Trading mechanisms are arrangements that match supply and demand of IP titles, whether for assignment or license. Examples include: clearinghouses (many over the Internet); patent auction houses (*e.g.,* ICAP Ocean Tomo); licensing markets (IPX, to be launched in Chicago in 2010); brokers (usually patent attorneys using their own network in particular industries); specialised internet portals (e.g., Yet2.com); university technology transfer offices, which act as intermediaries between university researchers and potential business users; iBridge, a website that discloses university inventions, researchers interests etc. to firms, particularly those that are newly established. These arrangements seem to be on the rise with much innovation in their development over the last few years.

49. The expected effect of these mechanisms on the economy is to boost licensing activity and other types of IP transactions as transaction costs are reduced: search costs are reduced thanks to the publication of supply and demand and to the use of Internet facilities; and negotiation costs are reduced thanks to a standardized contractual framework often provided, to complementary services sometimes provided such as insurance or expertise (*e.g.,* for assessing the value of the IP). Hence the direct impact of these forms of KNM on the economy is expected to be positive as they allow existing knowledge to be used at a broader scale, by a broader variety of firms, in differentiated contexts. In turn, the possibility of commercializing knowledge creates the conditions for firms specializing in knowledge production to be created (*e.g.,* biotech). One could expect that the expansion of Internet-based knowledge brokers could have a similar effect on the innovation industry as eBay has had on other sectors, *i.e.* leading to the creation of an eco-system of businesses using the network as a regular channel for selling their production. There is a possible cost however, as the broader licensing opportunities opened by these markets apply to low quality patents

as much as high quality ones: patents of low quality but held by aggressive entities (‘trolls’) could be enforced at a larger scale by using such vehicles.

Patent pools

50. Patent pools are bundles of patents held by separate holders which come together to give each other and others access to the bundle. Pools have existed since the mid-19th century, but they have recently been revived. They are often created in circumstances in which many inventions, owned by distinct parties, are needed to manufacture a class of products or to invent new ones. This is notably the case where agreed technology standards underlie the entire product class such that all products on the market must make use of the knowledge protected by their associated patents. This is common in many industries, such as software and telecom. One example is a pool managed by MPEG-LA over data compression techniques. In the absence of a pool, market actors may be confronted both by high transaction costs and by double marginalisation, both due to the high number of patent owners seeking their own interests while ignoring their collective impact. Patent pools are managed by (a delegate of) the group of patent owners who are in general practicing entities and are motivated by having the right to implement the standard. To comply with competition law, patents included in a pool must be validated by an independent expert who is responsible for ensuring that only those patents that are essential to implement the standard are included. Access to the pooled patents must also be granted to non members, as otherwise it would infringe competition laws (market foreclosure).

Patent portfolios and patent clearinghouses

51. A patent portfolio consists of entire classes of patents that a firm brings together in order to licence or transfer, on an individual basis, to those wishing to licence or acquire the patent. The portfolio holder provides potential licensees with one-stop access to a large number of patents relating to the licensee's activities to either bolster the licensee's patent position in the market or to remove potentially blocking patents. While portfolios will seldom be complete – there will always be patent holders who do not wish to transfer their rights to the portfolio holder and there are constantly new patents filed and granted – they can substantially reduce transaction costs involved in identifying patent holders and in negotiating licences. One example is Intellectual Ventures, a US based fund created in 2001, which has USD 5 billion of capital and gathered more than 30,000 patents as at the start of 2010 (Myhrvold, 2010).

52. Patent clearinghouses are similar to patent portfolios in that a clearinghouse administrator licenses-in (or obtains non-assertion pledges in respect of) entire classes of patents and licenses them out, usually individually, to those who need to clear rights. Unlike the portfolio, the clearinghouse only clears rights and does not provide exclusive rights over a patent. That is, the clearinghouse aims to clear right for licensees, not to transfer them to licensees. MPEG-LA has recently announced the creation of a patent clearinghouse – which it calls a supermarket – over diagnostic genetic patents, an area in which there has been much concern over access to gene patents in order to enable to development of and access to diagnostic testing services. A not-for-profit version of such a clearinghouse is the Eco-Patent Commons which provides freedom to operate with respect to included clean-tech patents on condition that licensees do not assert certain patent rights against those who contributed to the commons.

Patent aggregators

53. Patent aggregators bring together a set of complementary patents and either transfer or license sets of them out. Unlike a pool, the sets of patents are not ready-made: they depend on the needs of the acquirer. Aggregators reduce the transaction costs of identifying patents and of licensing them out.

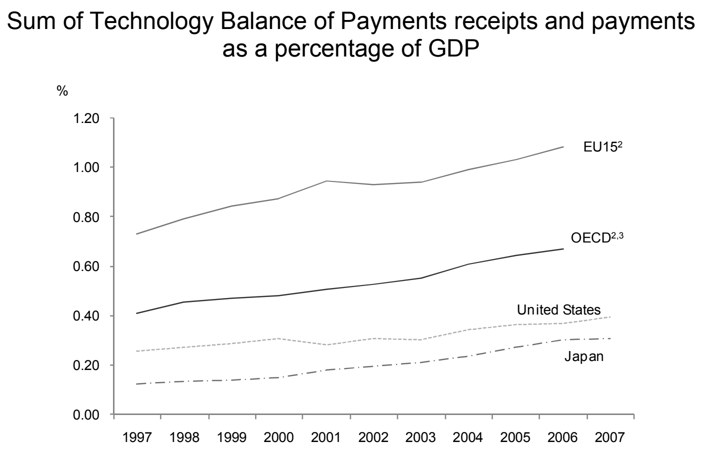
54. There are two types of aggregator. The first aims at bringing value to individual patents often held by different members of the aggregator. For example, the West Coast Licensing Partnership (WCLP) is a group of smaller university that aggregates technologies in select fields in order to increase the value of each university's individual patent portfolio. By combining complementary

patents, the WCLP reduces transaction costs involved with searching for patents and negotiating separate agreements. The second type of aggregator aims at creating defensive positions against potential patent infringement suits by third parties. It may do so by acquiring existing patents and/or by engaging in directed research to generate patents (*e.g.,* the Open Innovation Network). While aggregators may or may not be operated for profit, they nevertheless retain a commercial dimension as they protect the downstream revenue of companies licensing from the aggregator from infringement suits.

Statistics

55. There are no exhaustive and reliable data sources on licensing activity as the reporting of contracts and revenues is not compulsory, and is considered by businesses as a commercial secret. Only university associations, like the AUTM in the US, publish broad-based numbers for their members but these are relatively sketchy (Carbone *et al*., 2010). Hence only international transactions leave a track record which then allows the compilation of statistics.

