Fictitious Science[1]

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Abstract

Science and Technology (S&T), like Research and Development (R&D), has become a case of capital investment like any other economic sector. This has distanced R&D from social needs, to the extent that part of R&D ends up actually being fictitious, in the sense that it acquires a price on the market but never becomes part of material production processes. The concept referred to here as fictitious science is parallel to the fictitious capital used to account for financial assets that have no material counterpart. R&D and S&T have gone from being a service to the community to being sectors for capital investment, driven to producing profits by cost-benefit criteria. At the same time that scientific production is being productively exploited, a form of science has evolved that is not evaluated for its content but for its price. This is fictitious science that is not used for production and ends up being superfluous and with no relationship at all with social needs. However, the paradox is that although their products have a price, they end up in many cases not being used as part of material production processes.

Keywords: financial capitalism, capital investment, material production, science and technology, capitalism, social division of labour, intellectual property rights

Introduction

The concept of fictitious capital, which is used to account for financial assets that have no material counterpart, will be used in this article as a sensitizing concept for rethinking the nature of investment and output in relation to science and technology and science and technology research and development. We will use the fictitious science to do this. The argument that we will develop is outlined in the following paragraphs.

It is part of the nature of capitalism to increase the social division of labour. Capitalist relations of production turn the old and new divisions of social labour into spheres of capital valorisation, albeit at different rates. To be a sphere of capital valorisation means that the main objective of capital investment is to make a profit.

Financial capital is an area or sphere of capital investment, involving the circulation of money and how it occurs. The development of financial capital produces different types of titles, in accordance with what they represent (e.g., shares in capital investment, securities, bonds). These titles have a price. The price may correspond to the value of invested capital and, in this case, the title represents a real value. However, the title may have a price that does not correspond to any form of real capital, as is the case of securities, or when for reasons of supply and demand the price of the title distances itself from the material value that represents. These cases are examples of fictitious capital, which has no real material counterpart.

Science and Technology (S&T) is also a result of the capitalist social division of labour and as such has become a sphere of capital investment. The social division of labour in science has led to a subdivision of independent units. Examples of this subdivision can be found in the form of measurement laboratories, laboratories for mathematical and statistical data analysis, teams of pollsters or the preparation of specific computer programs. In this way, the scientific division of labour has taken place in that each specialization can sell a partial product or an intangible product such as intellectual property (IP). These products constitute one of the most significant results of scientific and technological development. Patents, for example, are negotiated on the market and can be purchased or licensed. In some cases, the patent, roughly speaking, tends to include the cost of its R&D. However, it happens that an important amount of patents are never sold or licensed, i.e., it never becomes an intangible part of a production process. Nevertheless, such patents continue to have a price which, in turn, boosts the portfolio of a company’s assets and are included as part of the value of the selling price of the company. The same holds true for financial bonds with no material counterpart that result in fictitious capital. Patents and other forms of intellectual property that are never exploited reflect the development of fictitious science.

When the aim of capital investment in science shifts from being a service to the community to be a sphere of capital valorisation, it might succeeds in closing the cycle of capital investment, generation of knowledge and sale of intellectual property without any contribution to material development, this is a situation of fictitious science.

The constitution of science as a field of capital investment has at least three results. First of all, it intensifies publication and patenting irrespective of the potential use of knowledge since publication and patenting alone can be converted into an intangible product that increases the price of a company, the ranking of the university and researcher’s salary. Secondly, it pushes R&D towards more profitable branches of research, drawing it away from meeting the needs of the general public. Finally, like any other branch of capital investment, it is subject to the concentration of capital, which turns the largest corporations and/or universities into undisputed producers of scientific knowledge.

