UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

I BATTELLI DEL RENO

Rivista on-line di diritto ed economia dell'impresa

(www.ibattellidelreno.uniba.it – www.ibattellidelreno.it)

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Redazione: presso il Dipartimento Jonico in Sistemi Giuridici ed Economici del Mediterraneo: Società, Ambiente, Culture - Sezione di Economia -
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ISSN 2282-2461 I Battelli del Reno [on line]

I Battelli del Reno, rivista on line di diritto ed economia dell'impresa, è registrata presso il Tribunale di Bari (decreto n. 16/2012)

SAGGI

Giuseppe Sanseverino

FROM TECHNOLOGICAL INFORMATION TO DATA AS TECHNOLOGY

1. Preamble. – The technological innovation of the last decade has been concerned mainly with offering services derived from the use of the internet and from the collection and processing of data of any nature, even of a simple kind. This technological conformation has made it necessary to access deposits of information, whether already processed or partly processed, structured or not. This type of innovation is based on two phenomena: the availability of large masses of information and the development of very large computational capabilities. Only to a lesser extent does this technology make use of qualified data or technological content.

The advanced development of digital technologies has assumed an extraordinary strategic importance both economically and geopolitically, therefore, in addition to private interests, there is also a public dimension to consider, such as national security and defense.

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Given the centrality of the concept of ownership of data and information, both as regards intellectual property rights and the resulting products, we need to reflect on its nature.
What we are seeing is the natural consequence of current technological developments. However, by focusing our attention on the legal aspects of intellectual property, we can draw some conclusions as to the concept of information and also as to the consequences that the nature of this intangible asset, generically considered, entails.
Massive digital innovation reveals the versatility of the concept of information, whether or not it has a technological content. In fact, the basic characteristics of the intangible asset generically defined as "information" is common to any type of cognitive data, and the intellectual property system and the world of innovation must come to terms with these characteristics, i.e. that the use of the information spontaneously creates a need for further information, and thus for access to data that is as free and open as possible; and that the content of the information does not influence its basic characteristics, but only the possibility of its use and its protection with intellectual property rights.
As we will try to illustrate below, the new digital worlds suggest an ideal line of conjunction between patent protection (claims in particular) for information with a technological content; free licenses and open-source contracts giving access to significant technological data (the source code), even if unprotectable; and raw information, i.e. information without technological concepts, and its computational use (big data).

2. Temporal rhythms of technological innovation and the dissemination of information. – It may first be useful to investigate, albeit very generally, whether there are links (and to what extent) between the pace of technological innovation and the possibilities of protecting such innovation, depending on the type of information that is developed as a result of research.[1]
Economic and statistical analyses of various industrial sectors have shown that the timing of innovation is not constant over time. In the long term, a dominant technical typology

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[1] The topic has been extensively covered. For an initial overview of the problems in the field, please refer to P. Dasgupta and J. Stiglitz, 'Uncertainty, Industrial Structure and the Speed of R&D' (1980) 11 *Bell. J. Econ.* 1980, 1. For the relationship between patent monopoly and pro-competitive function, see also R.P. Merges and R. Nelson, 'On the Complex Economics of Patent Scope' (1990) *Colum. L. Rev.* 839; R.P. Merges, 'Economic Perspectives on Innovation: Commercial Success and Patent Standards' (1988) 76 *Cal. L. Rev.* 803.

emerges, which qualifies as such precisely because it tends to determine the standards of a new product or process in its general lines.[2]

The appearance of this new technology, which results in a thorough reorganization of the service or market concerned, produces two effects: (i) it concludes a period of intensive research and creates a discontinuity of study of those lines of research that have not reached definitive outcomes, and (ii) it is the driving force for a new period of incremental innovation, and therefore of improvements in the technology that has become dominant. Studies of the formation phase of the dominant technical standard have revealed that the companies that survive are those that adapt to the new technology by playing the role of "followers" from a technical point of view, as opposed to those that determined the new development; and that recovery from the initial disadvantage often takes place quickly, as previous knowledge is enhanced. These studies have often drawn, among other parameters, on patent citations inserted in the texts of applications.[3]

The various study models tend to agree in identifying, theoretically and empirically, at least three phases in the circulation of knowledge and in technological evolution: a first preparatory period resulting in identification of the dominant standard; a second period of transition towards the prevailing prototype, and therefore the creation of the reference technology; and a third "post-dominant" period.

The process of technical "catch-up" on the part of the pursuing companies begins as early as the transition phase towards the winning model. This phase is always characterized,

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[2] See also F.K. Beier, 'The significance of the patent system for technical economic and social progress' (1980) *IIC* 563; and M. Lemley, 'The Economics of Improvement in Intellectual Property Law' (1997) *Texas Law Review* 75.

