Intellectual property rights and the commodification of nature: the case of seeds

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1 Introduction

The work of Nobel Prize winner Elinor Ostrom has had the merit of reintroducing the theme of the commons into the current economic debate. Indeed, the commons have become a very fertile field of research and a political perspective capable of providing solutions to the impasses of capitalism, particularly the economic, ecological and democratic (Peugeot, 2013) crises as well as the inequalities that now dominate the world-wide distribution of wealth. At the same time, the development of digital technologies, as well as the rediscovery of ancestral collective social practices, contribute to creating the framework within which commons have become a structuring axis for the analysis and implementation of systemic transformations of society. The commons therefore represent a way of criticizing the current neoliberal society based on the rationality of the *homo oeconomicus*, the efficiency of markets and methodological individualism, and a way to overcome it, as also mentioned by Bollier (2014a).

The reopening of the discussion on private property, as the best way to allocate resources, and on property rights, as a source of legitimization of the appropriation of resources themselves, are the fundamental points raised by Ostrom, from which to start this analysis, which will focus essentially on issues related to intellectual property rights (IPRs) over the living from the perspective of the commons. In this context , two spheres are involved: the legal sphere and the ethical one. This paper will discuss concepts arising from the links between intellectual property and agriculture on the one hand, and between intellectual property and open innovation on the other.

The object of this research on the living organism is represented by the analysis of seeds *vis-à-vis* the process defined by Coriat (2015) as "the hardening and diversification of exclusive private rights over knowledge".

In the first section we briefly review the historical reconstruction of the major stages of the implementation of IPRs on living organisms.

In the second section we will test analytically in an ostromian framework the characteristics of seeds in order to validate our starting hypothesis (H1) namely the transition of the seeds from common to private goods regime after the introduction of the IPRs.

Our starting hypothesis (H1) is as follows: throughout history, seeds have been CPRs and commons according to Ostrom's definition; however, the introduction of IPRs on living organisms has meant for these natural resources, the creation of an enclosure aimed at making them private property, thus preventing access and common use of seeds by farmers' communities that had guaranteed their sustainable development.

In order to validate our research hypothesis, we will use the analytical tools provided by the extraordinary richness of Elinor Ostrom's work. In this approach, first of all (s_0)[1], we will test the economic characteristics of seeds, in order to determine if they can be considered both CPRs (T1) and commons (T2). Following the introduction of IPRs on living organisms and seeds in particular (s_1)[2], we will carry out the same test (T1 and T2), in the new situation to determine whether the introduction of IPRs would imply that seeds can no longer be considered respectively as CPRs (T1) and commons (T2).

The third section of this paper will aim to propose a form of exceeding the seed enclosures created by IPRs, in order to make them commons again, by applying the bottum-up principles of free software. This analysis will be carried out on the basis of a comparative evaluation grid explaining the principles underpinning

[1] s_0 represents the period before the introduction of intellectual property rights.
[2] s_1 represents the period after the introduction of intellectual property rights.

open source software (OSS) applied to seeds. The aim is to see how the bottom-up forces of agriculture use the tools provided by the bottom-up forces of the new information and communication technologies. In this context, we will therefore try to highlight the parallelism between the principles governing seed as common and the foundations of the social and solidarity economy.

The final section then descrives crucial point in this paper and the highlights of the research.

2 Intellectual property rights on living organisms

As early as 1930, the United States passed the Plant Planet Act (PPA), which was amended in 1954 and 1998. It is a law that allows patents to be filed on certain plants; it applies mainly to ornamental plants and does not protect "an invention or discovery in functional terms or in terms of its characteristics [...] does not even protect the plant if it is reproduced by means other than asexual reproduction"[3] (Fonte, 2004, p. 65). However, the PPA is the first and so far the only law dealing with the patenting of life, adopted by the US Congress. This law was extended in 1970 following the introduction of the Plant Variety Protection Act, which covers seeds and more than 350 species of plants for food use. Since then, successive laws have strengthened the protection of the interests of large multinational companies.