Figure 1: Trends in technology flows by main areas, 1997-2007



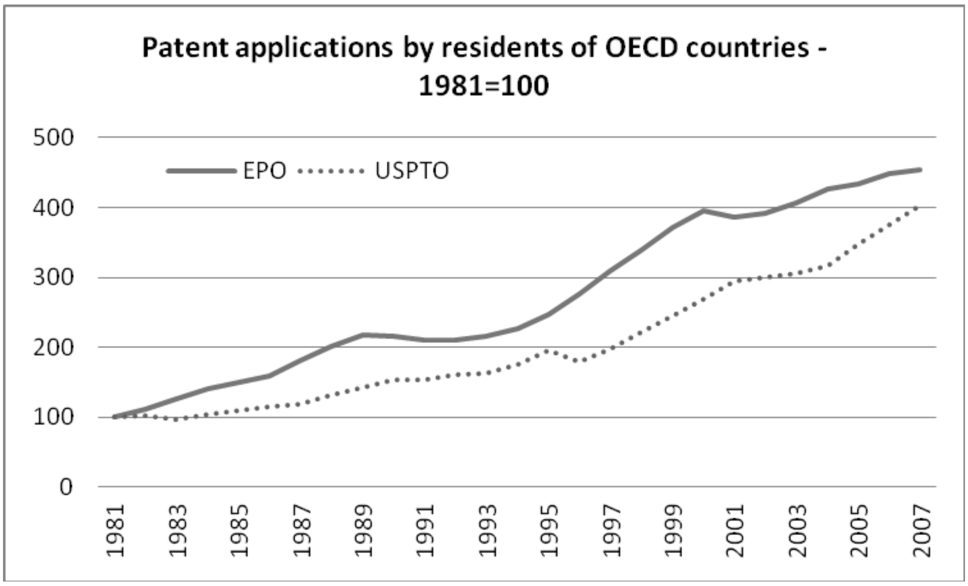
56. Technology receipts and payments constitute the main indicator of the value of the international circulation of explicit knowledge. Trade in technology comprises four main categories: transfer of techniques (through patents and licences and disclosure of know-how); transfer (sale, licensing and franchising) of designs, trademarks and patterns; services with a technical content, including technical and engineering studies, as well as technical assistance; and industrial R&D. The figures capture only a small portion of the international trade in knowledge as they only include the transfer of units of explicit knowledge that have been codified and acknowledged; they do not include most forms of implicit knowledge. Nevertheless, this indicator is useful in illustrating trends even if the actual figures are unreliable.

57. Figure 1 above shows that there has been a steady increase in international payments linked to knowledge flows over the past decade in the largest regions of the OECD: the European Union, the United States and Japan. Overall, these flows (the sum of payments and receipts) represented about 0.8% of GDP in the OECD in 2007, against 0.4% in 1997. These figures do not capture payments internal to countries, but they include intra-company international payments. The latter represent more than 80% of receipts in the cases of the US, France and Germany.

KNM and patents

58. One factor that has spurred the development of the above mechanisms is the sharp increase in the number of patents over the last decades. The number of patents filed by OECD residents has increased by a factor of more than 4 over the past 30 years (see Figure 2). This increase is the effect of a variety of factors, including an increase in business R&D expenditures – leading to a greater number of filed patents – in the ICT and biotechnology areas – and significant changes in patent policies and business strategy, initiated in many Member States starting in the early 1980s. Policy changes most often aimed at increasing the value of patents to their holders (*e.g.,* by granting larger damages in case of infringement) and making it easier to obtain a patent (*e.g.,* through a lowering in the inventive step (non-obviousness) test and the extension of patentable subject matter to software, biotechnology and business methods). Some of these changes have been reversed over the last half decade, following decisions of senior courts around the world (International Expert Group on Biotechnology, Innovation and Intellectual Property, 2008). Nevertheless, the earlier trend is reflected in the patent data as legal changes take several years before their effects can be observed. Certain patent holders, labelled as "trolls" – although the terms is not without controversy – have taken an aggressive approach to asserting patents, some of which are of low quality. For instance RIM, the producer of the Blackberry was forced to a settlement of more than 600 million USD in 2006 for alleged infringement of patents which were in fact all revoked a few weeks later by the USPTO (although these revocations are under appeal).

Figure 2:



59. As patents have become more numerous, there has been increasing concern in several fields – ICT and genetic testing (Secretary's Advisory Committee on Genetics, Health and Society, 2010; Carbone *et al*, 2010) to name two – over the ability to put into practice explicit knowledge contained in those patents. The concern is at least twofold. First, the transaction costs involved with identifying and negotiating licences (if licences are even available) over presents may be so high as to lessen research, development and dissemination of new products and services (the 'anti-commons' problem; see Heeler and Eisenberg, 1998). In the absence of coordinating mechanisms that would allow those wishing to use knowledge subject to patent rights to put together those patents, one might see a trend towards a "balkanisation" of knowledge, with knowledge users increasingly blocked upstream. A second concern is over patent holdouts in which the holder of one patent holder among an assembly of patents attempts to use his or her patent "to try to hold out for a price that appropriates all the gain that inheres in the assembly

project." (Bell and Parchomovsky, 2008). The emergence of certain forms of KNM – notably pools, clearinghouses, or aggregators – respond to these problems.

60. On a more positive note, the increasing number of patents can be seen as an enabler for KNM. If not patented, much explicit knowledge would remain secret, kept internally by the inventor firm, and they would be more difficult to mobilise, to circulate. Obtaining patents over this knowledge enhances disclosure by allowing the knowledge holder to disclose the knowledge at conferences, in publications and with potential partners with less fear that the knowledge will be taken without consent (Kitch, 1977). With the greater freedom to disclose knowledge while retaining a veto on use, patent holders have an incentive to disclose their knowledge broadly. This creates opportunities for users to identify knowledge of interest to them made by knowledge suppliers.

Knowledge exchanges

61. Rather than trading and clearing IP rights, other KNM focus on trading and sharing explicit knowledge itself. While some of the KNM explored above may incidentally involve the transfer or sharing of explicit knowledge (for example, knowledge protected by trade secret), those mechanism primarily seek only to remove legal barriers to the right to use that knowledge. The KNM explored in this section aim to circulate the underlying explicit knowledge itself rather than legal rights to use that knowledge. Mechanisms include the traditional – books, journal articles and conferences – while others rely on the Internet and new communication technologies. Explicit knowledge circulated through these KNM include data, methods of analysing data (usually implemented through software), expert opinion, research results, photographs and so on.

Expert knowledge networks

62. Often taking the form of online clubs (that is, with a selected membership) whose members contribute and share knowledge (*e.g.,* Spineconnect for spine surgeons), these KNM enable the process of sharing explicit knowledge held among members of a community of practice. While some of the knowledge will already be *codified* (that is, reduced to writing or other media) – in existing journals and other specialised sources –, much of it will, through the KNM, become codified. That is, this form of KNM not only shares existing text, but facilitates the creation of new text available for exchange. "Everyday, over 1400 spine surgeons from around the world log-on to SpineConnect to share knowledge, develop novel approaches to treatment, address the top challenges in spine healthcare, and create technological solutions that address voids in the current marketplace with the underlying goal of improving patient outcomes. With a growing case knowledgebase of over 1300 cases and 5000 reviews, SpineConnect is the place where spine surgeons look for insights into complicated cases, information on new technologies, and as a venue for conducting case-based research." (http://syndicom.com/physicians/spineconnect/)

Expertise markets

63. Whereas expert networks provide a method to share explicit knowledge among experts, expertise markets are intermediaries between knowledge holders (experts) and seekers. These KNM function by lowering the transaction costs of identifying the holders of explicit knowledge and of negotiating with these holders to access their knowledge. Traditional examples would include general-practice law or accountancy firms, hospitals and so on. What is different with these KNM is that they are, for the most part, Internet-based. In these KNM, seekers pose specific questions to which, usually pre-selected, experts can respond for a fee. For example, a firm confronted with a particular problem that can be answered using existing expertise (that is, does not require any research) – for example, Innocentive – will post the problem on the web site, which will, in turn, alert potential respondent experts. It can be thought of as an

on-line, open consultancy. Examples of expertise markets include Experts-Exchange for computer and IT; BitWine for diet, health, stress; and Sermo, a fee-based internet market for doctors, *etc*.