[3] The evaluation system using the so-called "patent citation analysis" method is not exempt from criticism; the studies that use it often jointly adopt other types of analytical filters. On this topic, see D. Barbera Tomas, F. Jimenz Saez and I. Castellò, 'Mapping the importance of the real world: The validity of connectivity analysis of patent citations networks' (2011) *Research Policy* 473, through some empirical results, this study evaluated the use of patent citations as a measuring stick, highlighting how this type of analysis can represent a valid tool for identifying the knowledge that is the starting point for further technological evolutions. For further information, see also J. Michel and B. Bettels, 'Patent citation analysis A closer look at the basic input data from patent search reports' (2001) *Scientometrics* 185; D. Harhoff, F. Narin, F.M. Scherer and K. Vopel, 'Citation frequency and the value of patented inventions' (1999) *Review of Economics and Statistics* 511-515; A. Jaffe, M. Trajtenberg and R. Henderson, 'Geographic localization of knowledge spillovers as evidenced by patent citations' (1993) *Quarterly Journal of Economics* 577; F. Narin and D. Olivastro, 'Technology indicators based on patents and patent citations', in A.F.J. Van Raan (eds.) *Handbook of Quantitative Studies in Science and Technology* (North Holland 1988).

among other things, by a high frequency of patent citations of technological precedents and represents a one-sided flow of knowledge from the forerunners to the latecomers. The number of citations is indicative, moreover, of the knowledge threshold that slower companies must reach in order to close the technological gap.[4]

The model of technological renewal therefore reveals itself as a system in constant mutation between major innovations and innovations that bring about only incremental changes or improvements. In this framework, there is no shortage of opportunities both for laggards to enter the market and reduce the technical distance between themselves and the dominant standard (incremental innovation), and for forerunners to be stimulated to continue their efforts to develop more important process innovations or even introduce incremental changes of their own.

Another important observation derives from the fact that companies following the dominant technology tend not to deal with the new technological feature directly but try to make up the lost distance by entering selected technological areas linked to the development of the dominant standard. In this sense, they tend to exploit their previous specialization, improving it precisely by assimilating the relevant knowledge data of their precursors.

In short, competitors who aspire to improve their own technology and use the dominant technology do not mount a direct attack but adopt a round-about strategy of small steps towards the fundamental model that has come to dominate the sector.

In particular, thanks to the now-dominant technology, the pursuing companies are able to filter their internal research and so understand what is useful and what is useless in their knowledge and technological activity.

In addition to this theoretical analysis of innovation cycles, we must consider that technological change is also determined by its interconnection with responses to the market. Indeed, each innovative phase is also conditioned by the ways in which new ideas

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[4] Literature that has analyzed the topic is vast, for this essay has been consulted: WJ. Abernathy and J.M. Utterback, 'Patterns of industrial innovation' (1978) *Technology Review* 80; S. Breschi, F. Malerba and L. Orsenigo, 'Technological regime and schumpeterian patterns of innovation' (2000) *Economic Journal* 388; Z. Griliches, 'Patent statistics as economic indicators: A survey' (1990) *Journal of Economic Literature* 1661; about the reflections indicated in the body of the text see also: J.A. Schumpeter, *The Theory of Economic Development: An Inquiry into Profits, Capital, Interests and the Business Cycle* (Cambridge, MA, Harvard University Press, 1934) *passim*; I. Wartburg, T. Teichert and K. Rost, 'Inventive progress measured by multi-stage patent citation analysis' (2005) *Research Policy* 1591; S. Winter, 'Schumpeterian competition in alternative technological regimes' (1984) *Journal of Economic Behavior and Organization* 287.

are developed in practical marketing, with the consequence that technological knowledge and its diffusion may assume different rhythms and be directed in different directions as it is transformed by evolutionary market processes and by the creation of other inventions or innovations in the competitive arena.

From this complex and synthetic picture we can grasp the main point that, under the current industrial and scientific system, the dominant technological rhythm is never (or only rarely) characterized by long intervals of technical definition following what preceded it.

The adoptable systems of protection or approach to the possibility of maintaining a competitive system are therefore the effect of the type of innovation and the typical temporal rhythm in relation to the nature of the underlying information. Even this premise of the economic nature of the temporal rhythms of innovation confirms the basic characteristics of the concept of "information", namely that the use of data results in a demand for further research and the use of other information, and therefore access to data, and the protection techniques provided by the intellectual property system are influenced only by their technological content.

3. The cyclical nature of the technological content of information. – It would therefore seem that the pace of technological innovation is determined in every phase (formation of the dominant standard, transition and commercialization), due to the limited distance of technological information between the different products and between the succession of techniques. This distance also tends to decrease rapidly in some phases of intense research activity.