The advent of genetic engineering opens the way for seed patenting. In 1994, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), promoted by the World Trade Organization (WTO), was signed. Article 27.3b allows for the reconciliation of biodiversity and IPRs. In this sense, the article requires the patentability of micro-organisms and non-biological or microbiological processes and allows the patentability of a *sui generis* system or a combination of these two modes for plants and animals. These clauses imply that the patenting of microorganisms derived from genetically modified plants or animals becomes possible (Laperche, 2008). The possibility of excluding patents on animals and plants, which was considered as a concession to developing countries in the TRIPS Agreement, is increasingly being abandoned in the bilateral agreements (TRIPS+) that developed countries, particularly the United States

[3] My translation.

and the European Union, establish with developing countries (Wright and Pardey, 2006, p. 19). In fact, the introduction of a *sui generis* system often involves restricting farmers' access to seeds.

One of the *sui generis* systems is that established by the International Union for the Protection of New Varieties of Plants (UPOV) International Convention signed in 1961, last amended in 1991. “The initial objective of this system[is] to protect the breeder's work, while allowing free access to the variety” (Chataille, 2005). In order to protect the breeder's right, UPOV issues the plant variety protection certificate (PVR). A first amendment, made in 1978, provides that a plant variety may be protected by a certificate if the following three conditions are met: it must be distinct, uniform and stable. The holder of the certificate thus acquires the exclusive right to exploit his variety. Each user must therefore pay a royalty to the breeder, except in two specific cases: use for research purposes and the "farmer's privilege", under which the breeder may use part of the harvest product obtained by growing the variety for breeding or multiplication purposes[4]. With the 1991 amendment, Article 15(2) of the UPOV Convention removed the mandatory nature of the farmer's privilege, which became optional. The choice is left to the signatory countries, which may exceptionally and to a limited extent allow the reproduction of seeds only on the land of the agricultural holding. In addition, this right must be exercised subject to the protection of the legitimate rights of the breeder (UPOV, 2009, p.10). The 1991 UPOV Convention also introduces a fourth condition: not only must the variety be distinct, uniform and stable, but it must also be new. The latter criterion means that the breeder must be remunerated even if it is an essentially derived plant variety. “This system meets the needs of seed companies positioned in the market but is far from the needs of small and medium-sized breeders” (Chataille, 2005, pp. 116-117).

[4] Reproduction using certain reproductive material (fruit trees, berries, vegetables) is forbidden.

3 Seeds and the introduction of IPRs: from common goods to private goods

3.1 Analysis at period s_0 (before the introduction of IPRs)

In view of the *International Treaty on Plant Genetic Resources for Food and Agriculture* which, as seen above, recognizes two fundamental characteristics of plant genetic resources, namely that of being the common heritage of mankind and, therefore, of being based on open access, we may wonder at this stage whether these characteristics are sufficient to consider these resources as Common-pool resources (CPRs), in the ostromian sense of the term. It is well known that to be considered as a CPR, the resource must be rival in consumption and not be excludable.

Table 1 - Classification of economic goods

	Rivalrous / High sustractability [5]	**Non-rivalrous / Low sustractability**
Excludable / Easy exclusion	Private goods	Club goods
Non-excludable /Difficult exclusion	*Common-pool resources* (Seeds)	Public goods

Plant genetic resources, and seeds in particular, are rivals, since the consumption of these goods by one user can lead to a reduction in consumption by other users, and they are also non-excludable, since it is impossible to exclude anyone belonging to the reference community from the consumption/use of these goods. This analysis is based on the historical experience of traditional farm management[6]. Ostrom defines

[5] In Ostromian terminology, the term "rivalrous" is replaced by the term "subtractable", and it is also essential to stress that there may be two cases: "high subtractability" and "low subtractability".

[6] As we will see below, modern agriculture, based on increased productivity, biotechnology and the commodification of natural resources, will determine a non-conformity of the good "seed" with the characteristic of non-excludability / difficult exclusion.

commons[7] as follows: ”a general term that refers to a resource shared by a group of people and often vulnerable to social dilemmas” (Hess and Ostrom, 2007, p. 349).