Public scepticism towards scientific work in some developed countries, such as the United States and European countries, is to a large extent a reaction to the doubtful societal uses of technology, such as the applications to military purposes or in food and medicine that have dubious benefits and can cause harm to the environment and human health. However, in addition to applied science in unproductive or superfluous technologies, there is science that has no applications at all, and the infrastructure of laboratories, conferences and other manifestations in the field engenders mistrust on the part of the public, when they reflect on the contrast between these investments and the pressing social problems they face. The drive by politicians and scientists for mechanisms that will encourage public participation in the construction of science (i.e. constructive technology assessment (Rip et al., 1997), are proposals that will rekindle public interest and draw the scientific community closer to the interests of the people, and from there the adjective *social* applied to "social" construction of science. Whether the public rejects scientific work or whether intellectuals seek to make science more connected to social needs, the fact is that the objective element that explains this gap between science and society is not analysed, or is only analysed very superficially, on occasions when science crystallizes in technologies or products that public turn down.

Two modes of science as a form of capital investment

S&T historians point to the Renaissance as the turning point, when science took on an identity of its own in the social division of labour (Bernal, 1959). This does not mean that scientific thought had not been developing since time immemorial, only that at this time it became a separate specialty in its own right. As a specialty in the division of labour, during the Renaissance science assumed a dynamic of its own in terms of formation, institutionalization, evaluation and dissemination.

With the advent of the industrial revolution and more profound and widespread capitalist relations of production, science little by little became integrated with production processes, becoming subordinate to the interests of capital. Nevertheless, a number of studies have pointed to the main innovations that took place during the industrial revolution, and until the mid-nineteenth century these were technological improvements derived from the practical knowledge of workers rather than the application of scientific knowledge (Landes, 2003; Rosenberg and Birdzell, 1986; Stuart, 1824).[2] Scientific and technical knowledge related to production had yet to become individualized in the social division of labour and thus functioned as a historical legacy and the property of society as a whole. It took over half a century of industrialization (late eighteenth to mid-nineteenth) for science, as an independent sphere of the social division of labour, to begin guiding production. In the mid-nineteenth century, science began to take its place in the division of labour with an identity of its own. This is clearly shown when science is used by companies as a way of improving technological processes and increasing productivity. Large companies set up their own S&T departments. This first took place in Germany, in a marriage between science and technology in the fields of organic chemistry, electricity, synthetic agriculture and synthetic dye. It then extended to the United States in the late nineteenth and early twentieth century in almost all branches of economic activity (Braverman, 1978; Landes, 2003).[3]

Science became an independent activity within the division of labour and subordinate to the dynamic of capital accumulation in two parallel ways and with different immediate purposes. These still exist in some universities and countries, and their similarities can confuse an observer in terms of the orientation and function of science in society. On the one hand, *science* is incorporated as a sphere of capitalist valorisation, when it is directly incorporated into specialist departments within companies. In this case, the immediate goal of S&T investment is profit. Investment in S&T by companies, like any investment in labour force or means of production is strictly driven by cost-benefit requirements. Of course, for science to achieve benefits it is necessary for its product (knowledge) to contribute to the production of a good or service that can be sold on the market, but this is only a means of achieving a profit on the invested capital, i.e., that science should accrue a higher monetary value than that invested in R&D.

On the other hand, *science* can take the form of a *service to the community* as its immediate purpose. The cost-benefit logic does not apply in this case and profit is not the aim of this form of technical and scientific development. This is the case of universities and public research centres that are financed by tax money provided by the state.[4]

Although both forms appear to be capital investments (infrastructure for laboratories and the employment of scientists and specialists), in essence they are quite different. In the first case, profit is the driving force and in the second case the driving force is service. Of course, capital investment in S&T as a service also aids the accumulation of capital and, therefore, increases profit. However, this occurs only indirectly, generating basic scientific knowledge in sectors in which private investors would prefer not to risk. This ensures a permanent supply of scientists whose education is not financed by a private company. In other words, this science as a service lowers the cost of R&D of capital in general, thus contributing to higher profits for individual businessmen, but not directly or immediately.

This difference between science for profit and science for services means that the orientation and pace of S&T will be different. In the case of science for valorisation of capital, R&D has to concentrate on the most profitable sectors. This is the case of medical research by large pharmaceutical corporations, whose research focuses exclusively on illnesses of patients with high purchasing power, such as cancer and cardiovascular problems, in detriment of highly infectious diseases of the poor (Foladori, 2005).[5] Furthermore, investment in science for profit is driven by the rate of return. Therefore, there is a tendency to take an invention from the drawing board to the market the shortest (Menahem, 1977).