If this is the technological presupposition, it follows that it is not unrealistic to imagine a conditioning that operates towards the possibilities of appropriation offered by the tools of the intellectual property system.

This conditioning would seem to operate on at least two levels.

A first area is determined by the measure that the technological rhythm offers to innovators, which – as described above – seems objectively to take place in small, rapid steps, with the consequence that all innovators are granted a limited possibility to appropriate technical information different from that which went before.

A second level of dependency arises from the ways in which innovation cycles affect competition. If, as seen above, a system would seem to take shape whereby competitors develop ways of approaching the dominant technique by enhancing the technological knowledge they already possess and relating it to the main standard, it is also logical to conceive that the characteristics of the technical information may be the object of only limited intellectual property right protection, their content necessarily having a strong specification of technical detail.

Consequently, adapting to the technological rhythm also necessarily entails adapting to the technical spaces left free for appropriation with intellectual property rights, thus determining a high level of detail in the information that can be the object of appropriation.

Ultimately, if the technology differs little from one competitor to another due to the very pace of innovation, it is logical that the techniques for interpreting the rules of intellectual property will also suffer proportionally.

When the concept of "information" has a technological content, as in the typical case of an invention patent, it reveals its systematic characteristic: it needs to be known to allow for subsequent innovation. It creates a need for access to information, and the prize (the economic monopoly granted by law) does not prevent the exploitation of the knowledge concerned by subsequent innovators but gives rise to a commercial monopoly only to the limited extent permitted by the content of the patent information.

4. The technological information. – The intellectual property system was essentially conceived to reward creativity. Over time, the system has entered into osmosis with the world of technological innovation and therefore, for several decades, almost all patent legislation has departed from the broad and generic concept of inventive idea, or an abstraction deriving from a synthesis of the elements present in each invention, and has focused on determining a global teaching. This is clear from what has been said previously since generic and non-specific technological information i) generates the widespread and erroneous belief that the patent system is based only on pioneering innovations subject to extensive economic exploitation and subsequent further technological developments; ii) is susceptible to subjective and summary judgments (adding problem to problem); iii) has proved to be inadequate with respect to the method of protection chosen by the legislator and the consequent links existing with the technological rhythm of the various sectors. (According to European Patent Convention [EPC] Art. 82, "A European patent application shall relate to one invention (…) such as to form a single general inventive concept", and Art. 84: "The claims shall define the matter for which protection is sought. They shall be clear and concise and be supported by the description").

This framework regularly interfaces with the general system criteria and the consequent balancing of interests. Although protection relates to what is expressly the object of innovation (indicated in the claim), it is also true that in this way it is possible to outline a balance of the positions in the field: a third party is able to identify the limits of what has already been technologically monopolized by others and, consequently, exclusivity is limited only to the contribution (i.e. the single technological solution) of the owner, allowing for further innovation with subsequent inventive activity, however large or small.[5]
A further important corollary is then that the patentee is obliged to exhibit his technological solutions in a useful and complete way. The resulting reciprocity seems to me to be fair: if the patentee was in possession of one or more solutions and decided not to claim them (or was unable to do so), any defect weighs on him, with the consequent limitation of the extent of the protection.
This reading certainly appears to allow the invention to be viewed in terms of an object or a process defined in its constructive aspects, and coherently and precisely in the design and concrete construction characteristics (as described and claimed) of the specific problem.
The analysis carried out up to this point allows us to arrive at some summary conclusions that complete the picture outlined previously regarding the role of technological information and its typical expression, i.e. patent claims.

[5] This point seems to me to have been clarified in absolutely and significant terms by Lord Hoffmann in a famous obiter dictum found in *Merrell Dow v Norton* [1996] RPC 76 ff: "The Amazonian Indians have known for centuries that cinchona bark can be used to treat malarial and other fevers. They used it in the form of powdered bark. In 1820, French scientists discovered that the active ingredient, an alkaloid called quinine, could be extracted and used more effectively in the form of sulphate of quinine. In 1944, the structure of the alkaloid molecule was discovered. This meant that the substance could be synthesized. Imagine a scientist telling an Amazonian Indian about the discoveries of 1820 and 1944. He says: 'We have found that the reason why the bark is good for fevers is that it contains an alkaloid with a rather complicated chemical structure which reacts with the red corpuscles in the bloodstream. It is called quinine'. The Indian replies: 'That is very interesting. In my tribe, we call it the magic spirit of the bark'. Does the Indian know about quinine? My Lords, under the description of a quality of the bark which makes it useful for treating fevers, he obviously does"; Moreover, beyond the concrete difficulty of identifying a univocal concept of inventive idea, there is no doubt that a broad and generic theorization of patent tends to remain abstract, and this generally reverses on the typical difficulty of patent law to give a precise meaning to the use of words using an interpretative criterion suitable according to the contexts.