With regard to this definition, it seems quite correct to consider plant genetic resources and seeds in particular as commons. The above characteristics therefore show their true nature. Seeds are actually shared resources within the farming communities that use them. The practice of seed exchange is essential to ensure and especially to increase biological diversity. The latter is the factor that guarantees the sustainability of resources and therefore the survival of the people (group of people) who derive their existence from them. Indeed, from a biological point of view, seed diversity implies a varied genetic heritage that makes it possible to obtain the harvest necessary for the survival of the community[8], even under the most delicate environmental conditions due to extreme shocks. An extremely relevant example is that of the Indian women of the village of Erukulapally, who have reintroduced traditional seeds into their territory, better adapted to the semi-arid soils and climatic conditions that characterize the region, than the crops introduced by the Green Revolution[9]. In order to rediscover agriculture based on biological diversity, these women turned to their mothers and grandmothers to look for the many traditional varieties that had almost been forgotten. After many cultivation cycles, they have succeeded in reviving traditional polycultures. They plant six or seven types of seeds in a field to ensure the safety of a crop, even in the event of extreme weather events. This is what Bollier (2014b, p. 22) calls “eco-insurance”. The development model for women in this community is based on the reappropriation of knowledge and the willingness to collaborate and share.[10] Free movement and trade contribute to the structuring of social, economic and ecological reference communities. In addition, because of the importance of seeds in society,

[7] The adaptation of plant genetic resources to commons management in accordance with the eight principles identified by E. Ostrom will be analysed below.
[8] The community must therefore be considered as the "group of people" of which Ostrom is concerned.
[9] See Bollier (2014b).
[10] As Bollier (2014b) states, each household has full control over its "gene bank".

particularly in traditional agricultural societies (but not only[11]), they also involve a value system and a body of knowledge that helps to structure social relationships and hierarchies in communities.

It therefore appears that these resources are often vulnerable to social dilemmas as available resources, but not to infinity. The so-called scarcity of resources is a characteristic that distinguishes Ostromian commons. Their use and exchange are carried out according to precise, shared and recognized rules that allow the preservation of the resources themselves, according to an intergenerational pact. In this sense, the variety and multiplicity of seeds is not only an important element from a biological point of view, but also from a social point of view of the links and structures that are guaranteed in this system. It is a system based on the sustainability of the management of the common resource.

According to Nonini's definition (2006, p. 164), common goods are "those assemblies and ensembles of resources that human beings hold in common or in trust to use on behalf of themselves, other living human beings, and past and future generations of human beings, and which are essential to their biological, cultural, and social reproduction". This definition is well suited to the definition of "commons of the living" in general and seeds in particular.

According to Ostrom, the long-enduring successful cases of CPRs self-governance institutions are characterized by the fact that they meet the following eight design principles:

1. Clearly defined boundaries.
2. Congruence between appropriation and provision rules and local conditions
3. Collective choice arrangements
4. Monitoring
5. Graduated sanctions
6. Conflict-resolution mechanisms
7. Minimal recognition of rights to organize

[11] Seed design in developed societies is a very complex and controversial subject. It has an impact on many issues, such as the ecological sustainability of agricultural models based on monoculture, the harmfulness of GMOs in human food, the loss of biodiversity and its values, the loss of traditional knowledge (tacit and explicit) and know-how, the role and status of knowledge, etc.

8. Nested enterprises

The eight principles identify something that goes beyond the common resource, but is nourished by it.

They allow to show all the elements that institutionalize a CPR system. This system is precisely that of the commons. As we will see, this system not only meets the values of sharing and eco-sustainability, but it is also economically efficient, i.e. it allows the best possible allocation of resources.

Another essential element of our analysis is that seeds are not only a natural resource sensitive to social dilemmas, but also because of the wealth of knowledge, information and knowledge they incorporate, as well as their management and use, according to the principles of participation and sharing, are also examples of knowledge commons.

Although knowledge is a non-rival/subtractable and non-excludable intangible resource because knowledge increases as it is consumed, the work done in 2007 by American librarian Charlotte Hess and Nobel Prize winner Elinor Ostrom shows that it is a common since, like natural resources, the eight principles of open resource management can be identified. This therefore seems a fundamental characteristic, even if knowledge cannot be introduced into Table 1 among the CPRs, if one relies exclusively on the characteristics of non-excludability and rivalry/subtractibility, it is nevertheless to all intents and purposes because it meets the eight principles set out above. Moreover, the knowledge, is fully in line with the Ostrom definition of CPRs. “The term 'common-pool resource' refers to a natural or man-made re-source system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use” (Ostrom, 1990, p. 30).