Science for profit suffers attacks from external factors, such as consumers, differently. External pressure can have an influence on the end product, according to the choices and tastes of the consumer, but always in such a way that profit levels are not affected, as this is the *raison d'être* of this type of science.

In the case of science as a service, there is neither of the two pressures. R&D is not obliged to focus on the most profitable sectors, nor is it obliged to hasten the conversion of knowledge into marketable products. Moreover, this type of science as a service is more apt to receive encouragement from end consumers, as its purpose is to meet their needs.

These two forms of capital investment in S&T (investment for profit and investment as a service) are interconnected and mutually attracted as a result of economic policies and S&T and the class struggle. But this does not mean that they cannot be distinguished analytically, although no empirical case can be found that corresponds to the conceptually untainted form presented here.

Both forms of doing science are subject to the vagaries of class conflict. A contemporary point in question is the conflict concerning the investment clauses in free trade agreements. The ongoing agreement between U.S. and the European Union, Transatlantic Trade & Investment Partnership, contains clauses for the protection of investments that makes possible to put an end to any monopoly on public health by the state. As in many countries workers have healthcare coverage provided by state institutions, such as the ISSSTE and IMSS in Mexico, the dismantling of this coverage and its replacement by private healthcare systems have been seen as harmful by their organizations. British trade unions, for instance, have undertaken political activities to oppose the inclusion of investment clauses that prohibit or limit public healthcare. Those clauses limit public healthcare on the charge that it constitutes unfair competition to private capital (TUC, 2014).[6] While the trade unions view investment in health as an S&T service, the pharmaceutical and medical corporations take a different view, supporting the investment clauses and seeing healthcare not as a service but as a form of capital investment that can turn a profit.

In addition to being closely interconnected, the two forms of capital investment in S&T are not equally strong. While science for profit is the "natural" mode that the development of capitalism adopts by advancing on a new branch of the social division of labour, science as a service is the result of a specific policy for the development and accumulation of capital, and hence of constant social struggles. The following section includes a brief summary of the history of the development of these two modes throughout the twentieth century, culminating in the prevalence of science as a sphere of valorisation of capital, with fictitious capital as an undesired but inevitable result.

Science as a service is encompassed by science as a sphere of capital valorisation

Capital investment in science is made in the R&D departments of companies as an investment for profit. This science is not freely distributed and is no longer motivated by the search for knowledge per se or to meet people's needs, but by profit (Braverman, 1978). It stands apart from the type of capital investment made by the state for the benefit of society.

For this mode of science as a form of capital valorisation to develop, aided by private enterprise, it is necessary for a company to be able to hire not only a workforce made up of qualified scientists and technicians, but past knowledge is also required, which is increasingly objectified and crystallized in products separated from their creators. The development of the publishing industry, scientific journals, laboratories with specialist technical teams and the various means of coding knowledge enable science to become autonomous, but within the social division of labour. However, the development of all these material means of channelling scientific knowledge has a twofold effect. On the one hand, they socialize scientific knowledge, and on the other they enable it to be monopolized. The confidentiality of scientific information is a key element in employment contracts signed by companies and scientists, and the development of legal means to protect intellectual property is a way of guaranteeing that it can be monopolized and, consequently, bought and sold on the market, constituting an asset equal to a machine.[7] Although patents originated in the fifteenth century, the different forms of patents were only consolidated from the late nineteenth century onward, in parallel with the subordination of science to capital.[8]

This type of science, the result of investment for capital valorisation, distances itself from the interests of society at large. It stands apart in historical and sociological terms, because knowledge is privatized and patented and access to it is restricted. In practical terms, because science is not done to satisfy social needs, but rather to enrich the owners of the capital; and if its results do meet certain needs this is because of having to sell products with some utility: a means to an end rather than an end in itself. It stands apart in individual terms, since researchers become part of a qualified workforce but their salaries are paid by capital, subject to the pressures of scientific orientation, with a set pace and working conditions and confidentiality. Scientists in the service of capital are nothing more than capital to be valorised It also stands apart in ideological terms, because new and different concepts such as competitiveness, competences, or entrepreneurship which support market goals, create a whole new strategic vision (Hall, 2015; McMurtry, 1991, 1998). [9]