Patent texts are writings with a legal content, even though they typically contain technical language deployed to delimit an intangible property. Like a set of instructions, they set forth precise technical indications and, unlike other types of legal writings that serve to identify a right (including property rights), they remain complex and abstract due to their detailed descriptive nature. Patent texts are increasingly characterized by needing to be deciphered according to their objective meaning as derived from their technical articulation, as indicated in the claims, making no allowance for the subjective intentions of the patentee.

Without wanting to give a precise and definitive conceptual definition, an invention certainly reveals itself, in its essential lines as set out in the patent laws of all countries, as the textual declination of a specific and analytically characterized solution to a technical problem not suggested by the known art.

The legislator has chosen this method to define the extent of the protection conferred by a patent for an invention and the central point of the patent text lies in its claims (as the well-known saying puts it: "The name of the game is the claim").[6] The use of claims has proved to be a massive success and this system is almost universally adopted in the patent laws of major industrialized countries.

The formal legal findings of the reconstruction made so far show that the interpretative technique applied to the patent also represents an effective instrument for regulating the economic leverage deriving from the right of invention.

The assessment of the breadth of patent protection also depends on the interpretative approach used by the courts and the patent office when issuing a title. The methods favoured and supported in proceedings involving the European Patent Office (EPO) tend to carry more weight because they are constant, unitary and well identified, unlike the exegetical readings that come from the courts, which are fragmented and lack an overall harmonious understanding of patent policies.

[6] The quote derives from an article by Judge G.S. Rich, 'The Extent of the Protection and Interpretation of Claims — American Perspectives' (1990) *Int'l Rev. Indus. Prop. & Copyright L.* 497 and precisely in the passage where he claims that "the U.S. is strictly an examination country and the main purpose of the examination, to which every application is subjected, is to try and make sure that what each claim defines is patentable. To coin a phrase, the name of the game is the claim . . . [and] the function of claims is to enable everyone to know, without going through a lawsuit, what infringes the patent and what does not".

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A careful analysis of this aspect, together with the complex of rules prepared by the European Patent Convention (EPC), reveals a system strongly hinged on the centrality of the role of the claims and the correct drafting of the information they contain through a binding model of robust literal detail. In the EPC system, the path of textual fidelity in the editorial office reflects the rules of interpretation and represents the model, if not chosen, at least strongly favoured to give certainty to third parties and configure innovation.
It seems to me, then, that the proliferation of productivity underlying current global economic processes is favoured by the fractionalization of technologies, and that this broad distribution of scientific results among competitors increasingly requires that third parties be robustly protected as regards exact knowledge of the techniques available.

5. Software protection: the form of significant technological information and the need for data circulation. – Another confirmation of the nature of the characteristics of the intangible asset we refer to as "information" comes from the study of copyright software protection and the effect of free and open-source licenses.
Free and open-source computer programs are software applications created as a result of the sharing of innovations among all participants in the world of computer research. Their characteristic is that free access is granted to the source code (the creative heart of any software), which, in products distributed by the industry, is protected as secret and inaccessible. This faculty granted to all users of free and open-source programs is one of the cardinal principles of the various cultural movements that support a different way of interpreting use of the exclusive rights guaranteed by copyright. The licenses governing the use of these programs are the key element when it comes to understanding the phenomenon and the interests of those operating in this field.
Open-source software is made available through a license under the terms of which the rightsholders encourage modification, study, use and redistribution of the source code. The main feature of open-source licenses is typically the publication of and access to the source code (hence the name).
There is no doubt that, due partly to the underlying social and economic motivations that have favoured its development, this type of license gives rise to a contractual exchange that allows for the creation of a different market in which the products concerned are able to circulate as envisaged by the owner only by virtue of the exclusive rights protected by copyright. In fact, the nature of free and open-source licenses explains why in recent decades the contract law on intellectual property rights – when important economic and

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competitive reasons require it – is fundamental to a trend towards widespread exploitation of the free contractual autonomy of private individuals as a way of broadening the spectrum of exclusive rights guaranteed by intellectual property legislation. In this sense, the contract has assumed the guise of an ordering category that has swept away any other theoretical evaluation and now offers economic operators an effective tool for the circulation of rights according to the schemes desired by the rightsholder within each market, without being significantly influenced by the existence of different legal systems.