This is one of the greatest contributions of the work of Ostrom and his disciples on the commons. It is implicitly recognized that a resource can be a common, not only on the basis of its nature, but also on the basis of institutional rules and principles of functioning, use, management and sharing. It also results in the constructed character of the commons, which is the result of social, economic and political choices. The term social dilemmas therefore encompasses all the rules and institutions that shape society, through antagonistic passages between different members/communities in order to obtain the satisfaction of

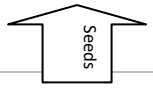
conflicting interests. It is in this sense that the dynamics of power can influence the status of the resource considered, in our case the seeds, by trying to change the institutional structure that allows them to be considered as commons. So, in the explanation of the term "common-pool resources", the emphasis is placed on the fact that it is expensive to exclude someone, but not impossible. It is precisely in this non-impossibility, as we will see, that IPRs will creep in.

3.2 Analysis at period s_1 (after the introduction of IPRs)

The main purpose of the introduction of IPRs is to challenge the non-excludability of plant genetic resources in order to make them, on the contrary, excludable resources. This process aims to transform CPRs, managed according to the principles of community sharing, into private goods that can be used exclusively.

The introduction of IPRs on biological resources and seeds in particular leads to the transfer of property from CPRs to private property. Table 2 summarizes this phenomenon.

Table 2 Introduction of IPRs and change of seeds status in the classification of economic goods

	Rivalrous / High sustractability	**Non-rivalrous / Low sustractability**
Excludable / Easy exclusion	Private goods (Seeds) 	Club goods
Non-excludable / Difficult exclusion	*Common-pool resources*	Public goods

However, the introduction of IPRs not only undermines the seed common resource by making it appropriate and preventing it from being managed according to the principles of free exchange and sharing. It also hinders the sharing, transmission and exploitation of knowledge (especially traditional knowledge).

With the advent of IPRs, we are witnessing the institutionalization of the denial of the right to joint management of the resource, even if it is a local resource.

Commons are all natural and/or artificial resources exploited together by several users whose exclusion processes are difficult and/or costly, but not impossible to achieve.

As highlighted above, most international treaties aim to introduce IPRs into seed commons. In line with the arguments of Chataille (2005, p. 110) "[with] the exception of the FAO International Treaty,[t]he agreements are based on a bilateral approach and on the private appropriation of genetic resources, long considered as the common heritage of humanity. They thus tend to restrict access to genetic resources." This questions the principle of free access to genetic resources, which had ensured development in terms of new varieties and sustainability.

In accordance with Article 27(3)(b) of the TRIPS Agreement, the prohibition of trade in seeds imposed on the farmer is the factor which affects his existence and survival. In addition, this measure undermines the foundations of biodiversity[12]. The ban on trade in seeds between farmers in developing countries has implications and strengthens the process of transferring capital from developing countries to the agro-industrial countries of the North, thus contributing to the increase in the debt of these countries.

From the analysis of UPOV's characteristics, two lines of thought develop on their nature and on the role they play in the complex system governing IPRs. On the one hand, it reveals an aspect which, as Chataille (2005) clearly points out, makes it possible to make a clear distinction between PVRs and patents. Unlike patents, PVRs involve at least partial free access, since the breeder's consent is not required to obtain new plant varieties. On the other hand, however, it is clear that the novelty of the variety for which the certificate is requested, and its effect in terms of royalties, seem to be mechanisms that tend increasingly

[12] Biodiversity was first defined at the Biodiversity Forum in Washington in 1986. By this term, I mean the variety of organisms at all levels: genetic variants belonging to the same species, species within communities, communities within the environment and environments within ecosystems and the biosphere, "[t]he diversity of life forms, so numerous that we have yet to identify most of them, is the greatest wonder of this planet" (National Academy of Sciences, 1988, p. v). In 1992, at the Rio Earth Summit was signed the Convention on Biological Diversity. Article 2 gives the following definition of biodiversity: "'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

to approach the patent (Gentilucci, 2015). This assumption is supported by the last important measure provided for in the 1991 UPOV Convention. It allows a double protection: by means of the plant variety certificate and by means of the patent. In doing so, it approves, validates and legalizes American plant protection practices (Chataille, 2005, p. 115).