Internet based aggregators of knowledge-containing material

64. Private companies, university libraries and government bodies have digitalized very large amounts of written and other material that they (or others) had in stock: books, pictures, sounds, movies etc. These materials and the knowledge they contain can then be made accessible to the public through the Internet. A prominent example of an actor employing this KNM is Google Books, which has a world-wide ambition; a regional example is Gallica in France. There is growing convergence between this form of KNM and Internet-based bookstores (such as Amazon) that tend to sell an increasing number of digital books through download. The benefits of these knowledge aggregators to society are significant: they reduce the access cost to millions of books and other knowledge-filled material; they make available publications that have been out-of-print and thus inaccessible for a long time; they drastically reduce the maintenance cost of libraries (since they are digital); and they overcome the difficulty of access by geographically remote users. On the hand, in view of the high (and sunk) cost of digitalization and of the network effects attached to these platforms (usage generates usage), these mechanisms may not, necessarily, lead to competitive markets, as the cost barrier to market entry for second comers is high. In addition, there are challenges in determining appropriate revenue sharing rules between the platform, knowledge contributors, knowledge editors and others (including the special difficulty of determining the shares of un-reachable content providers). As a consequence, the exact structure of these KNM are evolving.

Internet-based wikis

65. Through these wikis, individuals contribute their explicit knowledge on a particular subject which is then made available to the public. The model is usually non commercial (free contributions, free access) such as Wikipedia or Citizendium; alternative models are partly commercial, as they compensate authors and provide revenue by advertising (*e.g.,* Knol, launched by Google), or completely commercial as they are monetized both on the purchasing and diffusion sides (*e.g.,* Encyclopedia Britannica: in a way, encyclopaedia on paper, which were born in the 18th century, can be considered as the first knowledge platforms ever). Contrary to others of this type of mechanisms, Wikipedia is also collaborative in the development of knwoledge. One could also consider social networks (Facebook), photograph sharing (Flickr) and video sharing websites (*e.g.,* youtube) as belonging to this category even though the knowledge being circulated is largely of a personal nature.

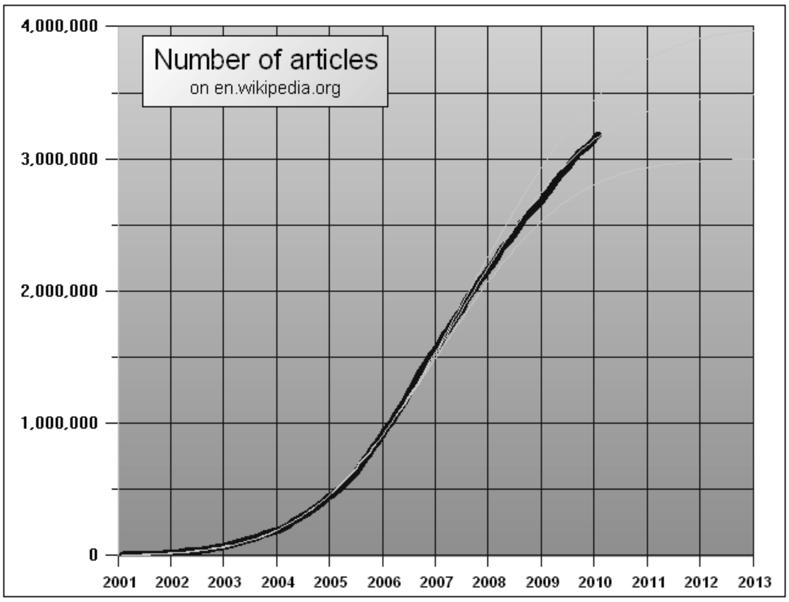
Search engines

66. These mechanisms provide an interface between simply formulated queries and web sites which contain potentially relevant knowledge needed to answer them. They use a particular type of data mining that leverages existing explicit knowledge.

Measuring knowledge exchanges

67. Most of the KNMs studied in this section are implemented through the Internet and involve active interaction of both knowledge seeker and knowledge provider. These KNM have seen exponential growth over the years, in line with most types other types of Internet-related activities and usage.

Figure 5: Size of Wikipedia in English



Source: Wikipedia

Incentives for innovation

68. The purpose of KNM that provide incentives for innovation is to facilitate the production of new explicit knowledge through the interaction of two or more actors, be they businesses, universities, or individuals. In some cases, one actor provides initial knowledge and the others use this to create new knowledge, and, in others, one contracts with another to create knowledge. We leave aside, in this discussion, jointly created knowledge as this relies on a significant amount of implicit knowledge and thus lies outside the scope of this study. Relationships to create explicit knowledge are governed by contracts (and, in many cases, intellectual property) that set out rules of engagement, the establishment of contributions and the allocation of the rights over the knowledge produced. There are various types of KNM that work through the market or arms-length arrangements that can facilitate these relationships.

Outsourcing R&D

69. Outsourcing involves a contract between an acquirer and supplier of knowledge. The acquirer may or may not contribute knowledge at the start of the transaction but the supplier always develops and transfers (although, in some cases, it may share) the resulting knowledge to the acquirer. Outsourcing is not new, but, as discussed in respect to licensing earlier, has tended to consist of one-off, bilateral and small relationships. With the advent of both new technologies and new business arrangements, outsourcing has grown in scale, with entire value chains being built through it. In the typical case, outsourcing involves a large firm which contracts various parts of its knowledge-generation program to a large number, or cloud, of start-ups (*e.g.,* the Philips high-tech campus in Eindhoven). Suppliers are often companies specialised in R&D (line 73 of the international classification of industries: ISIC). What is new also is the increased presence of universities in these networks or clouds as contract R&D is becoming a regular and important activity for many universities as a source of funding (used, for example,. to purchase specialised equipment that is then used in other, more basic, research), training of students, and of industry contacts (networking).

R&D crowd sourcing, prizes

70. As a hybrid between the Expert Knowledge Networks and the Expertise Markets discussed earlier, these KNM involve connecting the holders of specific units of knowledge to those who wish to acquire that knowledge. Unlike either Expert Knowledge Networks or Expertise Markets, these KNM involve the development of new explicit knowledge and not simply the provision of existing knowledge to acquirers. Existing mechanisms involve the use of the Internet to advertise research questions formulated by a (usually large) company and answered by any registered researcher. (These KNM started with the pharmaceutical industry but are now gaining followers in other industries as well). Once a question is posed, registered, individual researchers are eligible to submit responses to the call (usually in multi-stage process). The individual, if any, who first (or best) answers the question receives a pre-determined prize. Examples include Innocentive and NineSigma. InnoCentive began as a start-up incubated through the e.Lilly division of Eli Lilly in 1998 and spun-off as an independent company in 2001. Companies, which InnoCentive calls "seekers", post their unsolved scientific challenges on the InnoCentive website. Seekers include commercial, government and non-profit organisations such as Procter & Gamble, Dow Chemicals and The Rockefeller Foundation. "Solvers", who number more than 180,000, compete to win pre-determined cash "prizes" offered by the seekers. Solvers can search for challenges posted by Seekers based on their interests and expertise. Around 900 challenges have been posted so far by approximately 150 firms. More than 400 of these challenges have been solved. InnoCentive believes that its approach can work in a variety of fields ranging from chemistry to business processes and even economic development (*The Economist*, 2009).

Customer innovation

71. For a number of products (including mountain bikes and certain software), customers have taken the initiative of developing their own innovations and sharing them with each other and with the original producer. Being confronted with a wave of un-asked for customer innovation to their own products, certain companies have taken the stage to attempt to structure it, organising platforms on which customer-innovators can directly sell to other customer their innovations (Apple store, Nokia, Lego Mind Storm). An important issue raised by these models is IPR: how to share the IPR (hence the control and revenue) between the product originator and the customer innovator? There are different economic models there: some companies just play the role of intermediaries between innovators and other customers, offering a sort of platforms where all selected innovations are offered for sale; they play this role for free or with a fee (*e.g.,* Apple), while others go one step further, taking at least partial control of the innovation before re-selling it (*e.g.,* Nokia).