Study of the free and open-source licensing model leads us to predict that the last step on the road to the international standardization of the intellectual property system will be inspired from below, i.e. from the concrete, global application of the legal and regulatory provisions governing IP rights, with a great reduction in transaction costs and information asymmetries[7] through the drafting and acceptance of commonly known contractual rules. In this sense, harmonization of the various national systems will entail a review not only of regulatory instruments, but also of market structures, the use of technologies and, in general, the combination of juridical-economic and cultural factors which preserve the competitiveness of intangible assets.[8]

The system for protecting the various players in the contractual battle over exclusive rights is evolving towards a type of relationship that is no longer based exclusively on the status of the subject (author, company or user) but also on the type of goods and exclusive rights brought to market from time to time.

In other words, in an era when service providers have the whip hand over content providers, the latter must devise contractual and distributive systems that enable them to protect their economic prerogatives, even if in an alternative way.

Viewing the existing relationship between software protection and the development of free and open-source licenses in this way immediately triggers a basic intuition with regard to this contractual model: the realization that the free and open-source movements are not only a conditioned reflex of the lack of competition in the software market that prevailed until only a few years ago, but also that they represent an instinctive (and more considered)

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[7] Cfr. W.M. Landes and R.A. Posner, *The Economic Structure of Intellectual Property Law* (Belknap Press, 2003) *passim*.

[8] See R.T. Nimmer, 'Breaking Barriers: The Relation Between Contract and Intellectual Property' (1998) *Berkeley Technology Law Journal* 827; P.B. Hugenholtz, 'Copyright, Contract and Code: What Will Remain of the Public Domain?' (2000) *Brooklyn J. Int. L.* 77.

reaction on the part of some expert-user sectors to the accelerating decline in the possibility of "cognitive use" of intellectual property.[9]

In fact, the implications of the free and open-source licensing model are extraneous to perspectives of mere gratuity or simple dominion over a created work and any product derived from it.. The development of free and open-source software, on the other hand, is a valid stimulus to the search for alternatives for the circulation of exclusive rights (truly operational in the context of changing market scenarios), with a simultaneous balance of all interests protected by copyright. The regulatory structure governing the licensing model stimulates the articulation of predetermined rules of exploitation and concrete use which (i) are valid in every phase of product circulation, (ii) are mandatory for all those who come into contact with the intellectual property in any capacity, (iii) implement mechanisms that allow for the application of criteria of economic efficiency (the remunerative convenience for each negotiating party facilitates concrete and spontaneous compliance with the contractual precepts), and finally (iv) involve substantial respect for the rights functionally due by law to each contracting party. In the licensing model, the faculties granted to each subject are exactly proportional to the role actually played within the circulatory mechanism of the intangible asset, which is widely understood and which – in the final analysis – maintains the coherence of the system of copyright protection through the effective application of the founding principles. But, above all, it allows for the circulation of significant technological data, which is essential for subsequent innovation in the particular scientific and technical field and which the copyright protection of software completely frustrated.

In short, the advent and development of free and open-source licenses in the field of software confirms the nature of information as an intangible asset when it becomes one of the key elements for subsequent innovation.

The success of the free and open-source licensing model has not only had a technological impact in promoting a high number of software development projects, but has also aroused interest in exporting this type of contract from the discipline of computer programs to that of other intellectual works protected by copyright.

The free and open-source licensing model has therefore been proposed as a functionally useful contractual scheme for any other intellectual work that wants to adopt its particular

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[9] See also L. Guibault, *Copyright Limitations and Contracts. An analysis of the Contractual Overridability of limitations on Copyright* (Kluwer Law International, 2002) 18.

system of circulation of rights. The motivations behind these attempts to extend its scope have been mainly ideological, i.e. based exclusively on the fact that the widely participatory system promoted by this type of contract could represent an ideal model for incentivizing innovation.

However, in the light of the experience of more than twenty years' knowledge and diffusion of free and open-source licenses, it is possible to conclude that the extension of this license model to other intellectual works does not provide the same advantages as those achievable in the case of software, or tends towards mere emulation, in many ways meaningless from the point of view of economic-juridical efficiency. Beyond computer programs, free and open-source licenses have in fact been a failure.

The real reasons, however, are of a substantial nature, which once again relate to the very concept of information as involved in the innovation process.

A first reason is that, from a technical point of view, the creation of the original software in its particularity (being, in fact, protected by copyright, despite having a typically functional nature) applies only to a work that simultaneously combines both the identification of programming errors and the commitment to develop many small elaborations of the basic work. Although software can reach a certain degree of completeness, such as to make it usable, it can still be continuously optimized, and therefore is conditioned by the need to be constantly updated with new information for functional and technological reasons. No other intellectual work protected by copyright has these characteristics, with the exception (perhaps) of scientific and didactic publishing, and the relationship between research and innovation, as we shall discuss later.