The expansion of IPRs is based on an ideological premise that has become predominant, according to which the market is an efficient operator to ensure the dissemination and exchange of knowledge (Coriat, 2011). In this context, patents are considered the most appropriate instrument to address market failures in research and development. On the basis of this premise, supporters of systems that protect intellectual property through the use of patents or other forms, such as the sui generis systems mentioned above, identify a number of benefits that result from the use of these forms. These benefits can be summarized by the incentive that IPRs would provide to private investment in research and development, which would not otherwise be possible due to the characteristics of the knowledge good, i.e. it is a public good and therefore not a non-rivalled and non-excludable good. Thus, the artificial monopoly created by IPRs is considered to be the basis for innovation. The latter should be the social benefit to be derived from the establishment of the temporary monopoly, which would justify protectionist interference by the State (Fonte, 2004, p. 59). The basis for these arguments can be found in Hardin's famous 1968 article on the tragedy of the commons and proposes a market-based theory of collective action to ensure that the tragedy of environmental degradation, which occurs according to the author when a resource is used in common by many people, can be avoided[13]. Contrary to Hardin's (1968) conclusions, the work of Nobel laureate Elinor Ostrom has had the merit of reopening the debate on common goods and reversing the growing tendency to see the market as a panacea for all ills, highlighting instead that there are alternative forms to the state-market dichotomy that are sustainable and effective.[14]

[13] In particular Hardin (1968) refers to the overuse of the resource.

[14] Ostrom's most important criticism of Hardin is that natural commons are not open access spaces and resources, but well-defined spaces and resources, self-managed by a limited group of people, based on precise rules or institutions derived from customary law. These are not *terra nullius*, but territories where a certain group of people are able to apply the rules with the necessary coercive powers to impose appropriate sanctions against those who do not respect the rules and institutions. Two other essential elements of Ostrom's criticism concern, on the one hand, the prisoner

Far from resolving the issue of the effects of the strengthening of IPRs on research and development, on improving competitiveness, on consumer welfare, in the field of software and biotechnology, a number of studies have emerged to highlight their negative effects. A first element is certainly that patent or other IPR protection at the initial stage of research, commonly referred to as basic research, could have the effect of slowing down applied research and the development of new products for the market by slowing down imitation and thus the resulting "real" innovation. In his book The Public Domain: Enclosing The Commons Of The Mind, James Boyle (2003) compares the continued extension of IPRs to what he calls a "second movement of enclosures" that threatens knowledge as a common good. Scientific studies on the subject also highlight two other negative effects: the tragedy of anticommons and biopiracy[15].

Let me begin by defining anticommons: they are defined as non-rival goods, managed by private property regimes, which give them the character of exclusivity. The tragedy of the anticommons occurs

> "when multiple owners hold rights to exclude others from a scarce resource and no one exercises an effective privilege of use, the resource might be prone to underuse" (Parisi, Schulz and Depoorter, 2000).

Often, particularly in the field of biotechnology, IPRs cover some parts of the knowledge necessary for the development of the innovative product. This situation means at best slowing down innovation, slowing down the diffusion of innovation due to high costs and compromising public research in agriculture, as in the case of "golden rice"[16], for example.

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model, insofar as it assumes unrealistically that there is no communication between individuals in the community and, on the other hand, the stowaway model, because if there are people who behave in a selfish way, the countless case studies have enabled him to understand that in a group, certainly not all members behave in this way.

[15] To deep the anticommons and biopiracy analysis issues, see Gentilucci (2018).

[16] Golden rice is a genetically modified rice variety that, thanks to the presence of beta-carotene, can solve vitamin A deficiency problems in many developing countries, where people do not have access to food products rich in this protein. This would save thousands of children from blindness every year. The presence of about 70 patents held by individuals and universities has led to a huge slowdown in its diffusion, as it would be undermined by the IPRS put in place. It was only in 2008 in the Philippines that it was possible to plant the first fields with this cereal.

"Since we are talking about knowledge, which is the 'public good' par excellence (i.e. a good that by definition is not rival and not excludable), the management of private property systems (on knowledge) generates very high transaction costs"[17] (Fonte, 2004, p. 60).

The last negative effect considered by the scientific literature on IPRs is biopiracy.

> "In this sense the system of intellectual property rights and the norms that regulate seeds open the way clear to bio-piracy. According to this practice farmers are expropriated of their own knowledge and their traditional learning in favour of the large multinational corporations of the food industry. They thus lose their role as depositors of knowledge which had guaranteed the sustainability of development and agricultural selection as well as the increase of bio-diversity, for thousands of years. These dynamics implicate a break up of social ties, with the replacement of the farmer whose role ends up being taken over by the seed industry, agro-food multinationals and pesticide industries" (Gentilucci, 2015, p. 91).