Open source and open access communities

72. Open source mechanisms draw on reputation and acknowledgement as mechanisms to induce knowledge creation. Through voluntary and non-remunerated contributions, knowledge creators contribute, usually incremental, explicit knowledge to a common defined project. These KNM both establish the nature of the project – the development of software or research tools, for example – and the means through which contributions are made, usually over the Internet. These KNM also provide standard-form licensing arrangements for any IP covering the knowledge contributed. A central term of these licenses is that, as a condition of using the knowledge, the knowledge acquirer will contribute back any improvement he or she makes to the project on the same terms. Open source software (OSS) originated and still exemplifies this approach, although attempts have been made to expand it to other fields, such as biotechnology. Open source has proven itself to be an effective mechanism through which to share (rather than transfer) knowledge subject to copyright; it has not yet shown itself effective in sharing knowledge subject to patents because of costs and other concerns (but see the effort of BiOS).

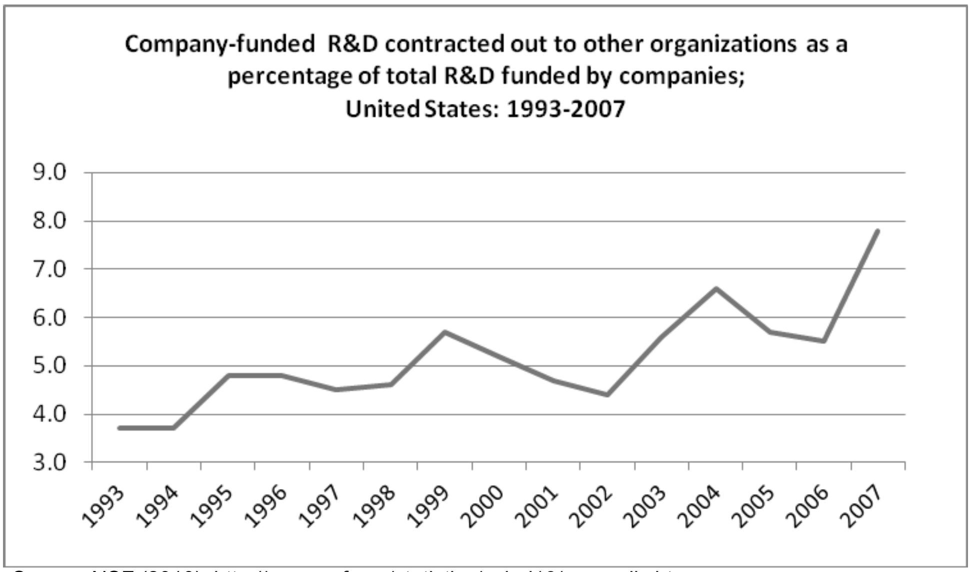
73. In contrast to open source mechanisms, open access KNM do not rely on IP rights in order to ensure that knowledge acquirers contribute improvements back to the project. As with open source mechanisms, in open access KNM, firms, universities and individuals contribute incremental knowledge to a joint research project. Through a combination of contract and community norms, participants are prevented from seeking IP rights that are used to prevent any other person from using the knowledge generated through the project. Community members not bound by practice are made subject of norms against blocking access; these norms must be understood and the community must be willing to enforce them. An example of this form of KNM is the Structural Genomics Consortium that seeks to develop probes to attach to histones in order to conduct research in epigenetics. Members of the consortium – including industry, researchers and universities – each contribute knowledge and agree not to obtain patents. All knowledge produced is publicly disclosed. Those using that knowledge – other firms and researchers – are subject to community norms enforced by funding agencies, universities and firms.

74. As there is no direct monetary incentive, the KNM described in this section provide alternative incentives for leading individuals and companies to contribute their time, effort and competence. For individuals, common motives include reputation, taste for technical challenges and ideology; for companies (which dedicate part of their staff's time to participating in open source projects) the motivation is usually either downstream revenue generation (*e.g.,* the project provides a cost-free infrastructure through which to attract customers) by providing customization or other services (*e.g.,* IBM) or reduction of the costs of acquiring infrastructure. Open source and open access are not only a way to disseminate knowledge but represent a way of organising the production of new knowledge within communities of practice.

Measuring KNM that provide incentives for innovation

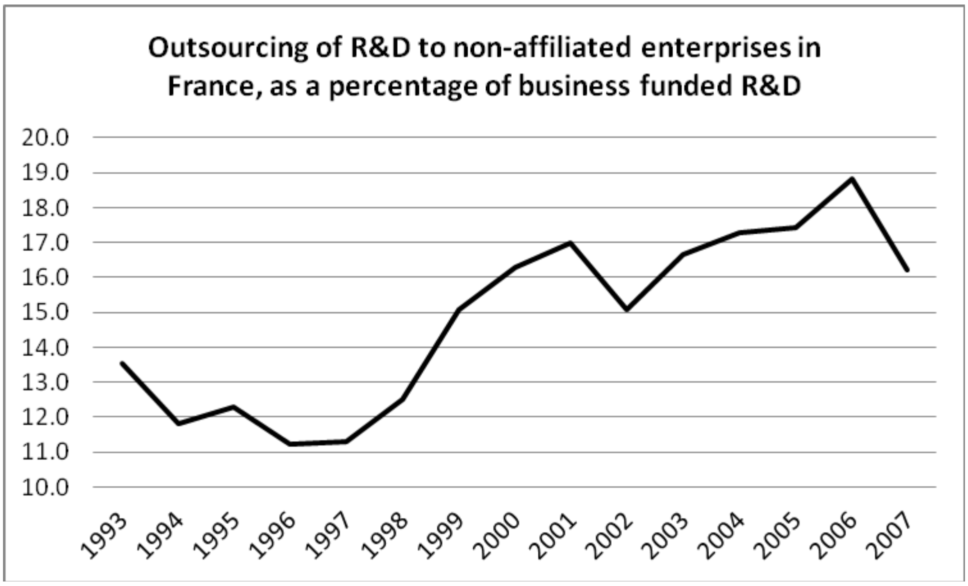
75. One, imperfect, indicator of the degree to which the KNM discussed in this section contribute to knowledge generation is the amount of extra-mural business R&D: R&D funded by a company but implemented in another organisation, company, university or other. This includes all R&D contracted out, hence one form of KNM discussed above. This measure does not reflect all KNM, particularly those that work outside of the market or that involve knowledge sharing (thus, a large portion of the KNM discussed). In the US (Figure 3), extra-mural business R&D performed in another company shows a significant increase between 2000 and 2005, from about 4.5-5% of total business R&D to about 6%. In France (Figure 4), the proportion rose from about 12% in the mid-1990s to about 18% in the late 2000s. These are still a relatively low numbers: R&D services are not yet very large as compared with intra-mural R&D. However, the increase is significant and R&D markets have been developing significantly over the past decade. Across industries, the increase has been sharper in the pharmaceutical and in the computer industries (in the US).

Figure 3:



Source: NSF (2010): http://www.nsf.gov/statistics/seind10/appendix.htm

Figure 4:



Source: French ministry of Research. http://cisad.adc.education.fr/reperes/public/chiffres/france/ent.htm

4. The impact of KNM on innovation and the economy

76. KNM are changing innovation modes and the economy in important respects. KNM render both knowledge (and the rights to use knowledge) more economically mobile; knowledge acquires its own economic life and value: it can then be produced, circulated, funded and sold for its own sake, separate from goods or people that may embody it; it circulates in a more fluid way, more rapidly and with a broader institutional and geographical reach. Collectively, these factors change the economics of knowledge in general, and the economics of research and innovation in particular.