This idea immediately suggests another. One of the fundamental characteristics of the rights circulation system as practiced under the free and open-source licensing model is access to the source code. The model in fact incentivizes innovation in a way that is absolutely antithetical to the provisions of the rules for the legal protection of computer programs. The legal rules provide for the "armoring" of the code,[10] whereas the free and open-source movements presuppose an alternative system for the exploitation of rights to that stipulated by the rules, based on free access to the source. However, no other intellectual work protected by copyright prevents the direct use of its contents during its enjoyment. For example, whoever listens to music has a direct perception of the melody,

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[10] Cfr. R.D. Clifford, 'Simultaneous Copyright and Trade Secret Claims: Can The Copyright Misuse Defense Prevent Constitutional Doublethink?' (2001) *Dickenson L. Rev.* 247.

just as whoever sees a film has immediate or easily reconstructed knowledge of every creative contribution present in the work, so that the flow of creative influences on successive innovators is not in any way hampered by a knowledge gap in relation to previous work (access to information). On the other hand, anyone who uses a computer program, even if he is an expert, has no immediate knowledge of the source code and therefore of the intimate creative essence of the asset he is using. In short, only computer programs need "disclosure" of their "soul" to allow for acquisition of the relevant knowledge and dissemination of their creative value.

A final consideration is that other intellectual works, unlike software, neither have a broad need to be updated nor offer advantages (whether to the author of the basic work or to subsequent elaborators) deriving from the modification and elaboration of the creative work itself. For example, the author of a musical work has no interest (generally definable as economic) in granting the processing rights to his own melody, since any modification would not increase or create an alternative system of remuneration for his rights nor prevent subsequent innovation due to lack of knowledge of the prior art. The granting of a processing right would be to the exclusive advantage of the subsequent user, who would thus gain (truly free of charge) an exploitable resource without any sacrifice, not even that of being a user and developing a network of users (without which, as already pointed out, there would be no alternative economic remuneration). The author of any intellectual work other than a computer program would not enjoy the direct and indirect advantages arising from free and open-source licenses in the IT field, especially in terms of information circulation.

The substantial failure of projects to develop intellectual works other than software under the free and open-source licensing model, as far as has been recorded to date, seems to me to confirm my thesis. Apart from the basic philosophical intentions that delight ideologically oriented audiences, initiatives that can be defined as "open content" register the almost exclusive and certainly majority participation of non-professional subjects. They remain at a promotional level, destined to be little used by experts and to have no impact on the reference markets.

Moreover, the arguments put forward above also explain why the free and open-source licensing model cannot be exported, *sic et simpliciter*, to any work definable as an "information asset". This category of assets is made up of traditional works already present on the markets, such as music, films and books. Although they share the common method of exploiting creative work and its information content through digital techniques, in many cases allowing a circulation similar to that which occurs for software, they do not create the need for access to information to allow for subsequent innovation.

6. Free and open-source licenses as an intermediate step to the computational use of simple information. – Recording the failure of the attempt to extend free and open-source licenses to other types of intellectual works confirms some systematic observations concerning the relationship between research, innovation and the market. In particular, it is interesting to note how any present or future success of so-called "open content" licensing models is directly proportional to the degree of acceptance that these systems receive in scientific research environments other than information technology. Such acceptance can only be achieved if the open-content model is accredited as an effective tool for improving the results of the interaction, widely understood, that exists between the world of research (non-IT) and technological development in the industrial field.

For several decades now, much economic research has demonstrated how, in almost all countries with advanced economies, it is not easy to distinguish between public research ("basic research") and the research conducted by industry ("applied research").[11]

The current systems for disseminating and circulating knowledge do not always make a clear distinction between results of a general nature (achieved with basic research and made known through scientific publications) and applied industrial innovation geared towards technological products. Knowledge of the latter kind would be disseminated by means of the patent for an invention, and would be presented as a product of the elaboration of basic research.

In today's scientific world, basic research is often directly involved in industrial projects, and this relationship seems to have at least two important consequences: a) an expansion of the funds allocated to institutes dealing with technological innovation, with a direct increase in incentives and results for the whole sector; b) an extension of intellectual property rights to the results of basic research because of companies' interests in the exploitation of technological products, with the consequent risk of weakening the social value and cognitive essence deriving from the promotion and circulation of knowledge, to gain possible technical and economic advantages.

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[11] On this issue, see also S.G. Levin and P.E. Stephan, 'Research Productivity over the Life Cycle: Evidence for Academic Scientists' (1998) *American Economic Review* 816; A. Agrawal and R. Henderson, 'Putting Patents in Context: Exploring Knowledge Transfer from MIT' (2002) *Management Science* 48.