There are two practical results of the development of science as a branch of capital investment. The first is the social division between qualified scientific work and simple labour. Scientists, whose workforce is more greatly valued than that of labourers and other employees, aspire to a bourgeois lifestyle and some of them, when they achieve this, become scientific entrepreneurs, differing from the rest of the working class in terms of livelihood and needs. The second result is that the social division of labour occurs within the realm of the scientific work itself (specialization), leading to the loss of a more general focus of the implications of research, as was highlighted in the uncertainties, unforeseen results and risks of S&T that were emphasized in philosophical and methodological proposals that emerged in the late twentieth century as post-normal science or the risk society (e.g. Beck, 1992; Funtowicz and Ravetz, 1993).

Science as a form of capital investment was born in the late nineteenth century but peaked in the late twentieth when it came to subordinate the other form of science, science as a service. Let us consider this subordination of one form of science by another in broad terms.

Capital investment in science as a service is what happens in public universities and government institutions that are financed by the public purse, and have no immediate need to obtain a return on the investment. To a great extent, this science maintains a degree of independence from market interests. This path represents the cultural and historical heritage of society as a whole and not exclusively of the capitalist class. Like capital investment for profit, science as a service requires capital investment, but the purpose is not immediate gain, but rather the constitution of a general basis for scientific development to which private capital can resort. In economic terms, it is state-subsidized science, not regulated by cost-benefit criteria. This science is the heir of historical knowledge and reached an important peak in the nineteenth and the first three quarters of the twentieth century. In the late twentieth century, a number of mechanisms led it to lose its autonomy due to capital investment for profit.

Whereas in science for profit investments stem from private capital, in science as a service investments are made by the state. The United States are a prime example of the development of these forms of science which other countries, little by little, are emulating, not without the contradictions of each particular historical context. Therefore, it is sufficient to exemplify the development of both modalities of science through the case of the United States.

Investment in science as a service to the community underwent a radical change in Germany and England during World War I and in the United States during the Second World War. These countries steered science as a service and also science for profit towards military research. In the USA in 1940 and under the coordination of the then National Defence Research Committee (NDRC), dozens of military laboratories were built. Therefore, “The NDRC organized a massive migration of personnel to the war laboratories it set up, funding these operations through government contracts” (Williams, 2010, 3). In the USA, a close relationship between the scientific apparatus, private production and military interests had been institutionalized. Private companies and public and private universities were integrated and awarded subsidies and contracts with public funding to develop military technology. The two paths of scientific development that we have referred to, science for profit and science as a service had joined forces under the command of the military and with state subsidies.

At the end of the Second World War, the physical infrastructure, volume of scientific production and research teams had achieved an inertia that was difficult to stop. However, things changed. The NDRC was discontinued and many laboratories and staff came under the jurisdiction of the Office of Naval Research (ONR), a section of the United States Department of Defence (DoD). In 1950, the National Science Foundation (NSF) was created, another publically funded institution for civil research that, to a certain extent, was created as a result of pressure from scientists to counteract the funds granted to the DoD. However, whereas the NSF received approximately 5% of the public funds for R&D, the DoD was given 70%, not counting another ten percent that went to the Department of Energy(DoE) for military and nuclear research, and also, to a smaller extent, to the National Aeronautics and Space Administration (NASA). Ultimately, the budget for military R&D accounted for approximately 80% of total R&D investments from the Second World War to the end of the 1980s, if the various military departments and internal security and intelligence agencies are taken into account. A scholar in this field, Forman, points out that in the post-war years, public expenditure on military R&D was thirty times higher than it had been before the war, reaching 90% of all federal funds for R&D. A survey of seven hundred and fifty universities and colleges conducted in 1951 showed that 70% of research time in physics was given over to military research (Forman, 1985). The communist threat had replaced the Nazi and fascist threat, and this justified maintaining the military budget.[10]

It is important to note that this marriage between public and private science due to military interests enjoyed a large long-term state subsidy. Those involved in the production of science, both institutions and researchers, became accustomed to subsidies for their own sake. As Kary Mullis said, as quoted by Greenberg, when commenting on the Nobel Prize for Chemistry (1993), “Probably the most important scientific development of the twentieth century is that economics replaced curiosity as the driving force behind research” (Greenberg, 2001: 331).