In the end, the introduction of IPRs on living organisms in general and on seeds specifically , has important consequences on the classification of the natural common. Particularly, it seems that the commodification of commons allows seeds to move from the status of a common resource to that of a private good. This therefore implies the commodification of aspects of social and economic life that were not previously managed from a market perspective. It seems that with this transition, what Karl Polanyi (1944) claimed is being achieved: the market economy would therefore need a market society, in which social activities and relations are coordinated through the logic of the market. This analysis would therefore confirm our initial hypothesis: with the introduction of IPRs, seeds could no longer be considered as CPRs (T1) and commons (T2) respectively.

These additional elements confirm once again that resources cannot be considered public, private or common only because of their nature, but that they are the product of a decision.

[17] My translation.

To counter this mechanism of transforming the natural common into a private good, through the process of enclosure and the subsequent commodification of knowledge, different solutions are proposed that concern both scientific conceptualization and systems implemented through operational practices of resistance to the enclosures themselves. During this research, we will analyze some of them, including the assimilation of seeds to free software and the creation of Open Source Seeds.

4 Overcoming seed enclosures created by IPRs: an application of the principles of Open Source Software (OSS)to seeds

Given the characteristics of traditional agriculture, it seems important at this stage to try to explore in a direct way what are the particularities and elements that, allowing assimilation with the free software system, make it possible to identify new development prospects resulting from a bottom-up dynamic that work for a common defence of a collective heritage.

"Since the Neolithic period, peasants have been choosing the most beautiful plants from their harvest. They saved the seeds and replanted them the following season. Over the course of the spring, this screening led to a differentiation of varieties according to local soil and climate conditions"[18] (Desfilhes and Dufour, 2005, p. 84) and an increase in the varieties themselves.

In this context, the role of farmers (the role of women is considered essential in the transmission of knowledge[19]) is particularly important because it has enabled the development of agriculture itself. The principle on which the selection process was based was that part of the seeds produced by each family should be saved for the following year as a central element of agricultural evolution and reproduction, accompanied also by numerous and essential exchanges with other farming families. In the process of disseminating exogenous varieties, adaptation and development, we can therefore find some essential common determinants, which are fluidity, free and informal communication between farmers. Agricultural research, species selection and dissemination were then carried out on the basis of a few rules which, as

[18] My translation.
[19] As highlighted by Desfilhes and F. Dufour, (2005, p. 84).

Desfilhes and Dufour (2005, p. 86) point out, are very similar to those governing the functioning of free software. In Table 3 below we can appreciate the analogies between the freedoms characterizing free software and those governing free seeds.

Table 3 The four essential freedoms

Freedoms	Free seeds	Free software
Freedom 0	The possibility to plant a plant freely and to harvest its fruits	The freedom to run the program as you wish, for any purpose
Freedom 1	The freedom to study how the plant functions and to adapt it to ones own needs	The freedom to study how the program works, and change it so it does your computing as you wish. (Access to the source code is a precondition for this.)
Freedom 2	The freedom to redistribute the seeds, or the cuttings and thus to participate in their geographical spread	The freedom to redistribute copies so you can help your neighbour
Freedom 3	The freedom to improve the plant and publish the improvements so as to cause them to profit the whole community	The freedom to distribute copies of your modified versions to others. By doing this you can give the whole community a chance to benefit from your changes. (Access to the source code is a precondition for this.)

As Vandana Shiva (2006-2011, p. 104) stated, freedom of seed is something that transcends the rights of individual farmers, it concerns "the freedom of cultures from centralised forms of control. Through the symbol of the seed, ecological problems are reunited with those of social origin."[20]

In fact, as Guy Kastler pointed out in the "*Réseau Semences Paysannes*", it is possible to establish a parallel between free software and seeds . In fact, "a hybrid variety, a GMO Terminator, a variety that has incorporated patented genetic information are 'proprietary software': since they cannot resow the harvested grain, the farmer cannot modify or exchange it" (Kastler, 2005). [21]

A variety protected by plant variety rights (PVR)and patents

> "is partially proprietary software: the'source code' remains secret and the farmer cannot exchange the harvested grain for evolution and adaptation. It is also partially OSS for the breeder who can use it freely to create another variety and for the farmer who can resow the grain harvested on his own farm. But the D.H.S. criteria (Distinction, Homogeneity, Stability[and Novelty]) to which[this variety] must meet make it almost exclusively proprietary software" (Kastler, 2005).