The picture that emerges where open content is concerned is perhaps ambivalent, consisting in the coexistence of two dependent but opposite visions. The first places the emphasis on the pro-competitive aspect of the use of privative rights and strengthens the rules that favour the anti-appropriation interests of companies in sectors where economic remuneration by traditional means is fundamental for producing creative works or for the circulation of information. The second assigns a closing function to an open system of information-sharing and imagines the existence of research sectors or production fields in which authors and companies find alternative compensation opportunities or in which the good of knowledge – and therefore of the free circulation of technological information or information that has an effect on the innovation process – remains a priority.

It would therefore seem that the free and open-source licensing model, rather than developing a regulatory framework designed to gradually eliminate the protection and circulation of intangible assets through the monopoly constituted by exclusive rights, attempts to highlight the existence of an aporia (internal contradiction) in the system in the essential relationship between the circulation of information and the innovative process.

The basic assumption is simple: research and the production of knowledge and information, whatever the objective and whoever performs it, always has the same characteristics, such as the initial costs (which tend to be high), their vocational utility for innovation and the high risk of free-riding. We can therefore conclude by arguing that the research circulation system advocated under the free and open-source licensing model and the traditional model of intellectual property rights comes up against an insoluble logical difficulty: both the proprietary and the open paths remain possible and fruitful under the right circumstances, but subsequent innovation can be created only on the condition of allowing information to circulate.

In many cases, the protection of information involves a choice of the type of diffusion that the work can allow. Under certain conditions, the system can offer a neutral option (from a legal and economic point of view) between open or proprietary circulation, thus giving all subjects the opportunity to take advantage of new circulation schemes and incentives for innovation in information markets. In any case, this option still requires a careful evaluation of interests in the field, and is never a preconceived and unreserved choice.

7. The current phase of computational innovation. – In the current historical phase, the innovations with the highest economic impact often derive from the use of computational techniques. This technology involves the use of large quantities of information, even information that is simple and without technological content, and consequently data has become a fundamental economic resource.

Competition is no longer a matter solely of improving the software that manages computational techniques, but also (and above all) of acquiring as much useful information as possible. Basically, innovation develops on different levels. Research is based firstly on the interaction between large amounts of data and their direct computational use for creating innovations or for training software systems (the second and third levels), then for producing more elaborate data, which represents an intermediate stage in moving towards a more advanced level of innovative achievement.[12]

The development of services involving computing technology cannot be considered in isolation from the technical infrastructure that allows the processing of the data collected and aggregated from various sources.

Computational technology is implemented mainly through the methods of so-called "machine learning" and "deep learning".

Machine-learning technology is capable of receiving a (theoretically infinite) amount of raw data, understanding its content and processing it to produce useful information. At the same time, this technology is capable of modifying its internal operational algorithms as the machine receives and verifies the information itself. In this case, artificial intelligence (AI) consists in a machine equipped with the ability to train its algorithm both on the basis of machine-learning and by comparing and sifting the information supplied to it. The more data provided to the machine, the more effective the operation and the results of the learning algorithm will be.

The deep-learning method ("deep learning") uses extensive computer neural networks with various processing units to enable the computational machine to both acquire a huge amount of data and to process complex information. These two AI technologies are often integrated with each other.[13] AI applications typically make it possible to organize data,

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[12] J. Drexl, 'Designing Competitive Markets for Industrial Data – between Propertisation and Access' (2016), Max Planck Institute for Innovation and Competition Research Paper No. 16-13 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id1⁄42862975>, 8–11.

[13] R. Calo, 'Artificial intelligence policy: a primer and a roadmap' 2017, < https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3015350>.

understand language, recognize objects and sounds, learn and solve problems deriving from the processing of the information collected. Although these computational practices are often closely related to the so-called internet of things (IoT), they can be used in any sector and for the most varied uses.

The basic technical set-up of AI is therefore based on the functioning of so-called "artificial neural networks": computer systems that physically imitate the mechanism of the human mind, using an architecture of mathematical models composed of artificial "neurons" inspired by biological structures. The starting point in developing their potential is the training of learning and processing algorithms. This fundamentally important phase is implemented by supplying the machine with a series of correct examples, which over time enable the artificial network to give correct answers not only to the examples already introduced in the training phase, but also to similar cases. In essence, the preliminary technical objective of any AI task is both to create and structure the functioning computer system, and (subsequently) to adequately train the machine.

On the basis of the premises set out above, and for the purposes of legal analysis, AI as a computer technology is characterized by at least four main aspects:

(i) It can understand the environmental and external information supplied to the machine through its sensors (visual identification of objects, textual analysis of documents and tables) and can correlate the data and derive new computational objects from it.

(ii) It can automatically calculate (and therefore process) the multiplicity of information collected, using the logical and/or artificial neural tools of the machine's operating algorithm.