From the time of the Second World War until the end of the 1980s, the subordination of science to capital rose, aided by the government, which acted as an intermediary for the military industrial complex, and through all kinds of subsidies for companies that could incorporate their R&D projects into the public universities.[11] The differences between science for profit and science as a service became blurred, since scientific development both in business and by public institutions is financed by public funds. However, in other countries this marriage did not take place, and both types of development remained until the early 1980s.

During the 1980s and 1990s, science as a service lost ground to science for profit. Little by little, public science disappeared to be replaced by science for profit. On the one hand, legal bases were established for public research centres and public universities to be driven by the logic of profit and be subjected to the requirements of sponsors. In the United States, the Bayh-Dole Act of 1980 allowed universities to retain ownership of the patents that they registered and any resulting profits, leaving them with the key commodity of intangible knowledge in their hands. The Stevenson-Wydler Technology Innovation Act, also in 1980, complemented the subordination of science as a service to capital by allowing government laboratories to sell services and guaranteeing the transfer of technology to companies. As pointed out by Nowortny, Scott and Gibbons, "Both schemes are now widely copied elsewhere". Prior to Bayh-Dole, universities in the United States produced around 250 patents a year. By 1998, this number had risen to 4 800 patent applications. This led to another series of effects, such as the possibility of professors retaining a percentage of patent property, and the rise of private companies created by professors who work in public centres and as a spinoff of these (Press and Washburn, 2000).

Alongside legal changes to facilitate individual and institutional access to private benefit, a series of instruments were created for assessing education from the elementary to university level to make institutions, teachers and students subject to competence under capitalist criteria. Assessment instruments for productivity were generalized at every level of education and research for the purpose of making education into an environment of capital investment and/or subordinating public education to the interests of capital (Hill, 2003). There is a long list of assessment instruments, productivity-linked salaries, productivity indicators for students, teachers and researchers, and also research centres, universities and countries with international ranking of S&T productivity. All these instruments are mechanisms with the purpose of increasing scientific productivity and enabling links between independent stages of research. They are analogous to labour market flexibility and outsourcing in the industrial sector. Educational policies accompanied science policies integrating the commodification of knowledge within the curricula (e.g. for European Union see: Arriazu Muñoz, 2015).

These changes were made possible most notably by the ICT (Information and Communications Technology) revolution which, because of digitalization and the rapid transfer of information, made research a more streamlined and cheaper process. Knowledge can now be transferred over large distances and easily stored (micro-optic, electronic and satellite revolution of the 1990s). The concept of the Knowledge Economy came into play and was spread around the world in the last five years of the twentieth century, promoted by almost all international multilateral organizations, such as the World Bank, UNESCO and the OECD.

Fictitious science

As investment in science for profit gains hegemony, the internal division of labour within the world of science deepens and widespread. All activities that once formed a unit are now separated into independent products with a price of their own. For research, groups and specialized centres have been set up to study a wide variety of themes and many of them have become part of the scientific division of labour. They do not offer an end product, but rather the intermediate stages. This is the case with all measurement centres, the systematization of information and systems for a variety of courses. The outsourcing of scientific activities has become a real possibility, to such an extent that there are now firms with scientists who specialize in presenting research projects to financing agencies and offer no other service. If the project is approved, a research team is outsourced. Experts on intellectual property development understand the advantages of outsourcing activities with a tradable product of their own:

> "Going further in the division of labour, the research process itself can be segmented between actors with different comparative advantages. In the pharmaceutical industry it involves for example research universities (basic research) biotechnology companies (upstream research), pharmaceutical companies (downstream research), and firms specialized in clinical trials (including phases III and IV). This division of labour should generate productivity gains´" (Guellec and Meniere, 2014).