The birth of Open Source seeds stems from the idea of applying the principles of free and OSS used in the IT sector to the seed sector. Indeed, it is a question of ensuring that the use of seeds is not prevented by the enforcement of IPRs.

The actions of promoters of open source seeds (Open Source Seeds) are part of a perspective of opposition to the appropriation and commodification of seeds to save biodiversity. In fact, as Vandana Shiva (1997) has argued, the issue of seed ownership through patents is unacceptable on the basis of these two points of view: first, from a legal point of view, because seeds are not inventions, and second, from an ethical point of view, because seeds are life forms.

[20] My translation.
[21] My translation.

This is why the central concepts of the open source philosophy, namely sharing, participation and free trade, are now being discussed in other areas, particularly in the agricultural sector. It would seem, in fact, that they could restore the status of seeds as commons.

In this sense, as Erika Becchi (2014) pointed out, efforts to save biodiversity and liberalize seed exchange have increased and intensified over the years. A project at the American University of Wisconsin seems very promising.

The idea of a group of American scientists and activists is to distribute 29 varieties of seeds to those who have agreed to sign an open source agreement that preserves farmers' ability to freely exchange hybrids, following the same logic as OSS (Becchi, 2014, p. 2). This initiative was also welcomed by FAO. It is easy to demonstrate that in reality, open source experience in the seed sector as well as in IT aims to provide goods (seed in this case, but not exclusively) and services, including the possibility of production sharing and exchange by the end user (the farmer). It is therefore a legal institute capable of returning to farmers, the environment and future generations the assets that the lobbies of multinational food companies have appropriated (and are still appropriating). Thus, Open Source is a system that has the characteristics of counteracting the commodification of knowledge, knowledge and life imposed by the current economic system. At the same time, open source also allows the development of incremental changes and innovations, which (in the case of free software, as in the case of seeds) have represented over thousands of years, the determinants of development and evolution that have contributed to the preservation of biodiversity through a participatory approach. In a way, it is a matter of preventing the source code (our seed) from acquiring legal ownership status. This would ensure the collective nature of this property and would ensure that it is not a res nullius that anyone could appropriate.

It could be argued that it is a kind of equivalent of GNU-GPL (GNU General Public License) copyleft for users of free software or Creative Commons Public Licenses (CCPL) for the distribution of a work (the creative commons).[22] The emphasis on freedom in the exchange, sharing and modification of seeds is very strong,

[22] For an analysis of the GNU-GPL and CCPL, see Córdoba M. S. (2006) and J-B. Zimmermann (2015).

the Open Source Ecology is an initiative for the development of "open source industrial machines that can be made for a fraction of commercial costs, and sharing our designs online for free. The goal of Open Source Ecology is to create an open source economy - an efficient economy which increases innovation by open collaboration."[23]

In this respect, we can identify projects for the construction of agricultural machinery, such as tractors, milling machines, etc.[24] In fact, this project is not limited to agriculture, it introduces a fundamental innovation from the common point of view: it is a new mode of production based on open access and efficient production in order to overcome the artificial shortage caused by the current economic system. It is a design company based on a vision of sharing and openness, aiming at an eco-compatible development. Open technology requires appropriate technology and the optimization of respect for the environment. Thus, the trend towards environmental degradation can be reversed in favour of regeneration[25], overcoming the nature/technology dichotomy.

Faced with these forms of appropriation of life by intellectual property law, it is a whole movement that fights for the freedom of seeds. *Shiva*, *Lockhart* and *Schroff* (2013)proposes to apply the principles of Open Source to seeds, thus combining this issue with that of commonsand the preservation of traditional knowledge. Others, such as David Bollier, propose to go even further by creating a Copyleft for seeds, like the one that already exists for software.

5 Conclusions

The first part of this research made it possible to justify the parallelism between seeds, common resources and commons. Traditional agriculture is a form of shared ownership that has enabled, through the generation of ecological value, the reproduction, development and growth of the social, economic and environmental system on which this sharing is based. In particular the first part of our analysis allowed us to validate s_0, namely the fact that seeds have been throughout history both CPRs and commons. The

[23] http://opensourceecology.org/ accessed on 24 April 2015.
[24] See http://opensourceecology.org/wiki/Civilization_Starter_Kit_DVD_v0.01/it#Trattore accessed on 24 April 2015.
[25] See http://opensourceecology.org/wiki/Open_Source_Ecology_Paradigm/it accessed on 24 April 2015.

analysis carried out showed the double character of the commons of seeds: on the one hand as a natural resource and on the other hand as commons of knowledge. Following Ostrom's thought, the analysis of commons allowed us to highlight the constructed nature of the commons themselves. This element has allowed us to highlight the possibility that their status may change as a result of changes that, due to power dynamics, can be made to the principles that institutionalize it. t is only necessary to modify, exogenously or endogenously, at least one of the principles that characterize commons, to seriously endanger its existence.