The organisation of research

77. The emergence of KNM changes the costs and other characteristics of transactions involving research; that is, the relative cost of research done outside vs. inside the firm. Many large firms now emphasise their reliance on external ideas and research, creating and structuring mechanisms to harness explicit knowledge in the eco-systems around them (*e.g.,* Procter and Gamble, IBM, Microsoft, Phillips etc.). In these eco-systems, an increasing number of firms specialised in doing research and selling the knowledge produced have flourished. Universities have developed links with industry, although many challenges remain in ensuring that these links preserve the essential balance between static and dynamic efficiency (SACGH, 2010; Carbone *et al*., 2010). Hence a new organisation of research is emerging, in which the firm takes on the role of node in a network rather than act as a self-sufficient innovator, knowledge sharing and trading across organisational boundaries is common place, and in which a variety of actors (firms of various characteristics, universities, individuals of various skills) interact with one another, exploiting their complementarities. New, non-market communities of practice emerge that relying on open source and open access in order liberate important forms of explicit knowledge from legal rights that would otherwise impose high transactions costs to overcome.

78. By changing the organisation of research, KNM have the potential to also affect its orientation (Munos 2009). KNM allow greater decentralisation of research decisions (through distributed networks), leading to a greater variety of attempted research lines. Outsourcing and "crowd sourcing" are typical attempts by large firms to generate ideas out-of-the-box knowledge production, something at which corporate labs – hierarchically structured, closed, risk-adverse and in silos – are not very proficient. On the other hand, corporate labs are very good at exploiting ideas, testing their validity, and applying them. Through KNM, large firms can spin-out the development of new ideas that are not directly in-line with current research priorities while still maintaining an interest (see, for example, the success of Chalmers Innovation in incubating industrial spin-outs (http://www.chalmersinnovation.com/english/our-offer)).

79. Another effect of KNM is that they facilitate the exploitation of inter-disciplinary research. The skills and backgrounds of employees of corporate labs tend to reflect established disciplinary boundaries: this makes sense for standard research but does not encourage the emergence of solutions based on cross-disciplinary work. Externalisation of research can facilitate inter-disciplinarity. For example, many of the winning solutions offered through Innocentive were offered by scientists working in a different field from that of the firm asking the question. This was especially true among the most valuable solutions. Decentralisation of research among a multiplicity of small, independent players also allows competition between ideas, which is stronger as the corresponding incentives are more significant.

80. Another possible fundamental change associated with the emergence of KNM is the 'democratisation of innovation' as exemplified by innovation platforms, by user innovation and by open source and open access communities (von Hippel, 2005). Individuals with no institutional or business link can directly propose their ideas to other individuals, firms and markets without having to pass through organisational filters. They can directly compete and cooperate with one another. This has the potential to significantly increase the quantity of effort allocated to research.

81. The organisation of public research is also affected by KNM. The emergence of KNM offers new opportunities for cooperation between scientific teams working in different institutions and for setting up joint research infrastructures (shared databases etc.). These can result in the creation of conditions that encourage inter-disciplinary research, an approach that is particularly fruitful in the most advanced and emerging scientific fields (*e.g.,*, nanotechnology and bio-informatics) that, almost by definition, have not yet an established status in the disciplinary landscape and progress by sourcing knowledge from other fields.

82. There is now an emerging model of universities as research and innovation hubs, being at the core of networks involving firms and communities of practice. This is an extension of the university/industry linkage model, which consists in capitalising on the multiplicity of individual links that have been developed and structuring them so as to generate more value from the entire network. Through these mechanisms, the university can enhance the circulation of knowledge not only on a bilateral basis, but multilaterally, with members crossing the entire network, realising economies of scale in knowledge diffusion and being in a position to mobilise the entire network's knowledge.

83. Interestingly, certain large firms are attempting to mimic internally the types of linkages and functioning they have developed externally. For instance, IBM's "innovation jam" is a repeated experiment that has mobilised thousands of employees worldwide with the view to elicit and discuss new, innovative ideas, using monetary and non monetary incentives, electronic tools etc. This type of "crowdsourcing" is easier within the firm, where IP issues ("who owns this idea"?) are not raised so that ideas can more freely circulate and be modified by interventions from a number of individuals.

The financing of explicit knowledge production

84. Both the public and private sectors are active in the funding of the production of explicit knowledge. Within OECD countries, the private sector is responsible for approximately two-thirds of direct research and development funding (OECD, 2009). When indirect public sector funding (*e.g.,* tax concessions, bonuses, exemptions and purchase exclusivity beyond patent terms) is taken into account, the relative importance of public funding increases in some countries. (For example, McKenzie (2008), using 2003 data, found that effective marginal tax rate in Canada on R&D capital varied from -33 percent to -200 percent.)

85. Apart from tax subsidies and other tax benefits, firms generally finance their research and development activities out of their own capital or cash flow, on venture capital or on government grants. External, market or bank funding of research is not common. This is due principally to the high risk and information asymmetry attached to R&D projects: external parties have more limited knowledge of the quality of the R&D projects and of their management than do firm managers. In case of bankruptcy of the firm – whether related or not to its innovation activities – it is usually simpler to sell physical assets than to assign intangible ones as the secondary market is more active for the former than for the latter. Hence, investors will consider it less risky to invest in a company with more physical than intangible assets, leaving investments in intangibles to the firm's own funds. This traditional scheme is modified by the KNM examined in this study that both reduce the risk of investing in knowledge and create new opportunities for specially tailored financing.

86. Category 1 KNM (IP marketplaces) favour the circulation and independent valuation of IP assets. First, the very existence of these mechanisms facilitates the exit of investors in case the firm fails, hence limiting the risk investing in intangible-intensive firms. Second, the circulation of IP assets is a source of information regarding market value. If IP assets are valued separately from the rest of the company, then investors can better track and monitor performance.

87. The separate valuation and circulation of IP assets can give rise to new ways of financing innovation, for example, through securitisation. This approach is favoured by companies in search of funding based on the value of their IP assets but which do not want to lose control over the IP. Securitisation consists in selling the future revenue flows associated with the IP while retaining title to the IP itself. There is a wide variety of possible ways of securitising IP assets that share risk and liquidity in different ways (*e.g.,* collateralisation of IP for bank loans etc.).

88. Similar sophisticated financial instruments can be used to fund applied university research. For example, the European Investment Fund finances certain universities while obtaining partial title to the IP resulting from this research. The Fund is prepared to provide further funding needed to develop downstream industrial applications of the research through public/private partnerships.

89. Another model is exemplified by the patent fund, Intellectual Venture (IV). IV directly sponsors research on issues it has identified as being a "missing piece" in sets of complementary inventions the development of which would allow broader technologies to become operational. Such missing pieces are identified after careful analysis of the relevant technical fields using external experts. The research is mainly outsourced to university researchers (notably in Asia).

90. Prizes are another way of funding research using a different risk-sharing model. Most of the risk under a prize system is borne by those conducting the research as the knowledge seeker only pays if the required solution is found. That is, the seeker need only incur the costs necessary to formulate its question; all research expenses are borne by those who attempt to provide the knowledge. This approach is in use in the pharmaceutical sector through Innocentive, by G8 countries for the Global Fund for diseases, and by the DARPA, in the US, for various research projects (*e.g.,* the "Grand challenge" for a driver-less vehicle).

5. Economic and policy issues

91. In view of the actual and potential positive effects of KNM on explicit knowledge production, it is essential that governments ensure the existence of appropriate conditions to support the creation and maintenance of competitive and well-structured KNM. In particular, policymakers should ensure that KNM support competitive environments and lower market inefficiencies, that they assure a fair and efficient distribution of knowledge and that the related distribution of revenues generated by knowledge is fair and balanced, etc.