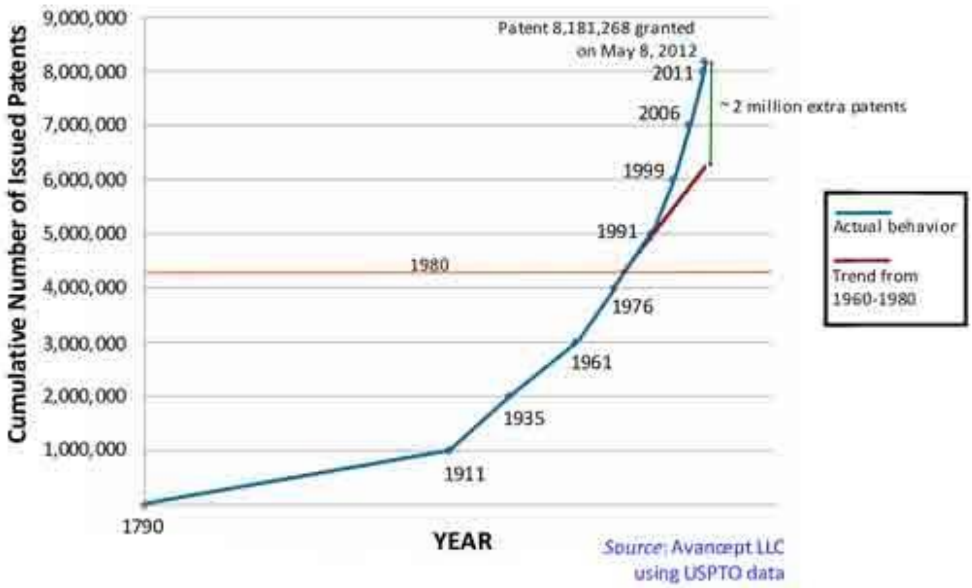
This is also the case with researchers, as every article, book and conference has a value of its own in terms of scorecards and piece rates, which become an important, if not the most important, part of a researcher's total earnings.

The concept of basic science that was generalized during the Second World War has in practice disappeared, although it remains in the discourse, since most of the financing that is available is given over to technological applications. Research centres and public universities find themselves forced to form partnerships with private companies to be able to compete for this funding.

The prodigal son of this process of the scientific division of labour and its incorporation into science for profit is the mechanisms for intellectual property, of which patents are a prime example. In addition to its flow of accumulated information, science as a service inherits know-how that is often unconnected with practical applications and the possibility of transforming knowledge into a marketable product. Even today, in the 2010s, policymakers and analysts of scientific development in Latin America complain that public universities are divorced from private enterprise and are in need of an entrepreneurial culture that enables them to hitch their knowledge and inventions to private enterprise. Patents help to bridge this gap between knowledge and its practical application. Universities and research centres can invent new processes and products, but they lack the skills and capital to manufacture and market them. Patents are the bridge between inventors and manufacturers (Guellec and Meniere, 2014). This does not mean that patents and other forms of intellectual property are the most important part of knowledge transfer.[12] They remain a minor part, but they are the most clearly demonstrative examples of the term "scientific waste" or what we refer to here as fictitious science, i.e., scientific knowledge that is only produced to be incorporated by other companies for a price paid via circulation of the financial capital of these companies. The knowledge will never become a part of concrete production process. [13]

The growth of patents is in keeping with the process of converting science into a sphere of capital investment in the twentieth century, and the boom of the 1990s also occurred alongside a rise in and the expansion of fictitious science.

Figure 1: Evolution of registered patents in the United States



Source: (Smith, 2012)

Basically, there are three ways in which a patent can be converted into money. The first and simplest is by selling it. The second option is to license it, which can be done in a number of ways. The most common are licensing for a given period of time, and within a restricted geographical space or area. However, this form of licensing can be subject to many conditions and restrictions. The third way is when a package of patents is used as collateral for a loan. These methods can be combined many ways, forming a myriad of hybrid mechanisms.

> "Over the last decade, the market for patents has flourished. Patent intermediaries, brokers and other agents have developed a liquidity pool for patents and patent rights, including license rights, covenants not to sue and other hybrids. These products are marketed, sold, purchased, bartered, exchanged, traded, consorted, leased and disposed of just like other assets, goods or properties" (McClure, 2014).