It is on this last element that the new enclosures created by IPRs (PVRs and patents) stand. We have demonstrated in our analysis s1, namely, the fact that the introduction of IPRs implies that seeds can no longer be considered respectively as CPRs (T1) and commons (T2). The "new enclosures" raise a number of questions relating to biodiversity and the very survival of millions of small farmers who depend on this traditional activity for their livelihood. The effects on developing countries are all the more important because, in their bilateral trade agreements, they also call for the acceptance of rules on plant genetic resources, as demonstrated by the practices of the United States and the European Union. It is obvious that the union between the logic of the market and that of the State unite in this process of "theft of knowledge" linked to life. This element provokes deeper reflections on the dynamics of power which, by becoming self-referential, succeeds in exploiting all the spheres that can be commodified, by commodifying[26] them: no matter if the living itself undergoes this process. In accordance with historical-institutionalist theories, we can observe that power seems to find no external limits to its self-realization.

It is clear that the reality of open seed, which offers agro-environmental sustainability, provides food, protecting the future through biodiversity, with seeds that adapt to changing environmental conditions without the need for support from the agrochemical sector. The reality of free seeds is confronted with institutionalized powers which, through a set of rules, tend to preserve and protect the specific interests of large private companies in the agri-food sector. This observation supports historical-institutional analyses

[26] According to Guerrien's (2003) definition, “commodification[is defined as] the process of making a relationship that was not previously commoditized”. My translation.

where they exclude that companies can carry out sustainable development on their own. In the final analysis, the expropriation of knowledge, tacit and explicit knowledge, made by companies in the agri-food sector, aims to build a position rent built by appropriating humanity's common resources.

Among the characteristics that seeds must possess in order to be patentable or to be registered in the UPOV register and therefore marketable, those of uniformity and stability pose serious problems that affect biodiversity, the very principle of maintaining life, and the social and ethical sustainability of a system that thus calls into question the very work of farmers. The latter are dispossessed of their knowledge and skills, which thus lose all forms of social and economic recognition in the evolution of the contemporary capitalist system. The traditional agricultural system is therefore being challenged, and with it the role of women in this system. Thus a key element emerges: the role of knowledge appropriation in capital development and the forms of production organization (Vercellone, 2004).

The characteristics of agriculture, recognized and protected by international treaties and IPRs protection systems, have repercussions on biodiversity, seriously undermining the sustainability of these development paths. The characteristics of homogeneity and stability contrast sharply with the heterogeneity and variability of seeds in traditional agriculture. In fact, the seeds of the latter are similar to each other, but not identical (which happens more often in the case of genetically modified seeds where each seed is an exact copy of the other). The diversity that characterizes traditional seeds is also their strong point, according to which the survival of the species is ensured even in the face of natural disasters that could decimate the harvest. In short, the heterogeneity of seeds in agriculture is the element that guarantees at least a minimum harvest for the survival not only of the farmer but also of the seed. Seed exchange practices that have always characterized agriculture should therefore be read in this analytical framework. They illustrate the concept of sustainability in terms of ecological, social and economic sustainability.

Ultimately, therefore, it seems that IPRs and sui generis systems aim to destroy this space of shared ownership and self-management represented by the selection, harvesting and cultivation of seeds by the

farmer. From this perspective, seeds are therefore transformed from a common good into an appropriate good.

The bottom-up dimension of resistance to the commodification of life and the appropriation of knowledge that characterizes seeds implies that the local dimension, on which Elinor Ostrom based its theoretical articulation of commons, reaches the global dimension through the network of experiences of resistance and alternative economy based on ethical principles as in the case of free software. The new principles relating to the freedoms of free software applied to seeds make it possible to consider a form of overcoming the seed enclosures created by IPRs in order to achieve a new "commonification" of these shared resources.

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