92. Several policy areas seem to be particularly relevant in this context. First, IP policy established rules and processes over the legal rights affecting use and circulation of knowledge subject to IP rights. Second, competition policy aims at ensuring that market mechanisms are not distorted by collusive or monopolistic behaviour (which have to be specifically defined in the context of knowledge). Third, policies relating to the valuation of IP (*e.g.*, by promoting standards), which is an important condition for well functioning IP markets to develop. Fourth, taxation policy will affect the flows of knowledge across international boundaries. Fifth, R&D policies can stimulate the creation and circulation of knowledge through KNM (International Expert Group on Biotechnology, Innovation and Intellectual Property, 2008).

93. In addition, given the central role of knowledge in many economic processes, the government should explore the possibility of mobilising KNM to achieve particular policy goals that involve knowledge transfer, such as fostering international technology transfer, addressing environmental challenges, and so on.

IP policy

94. The trade-off at the core of all types of IP is to boosts incentives to create new knowledge while not hampering the sharing of knowledge necessary to actually create that knowledge (OECD, 2010a). KNM provide soft mechanisms that assist actors in attaining this trade-off. While IP rules are unitary in that they apply the same basic principles to all industries (although with some variance in application (Lemley and Burk, 2003)), KNM provide a means through which to develop subtle and flexible mechanisms suited to the particular field and set of actors involved. Nevertheless, "consideration may need to be given at some point to adapting the legal framework itself, for example by differentiating the rights

and obligations of the rights holder on a menu from which inventors could choose their preferred option" (OECD, 2010a, 149).

95. In this context, the central policy question to be addressed is: how can patent and copyright law adapt to the increasingly collective nature of inventive and creative processes? A clear delineation of the respective contributions of the various parties is not always possible. The multiplication of overlapping rights in certain technical fields, such as semiconductors, has been a source of litigation. In some cases, large players have addressed the difficulty by entering into cross-licensing agreements. These have the drawback of potentially limiting competition as third parties are normally excluded from these transactions. In some fields, such as diagnostic genetic research, the large number of patents seems to have increased the difficulty of conducting research on certain diseases (OECD, 2002). On the other hand, excessive weakening of patent rights could encourage inventors to rely use more secrecy, at least in those fields (but not, for example, in genetics) in which secrecy is an option. If firms do so, there is a risk of limiting, rather than expanding, the sharing of knowledge. Given the relative novelty and experimental nature of current KNM, it remains to be seen whether they provide sufficient means to mediate the positive and negative effects of IP rights without a change in the law. For example, one could contemplate the introduction of specific incentives to encourage patent holders engage in more licensing out. A mechanism known as "licenses of right" has been in place in several countries. It consists of granting a discount on administrative fees to patent holders who commit to grant a license to any applicant, on a fair, reasonable and non-discriminatory basis.

96. Equivalent questions could be raised regarding copyright. The notion of "fair use" and its international equivalents may need to be reviewed in light of new developments enabled by IT. In the context of the emergence of internet-based aggregators, which distribute copyrighted (and public domain) material on a large scale, the rights of the creator, user and consumer need to be balanced.

97. The challenges presented above become even more important given the increasing geographical scope of some KNM. As KNM are often of international or even global reach, the legal challenges become more complex as the heterogeneity of legal and regulatory systems across countries make it more difficult to plan and manage transactions. International convergence through the identification of best practices and standards in areas is desirable.

98. Patent quality is another issue with a significant impact on the functioning of KNM. High quality patents are needed to facilitate the development of trust among participants and to avoid having the value-multiplier effect of KNM benefit those holding 'bad' patents. The revocation of a patent after it has been assigned or licensed means that the acquirer has lost money in the transaction. A high rate of revocation of patents after transactions have occurred would hamper trust on the buyer's side and thus reduce the volume of transactions. If patents of poor quality are granted, KNM may, instead of achieving a fair balance between inventors, users and consumers, facilitate the channelling of undue revenues to undeserving patent holders than would have occurred in a less efficient market.

Competition policy:

99. Competition policy must also address the specific nature of KNM. Some of the questions that arise are traditional, relating to knowledge sharing and alliances, while others are new, relating to IP aggregators and the problems of transparency on IP markets.

100. Sharing knowledge between independent businesses can enhance efficiency, which is one of the reasons for its increasing use by firms. On the other hand, the mechanisms to ensure knowledge sharing – by connecting individual firms – can reduce the intensity of market competition, both by strengthening links between existing competitors and by excluding potential competitors. Competition authorities already

have experience in handling R&D cooperation. The National Cooperative Research and Production Act of the US (1993) relaxed restrictions on cooperative production activities, allowing research joint venture participants to work together in the application of technology that they have jointly invented. The novelty that KNM bring to such relations is the number, size and complexity of arrangements as well as the increasing involvement of universities or public labs with businesses etc.

101. IP marketplaces and knowledge exchanges favour the aggregation of IP and explicit knowledge. The non-rival character of knowledge and its potential excludability could give rise to situations of "natural monopoly" (*i.e.* a situation in which a monopoly is technically more efficient than competition between several players, a "one stop shop" for customers, reducing search costs, increasing joint access to complementary pieces etc.) depending on how transactions are structured and on the specific industry. Competition authorities also have experience in dealing with natural monopolies and in addressing such issues as how to preserve fair market conditions (including price), openness of access to new players, what kinds of international framework can apply to these markets, how to include emerging countries in the market, and how to preserve public/civil rights (privacy etc.). Specific reflection on these issues is needed for example, as the US FTC had done in holding public hearings in 2008-2009.

102. Another issue that emerges in the context of IP markets is transparency. As stated by Lemley and Myrvhold (2007) (the latter is the founder of Intellectual Ventures), "patents exist in a blind market. Want to know if you are getting a good deal on a patent license or technology acquisition? Too bad." The lack of transparent price signals results in inconsistent and possibly distorted incentives to participate in the market. The inability of actors to rely on market references can give rise to a risk of opportunistic strategies which, if anticipated, might deter others from entering the market. Further, more complex transactions are developing, involving futures contracts (*e.g.,* on unit licenses), which could improve the efficiency of the market but could also give rise to the possibility of speculation that results in misallocation and in price bubbles. Transparency of transactions (publicity of some of the terms of the deals) could help market actors and regulating authorities to monitor these evolutions. This has to be balanced against the possible negative impact that transparency might have on competition (*e.g.,* implicit coordination).

IP Valuation

103. KNM are vectors of value creation and transfer between players and across countries. Such value transfers raise important issues.

104. The valuation of IP is a very difficult operation, especially for small entities (SMEs or universities). The lack of references hampers the ability of KNM to converge on reliable prices, which in turn might deter the entry of potential participants. Currently, significant private and public efforts are underway to establish standard and transparent methods for valuing patents. A proposal (from Germany) is under review by the International Standards Organisation (ISO) to establish standards on patent value assessment. However, in view of the difficulty in valuing IP, in particular patents, it is generally acknowledged that these standards, if any, should be flexible and voluntary.

Taxation

105. Taxation is another area of possible policy intervention in the context of KNM. This stems from one of the key attributes of most KNM: their global reach that allows knowledge to circulate across boundaries. Transfers of knowledge also entails the transfer of revenue either on a market basis (transactions between independent parties) or between national branches of multinational firms (transfer prices). Thus, the distribution of income and wealth across countries is now directly influenced by knowledge transfers and pricing. This is not new, but the fluidity provided by KNM translates into rapidity and size of monetary transfers, hence raising the economic impact of these transfers. As KNM decouple the

production of knowledge from its use, these two functions can now be carried out in different countries. Where the value is actually created or realised, hence which country will be in a position to tax, remains an open issue.