In any of these cases, it could be supposed that the monetary equivalent of a patent largely corresponds to the value incorporated in the knowledge that was necessary to create it.[14] But this occurs if we consider that the patent will end up being effectively used in a production process. Nevertheless, it is quite possible that the knowledge included in the patent may never be used.

It is very difficult to estimate the relationship between registered patents and their exploitation or actual use. Many patents are not commercialized, and therefore it is not known whether they are used or not. Others are traded privately. Others appear to be commercialized but are not because the companies that own them might be merged and change their names. Furthermore, the fact that they are commercialized does not mean that they will be put to use, because despite the laws that forbid monopoly,[15] the fact is that many corporations purchase patents for the sole purpose of avoiding competition. Consequently, it is likely that a great deal of knowledge in patents will never be transformed into a product, with this knowledge not becoming part of the social global product of society and ending up becoming superfluous. According to research on patents, in the European Union:

> "one-third of European patents granted are not exploited, either because they are used as weapons to block competitors or because the underlying technology is not exploitable in the market" (Gambardella et al., 2007 cited by Caillaud & Méniere).

However, in any case, in general terms it can be imagined that the trading of a patent means a transfer of technology. Nevertheless, the patent does not only mean the cost of the transfer of technology. It is also necessary to protect it from those who wish to use it without paying for it. Litigation concerning patent violation implies a considerable sum of money without any material counterpart. In this case, there is no transfer of knowledge and no application to a production process. It is hard to argue that these costs of litigation offer anything productive or generate any economic value. They are nothing more than the result of fictitious science, and though fictitious capital.

Patent litigation is big business. The problem arises because companies develop production processes that they believe to be their own invention without realizing that these processes have already been patented and that a license has to be obtained to continue producing. Considering that there are approximately sixty million patents, it is likely that part of the production process has already been patented without the knowledge of those who develop it. This myriad of patents has led to patent trafficking. In the United States, the term *patent trolls* was coined in reference to agencies that are exclusively dedicated to acquiring patents of dubious value in order to file numerous lawsuits against companies that are allegedly in violation of these patents.[16] As the cost of litigation is very high, the alleged offenders often prefer to settle out of court.[17] In short, these Patent Assertion Entities do not produce anything and obtain a benefit as a result of a private deal with alleged offenders, even when there has been no patent violation at all.

> "A recent study concludes for instance that litigation cases initiated by non-practising entities between 1997 and 2000 have brought about a total decrease of about $320 billion of the US stock market value of the sued companies" (Madiès et al., 2014: 14 citing Bessen et al).

Lawsuits over patent infringement can lead a company to bankruptcy. Christiansen et al (2009) described the case of a nanotechnology company, Evident Technologies Inc., which filed for bankruptcy due to a legal bill for a million dollars as a result of patent litigation, which amounted to over a quarter of the company's capital assets. The authors also wrote about Luna Innovations Inc., another nanotechnology company that filed for Chapter 11 after being ordered to pay thirty-six million dollars for contract violation, almost double the company's capital assets. It is difficult to argue that all this capital being moved around in the financial sphere and the transaction of securities have any material counterpart. This is another case of fictitious capital.

As capital that is moved around the commercial and judicial sphere in the form of intellectual property is mostly fictitious, with no productive counterpart, the knowledge that this money and these securities represent is knowledge and science that are removed from production processes to float around in a purely fictitious environment. Since stages of scientific knowledge can be negotiated in some way as intellectual property, it acquires a price. The price is an end in itself, especially when the intellectual property in question has never been part of a production process. This provides the careers of scientists and universities involved in patenting with an economic benefit, although the knowledge never materializes in any product. The peculiarity of science as a sphere for capital valorisation is that it views the equivalent of knowledge, i.e., the *price* of intellectual property, as an end, rather than the knowledge per se. Intellectual property in the form of titles is negotiated in different markets and a whole pyramid of fictitious knowledge is created that is increasingly removed from production and, obviously, from social needs.

The fictitious nature of this science is not an obstacle to it being used for the concentration of capital. A point in question is that patents are concentrated in the hands of large corporations and some public universities and research centres. A new field that is developing, such as nanotechnology, is rife with this practice. In the United States until 2008 two institutions alone held over one hundred patents: IBM and the University of California (Chen et al., 2008).