(iii) It can interact with the environment and with human beings.

However,

(iv) the phases indicated above always require a preliminary stage of learning in which the AI is addressed specifically to the problem (or to the information being sought) during a period of "understanding" stimulated by the communication of "correct" entry and exit data, so that the machine learns to perform the various functions typical of the specific task required of it.[14]

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[14] See L. Vertinsky and T. Rice, 'Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law' (2002) *Boston University Journal of Science & Technology Law* 574; R. Plotkin, *The Genie in the Machine: How Computer-Automated Inventing is Revolutionizing Law & Business* (Stanford, 2009) *passim*; R. Abbott, 'Hal the Inventor: Big Data and Its Use by Artificial Intelligence', in C.R. Sugimoto, H.R. Ekbia and M. Mattioli (eds.) *Big Data Is Not a Monolith,* (MIT Press, 2016) 187; R. Abbott, 'I Think, Therefore I Invent: Creative

In fact, the data analysis carried out by the AI must necessarily adjust (through the activity of the human operator) its deductive process based on the operating peculiarities of the reference technological sector. And it is possible that this process may be subject to errors, to the introduction of irregular or incomplete information. If, for example, the AI has to analyze the automatic facilitations for driving cars on unpaved terrain, this will involve the learning and programming by the machine of the data relating, in general, to the recurring and/or rare characteristics of unpaved roads in different climatic states; the processing and induction of data in relation to the particularities and road behaviour of cars in those particular road contexts; and, finally, verifying everything specifically for the type of car being designed. Note that, in this example, the learning activity could be subject to errors, even errors of a structural nature. For instance, the data supplied to the AI machine will certainly concern cars with older construction techniques, information which can, if not corrected, distort the final result.

The acquisition and processing of information is therefore as vital as the technology that uses the data: information has become technology itself. In this case, too, access to and circulation of information is necessary for subsequent innovation.

8. Final remarks. – Digital technology is expanding the methods of exploiting information to achieve innovative results. Historically, we have moved from the exploitation and protection of information with a technological content (use of patents for inventions), to the use of significant technological data (software) protected by copyright, and now to the point where simple information considered in the context of large deposits of data, together with their computational use, becomes technology itself.

Ultimately, when computational techniques use large deposits of information of any kind, there is a double effect: firstly, innovative techniques are the result of the union of two elements which, considered in isolation, do not have innovative characteristics (only the combination of large amounts of data using adequate computational power generates results); secondly, information, even of a simple kind, is characterized by its function of being "fuel" and "engine" at one and the same time, even in the absence of content that can be protected under intellectual property law.

Computers and The Future of Patent Law' (2016) *Boston College Law Review* 1079 <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2727884>.

The problem then arises of guaranteeing, even in this new phase, the development of the subsequent innovation and the protection of the innovative results. Where computational technology is concerned, the paradigm of intellectual property is therefore in tension as it has upset the existing balance between appropriation of innovative results and the need to make knowledge available to other researchers.
It is therefore necessary to find a way of a) allowing access to information to ensure subsequent innovation, b) guaranteeing proprietary use (otherwise no one will invest in expensive technology), and c) providing proprietorship that is limited only to the small degree of innovation that this type of technology allows.
This being the case, digital technologies should permit broad freedom of access and use of information resources for the sake of subsequent innovation, while second- and third-level information should be considered accessible but also protectable, as if they were innovative results that arise from the interaction of computational power and first-level raw data.
However, such an arrangement does not seem to be easily achievable: the collection of data often has huge costs; the potential of second- and third-level information is revealed in their reserved use; their knowability would destroy the competitive advantage deriving from the initial investment spent in creating them; and, finally, protection of the simple effect achieved by the computational use of information is not even imaginable, since industrial competition almost always operates at the level of efficiency of the effect achieved among competitors. For example, in the case of a car's automatic braking system or digital navigation maps, innovation does not operate on the effect that is created (automatic braking or reaching the destination) but on the quality of the service, and ultimately on the different use of computational information resources.
In this technological panorama, in which public and national interests in the management of personal and sensitive data play an important role, information has itself become technology, and there are strong opposing needs, perhaps we are seeing a repetition of the competitive and pro-innovative drives that favoured the birth of a system based on a dual structure, as has happened in the software industry over the last two decades.
It is perhaps conceivable that the opposing interests of research and industry – because they are faced with the same technological characteristics and difficulties in ensuring that the rules of intellectual property provide a sufficiently balanced structure – can move towards an order in which the computational uses of proprietary and secret data can coexist with uses that can be defined as "open source". Certainly, it is desirable that both

ISSN 2282-2461 I BATTELLI DEL RENO [ON LINE]

solutions be managed, when possible, by public institutions taking into account the different interests involved.