Research and innovation policies

106. Policies aimed at fostering research and innovation – through, for example, public support of innovation, university-industry linkages and entrepreneurship – can both influence the structuring of KNM and be modified to take advantage of the advent of KNM.

107. Public support for innovation can take into consideration the networking effect of KNM. As such co-operation generates greater social value, one can expect greater amounts of spillovers than in a purely in-house (closed) R&D model. Open models permit participants access to greater knowledge, thus compensating them, in part, for the extra spillovers that they generate. There is some experience with policies which explicitly encourage networking. The European Commission, in its FP6 framework, made "networks of excellence" a major goal and instrument for allocating innovation support. Such networks, gathering businesses and academia in a variety of configurations, received the greatest part of the FP6 budget in an attempt to develop connectivity within the European research system, particularly between countries. Certain countries also have policies for incentivizing cooperative research and networking: Canada has experimented for some time with networks of centres of excellence; in France, the ANR (national research agency) offers funding for "participatory projects", and OSEO (a government SMEs agency) gives support to "industrial strategic innovation" projects that are usually cooperative. A census, review and evaluation of innovation network promotion policies across countries is yet to be conducted.

108. Encouraging technology transfer between universities (and other public research organisations, PROs) and industry has been a major policy goal in most countries for the past 30 years. KNM can facilitate both IP and knowledge transfer and sharing between universities, industry partners, community organisations and government. While technology transfer activities have achieved some notable success, many offices are hampered by limitations in funding, size, skills of its staff and by mandate. Technology transfer offices tend to be on short-term budgets, limiting the ability to plan, and staff are frequently overburdened, thus not permitting them to develop and implement new KNM. Further, mandates that focus on revenue generation or on obtaining IP clash with the reality of technology transfer in which it is only the rare university that generates any sizable revenue. Mandates focussed on knowledge sharing and the generation of social capital and social benefits would permit technology transfer offices to more fully engage in KNM.

109. Certain universities are already taking the lead on exploring their potential function as knowledge hubs. These universities not only are significant producers of knowledge, but also act as nodes within KNM, exchanging knowledge with a multitude of actors, providing basic knowledge to those who need it, integrating applied knowledge generated by cooperative projects with industry and reinvesting resulting knowledge in other projects. Chalmers Innovation in Gothenburg Sweden has, for example, established itself as a regional hub for innovation. It takes a broad view of knowledge and of its role in producing and disseminating knowledge. IP is not, notably, at the centre of its activities. Universities are particularly well-placed to play the a role of knowledge (and not simply IP) flow accelerator as they operate in the "open science" world in which disclosure, peer review and systematic sharing of discoveries are the norm.

110. Entrepreneurship policies can also benefit from KNM. KNM are of highest value to smaller actors which have fewer internal capabilities and therefore rely more on external linkages. KNM allow small firms to access world-wide supply and demand for knowledge, hence finding suppliers or acquirers that are not present locally. KNM are key for the development of small firms using knowledge produced in other parts of the world in the specific competencies required to implementing that knowledge (e.g.,

organisational capital, skills etc.) are not available. Hence, entrepreneurship policies might include a KNM component.

111. Local innovation clusters, which are a subject for policies in many OECD countries, are affected by KNM. While one advantage of KNM, as compared with traditional approaches, is their broader reach, they can also be of interest for the development of local innovation clusters for at least three reasons. First, they can help promote a number of local leaders with world-wide reach. Second, they can be used locally to structure deals for knowledge sharing among firms and universities, thus serving as the glue for a local innovation eco-system. Third, access to a world-wide pool of knowledge can allow certain regions to develop new activities based on their comparative advantages (skills, industrial tradition etc.) and technology developed elsewhere.

Using international KNM for achieving societal policy objectives:

112. Societal objectives include green innovation and international technology transfer. KNM can be used in both cases for encouraging innovation and technology diffusion.

113. *Fostering North/South technology transfers*: Economic development requires better mastering of knowledge and innovation. Access to knowledge and the building of capacity to access it, adapt it and improve it are necessary conditions for this to occur (Muñoz Tellez, 2009). KNM can play an important in increasing both access and skill development. There is experience with such an approach with the Golden Rice consortium: a group of (32) companies owning patents on a special type of rice (rich in vitamin A) which collectively agreed to bundle their IP and allow small farmers in developing countries to grow the rice royalty-free. They agreed to charge a fee only if the income generated reached a certain level which, in almost all cases, it would not. More generally it is possible to complement these KNM by mechanisms to share know-how (e.g., organising the mobility of researchers from the South, training, research co-operation etc.). These KNM can be funded either by governments of developed countries or by voluntary contributions from businesses (as in the Golden Rice case).

114. KNM can also be used for creating incentives to conduct research anywhere in the world on issues of relevance to developing countries, such as in respect of infectious and tropical diseases. Mechanisms such as advanced market commitments, prizes and other novel funding mechanisms can be used so as to elicit more research. They can be funded by contribution from developed countries or businesses.

115. *Addressing environmental challenges:* There is a general interest in having green technologies implemented world-wide, even in countries which cannot afford to pay the market price for these technologies. Special mechanisms have to be set up for those countries to access these technologies. The proposed “Global technology fund for climate change” is potentially one such mechanism by offering a discount, at the very least, to developing countries. Another mechanism is the Eco-Patent Commons in which firms agree not to assert their rights over certain patents.

6. Conclusion: A research agenda on market and arms-length KNM

116. On the basis of the review presented above, a series of issues emerge with respect to the particular sub-set of KNM examined in this study: those that rely on the market on arms-length and usually isolated relationships. These issues include the following:

- Measuring KNM: which indicators are most appropriate based on which data sources? A survey of KNM could be conducted once concepts and definitions have been clarified, the target population well defined etc.
- Green growth: the development and contribution of KNM to environmental technology in an international framework.
- International knowledge transfers in emerging countries using KNM.
- The role of KNM in creative industries and in non-technological innovation.
- IP and competition policies for KNM: patents, copyright, transparency, "natural monopolies".
- The connected university: university/industry technology transfer in the eco-systems.
- Innovation and knowledge markets in the ICT industry.
- ICT-based research and innovation (using the internet for organising research in a distributed network).
- Understanding the structure and working of research networks involving public laboratories, with a focus on the life sciences: Rules, types of agreements, motivation of the participants, composition, management of knowledge and other aspects.
- Policies with respect to encouraging the development of KNM in emerging countries context.
- Innovation clusters and eco-systems: geographic, virtual; the impacts of proximity on KNM.
- The management of government owned data and knowledge (generated by government activity or by public research organisations) and of the public domain on the internet: What policy for the public domain?
- Government policies aimed at fostering cooperation for R&D and innovation: a cross-country comparative review.

Table A1: Typology, characteristics and policies for KNM

Type of KNM	***Examples***	***Characteristics***	***Main policies***
IP Marketplaces			
Trading mechanisms	Ocean Tomo; Yet2.com	BM commercial; open access with payment; members are businesses, universities; incentive: monetary.	IPR; competition; valuation/taxation
Patent pools	MPEG-LA	BM commercial; access restricted (suppliers), open with payment (users); members are businesses; incentive: monetary and reciprocity.	IPR; competition;
Patent funds	Intellectual Ventures	BM commercial; access: open with payment; members are businesses; incentive: monetary.	IPR; competition; valuation/taxation
Non commercial pools and funds	Open Inventions.com; Golden rice.	BM PNP; access: open; members are businesses (can be universities, NGOs); incentive: reputation or (indirect) monetary.	IPR; Social challenges;
Collaborative innovation			
Joint research agreements	R&D joint ventures, university/industry agreements, etc.	BM commercial or government or PNP; access: club; members are businesses, universities; incentive: monetary and reciprocity.	Competition; R&D; Social challenges;
Outsourcing R&D	Corporate innovation eco-systems	BM commercial; access: club; members are businesses, universities; incentive: monetary.	R&D;
Crowdsourcing R&D, prizes	InnoCentive; NineSigma	BM commercial; access: usually club; members are businesses, individuals; incentive: monetary and reputation.	Competition; Social challenges;
Customer innovation	Apple store; Nokia	BM commercial; access: usually open; members are businesses, individuals; incentive: monetary, or reputation.	IPR
Open source communities		BM PNP; access: usually club; members are businesses, individuals; incentive: monetary, reciprocity or reputation.	IPR;
Knowledge platforms			
Experts networks	SpineConnect	BM PNP; access: club; members are individuals (suppliers and users); incentive: reciprocity.	
Expertise markets	Experts Exchange; Sermo	BM commercial; access: open with payment; members are businesses or individuals; incentive: monetary.	
Internet based agregators	Google Books; Gallica;	BM commercial, government or PNP; access: open, with or without payment; members are individuals (users); incentive: monetary, or reputation, or public interest.	IPR;
Internet based wikis	Wikipedia	BM PNP; access: open without payment; members are individuals; incentive: public interest.	
Search engines	Google; Bing;	BM commercial; access: open; members are businesses (suppliers), individuals (users); incentive: participation is not asked.	

Table A2: Examples of different types of KNM and their characteristics

KNM	**1. The purpose:** (1) Circulate (share, trade) IPR (2) Organise joint production of new knowledge. (3) Circulate (share, trade) existing knowledge.	**2. Incentives to participate (The supply side):** (1) Monetary reward/payment (2) Reciprocal access (3) Reputation, contact (4) Public interest:	**3. Conditions of access (The demand side):** (1) Exclusive club (2) Open access, contribution required (3) Open and free access	**4. Participants:** (1) individuals (2) universities (3) government (4) businesses (start-ups and / or established)
MPEG-LA A firm which licenses patent pools covering essential patents required of some media storage standards (e.g., MPEG-2 and MPEG-4)	(1)	(1) and (2)	(2)	(4)
Golden Rice An initiative dedicated to increase accessibility to some agricultural technologies to users in the developing countries.	(1)	(3)	(3)	(3)
Ocean Tomo LCC A company that focuses on in intellectual property	(1)	(1)	(4)	(4)

transactions, such as financing the sale and licensing of patent rights.				
Yet2.com An internet based service that offers a selection of intellectual asset management products and services based on a proven methodology of achieving success quickly. The methodology includes out-licensing ("sell-side") solutions, and in-licensing ("buy-side") solutions, software tools for managing intellectual assets, and a global Technology Marketplace for transferring intellectual assets, knowledge, and other expertise between organizations.	(1) and (3)	(1)	(3) – basic functions (2) – advanced functions (quick matching, advisory services, etc.)	Mostly (4) (start-ups and established)
Intellectual Ventures Intellectual Ventures a patent fund that builds a large patent portfolio and grants access to it by monetary payment.	(1)	(1)	(2)	(4)
Canada-California Strategic Innovation Partnership The CCSIP is an initiative intended to facilitate cross-border collaborative research projects by identifying IP issues and their management considerations related to multi-party collaborations, multi-jurisdictional issues, and good practices for quality IP management.	(1) and (2)	(2) and (4)	(1)	(4)
GRAVIT The GRAVIT initiative is a network of seven institutes in Grenoble (France) that has developed a collaborative mechanism incorporating a common intellectual property methodology and framework. The	(2) and (1)	(2) and (4)	(1)	(2), (3), to a lesser extent (4)

framework provides a process for the clearing of rights with a view to valorising innovations and inventions, enhancing sharing within the public sector and accruing accessibility for the private sector. Its carries out its objectives by detecting innovative and disruptive technological projects in laboratories which may be of interest to industry and by prospecting and identifying industrial and market needs.				
West Coast Licensing Partnership An affiliation of seven west coast research institutions which have aggregated their animal models and biomarkers to promote marketing, licensing, and ease of industry access.	(2)	(2)	(1)	(2)
Lambert Toolkit for Collaborative Research An initiative that provides model agreements for universities and companies that wish to undertake collaborative research projects with each other.	(2)	(2)	n.a.	(2) and (4)
TI Pharma Collaborative structure, establishing as a public-private partnership, consisting of Dutch industrial and academic research teams.	(2)	(2) and (4)	(1)	(2) and (4)
MAGNET The Program is sponsored by Israeli Government and aims to enhance the development of long term competitiveness of Israeli industry. It does so by creating clusters of companies and research institutes in specific areas.	(2)	(2)	(1)	(3) and (4)

Apple Development Program A program that offers registered users to develop applications for selected Apple products (e.g., iPhone, iPad, iPod touch).	(2)	(3) and (1)	(2) and (1)	(1) and (4)
Open Invention Network (Linux) The (OIN) initiative was formed as a collaborative environment for using the Linux system. OIN's goal is to ensure openness of the Linux source code, so that programmers, equipment vendors, ISVs and institutions can use Linux with more freedom to operate about intellectual property issues.	(2)	(3)	n.a.	(1) (2) (3) (4)
Apache Software Foundation A non-profit foundation that support open source software developement unbder the Apache umbrall. It is a decentralized community of developers, that offer softwrae distributed under the terms of free and open source software.	(2)	(3)	(3)	(1)
InnoCentive A company that follows the "open innovation" principle in a wide range of areas such as engineering, computer science, math, chemistry, life sciences, physical sciences and business. In these areas Innocentive formulates research problems, and opens them up for anyone to solve them.	(2) and (3)	(3) and to a lesser extent (1) (monetary rewards provided for best solutions)	(3)	(1) knowledge suppliers and (4) knowledge demandeurs
NineSigma Open innovation services provider.	(2) and (3)	(1)	(3)	(1) (2) (3) (4)

Experts-Exchange.com (EE) An online "ask an expert" site for computer and IT related questions	(3)	(2)	(2) free access for active users (who actively provide answers); subscription fee for other users	(1) individuals
Knexa.com online service for companies to manage and exchange knowledge	(3)	(1)	(2)	(4) Businesses
Crowdspirit Crowdspitir links solution seeking companies that have problems or offers opportunity to be addressed with knowledge offering individuals. Covered areas include innovation in products, services, business models marketing, logistics. Companies may post such problems or opportunity and may offer a compensation (“Reward”) for proposed solutions submitted by a user.	(3)	(1)	(3)	(1) knowledge suppliers and (1) , (4) knowledge demandeurs
IdeaConnection IdeaConnection addresses problems formulated by companies by employing a network of experts. Area covered range from nanotechnology, virtual reality, biochemistry, to marketing and sociology.	(3)	(1)	(1) (knowledge suppliers are invited by IdeaConnection to participate)	(1) knowledge suppliers and (4) knowledge demandeurs
Yahoo answers A community-driven question-and-answer (Q&A) site, 2005 that allows users to both submit questions to be answered and answer questions asked by other users.	(3)	(3)	(3)	(1)

Wikipedia On-line user generated encyclopaedia	(3)	(3)	(3)	Mostly (1)
Google Search engine	(3)	n.a.	(3)	(1), (2), (3) and (4)
Google Books An internet library offering online access to a large collection of books	(3)	(4)	(3)	(1), (2), (3) and (4)

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