This trading of titles with no material counterpart has led a number of authors and experts to look at the field of intellectual property rights and doubt the role that patents play in development. They even go as far as to suggest that these mechanisms hold back development instead of promoting it.[18]

Conclusions

Throughout the twentieth century, S&T went from being a service to the community to becoming a sphere of capital valorisation like any other branch of economic activity. In this, S&T is following a natural trend of the development of specialization and the social division of labour in a context of capitalist production. Nevertheless, the state has played a key role by adapting education and S&T policies for the purpose of making a profit. Consequently, public institutions that used to invest capital in order to guarantee a public service have simply become middle men for private enterprise.

The interesting aspect of this change is that education and science are not evaluated for what they are but for their price, meaning that intangible products of science have a price without ever making any contribution to material development. In the case of professional work, articles, books, patents and other products are not evaluated because of their content but by indicators, many of which also set the price, such as the different forms of IP and products that help professors and researchers to earn piece rates.

After almost two decades since these institutional, regulatory and financial changes in the way S&T is managed, the result is highly uncertain, when not debatable. At the same time that scientific production is being productively exploited, a form of science has evolved that is not evaluated for its content but for its price. This is fictitious science that is not used for production and ends up being superfluous and with no relationship at all with social needs.

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Notes

[1] I thank the anonymous reviewers for their constructive comments

[2] Technical skill "This should not be confused with scientific knowledge; in spite of some efforts to tie the Industrial Revolution to the Scientific Revolution of the sixteenth and seventeenth centuries, the link would seem to have been an extremely diffuse one: … the growth of scientific knowledge owed much to the concerns and achievements of technology; there was far less flow of ideas or methods the other way; and this was to continue to be the case ell into the nineteenth century" (Landes, 2003: 61).

[3] Examples of the earliest R&D departments in companies are Eastman Kodak, 1893; B.F. Goodrich, 1895; General Electric, 1900.

[4] The same process happens with education. Educational institutions can also be considered as a service to the community when public, and as a sphere of capitalist valorization when private.

[5]The Ebola outbreak in 2014 was a point in question. The deputy director of the World Health Organization referred to a market failure in the sense that the pharmaceutical industry does not research on diseases of the poor -neglected diseases-(Millman, August 13).

[6] Similar examples can be found in Canada, with the equivalent of the TTIP, the CEPA (http://healthcoalition.ca/main/issues/ceta-trade-deal-threatens-medicare/), and in practically every European country with the trade unions (http://www.iuf.org/w/sites/default/files/ONLINE%20TradeDealsThatThreatenDemocracy-es.pdf) and other organizations.

[7] "The formalization and codification of knowledge and the extension of intellectual property rights that have occurred in recent decades are aimed at allowing companies to appropriate the knowledge, skills, experiences and capacities of their employees..." (Serfati, 2013).

[8] In 1883 the Paris Convention was signed, the first international convention to protect industrial property and still in force in its updated version. In 1886 the Berne Convention was signed, regulating copyright and other rights.

[9]"Even the language of educational purpose has undergone a sea-shift of transformation into business terminology and the going discourse of the corporate culture "resource units" for what used to be subject disciplines and their professors; educational "consumers" for what used to be students and learners; "uniform standards" for what used to be the search for quality, depth and originality; "program packages" for what used to be curriculum; "products" for what used to be graduates; "buying" ideas for what used to be the search for truth.

It is difficult to avoid the conclusion that the educational process has been so pervasively subordinated to the aims and practices of business that its agents can no longer comprehend their vocation in any other terms" (McMurtry, 1991: 211).

[10]During the 1990s and as a result of the end of the Cold War, there was less research and fewer military subsidies, but in 2001 they increased more than ever due to fears of a terrorist threat.

[11] The distinction between basic science and applied science, which despite being older effectively took shape in the discourse of scientific policy during the Second World War, is an ideological instrument that enables scientists working on military projects to morally justify their work by claiming that they are conducting work in basic (neutral) science.

[12] ´Market transactions based on patents account for only a small share of the overall trade of knowledge. They encompass two main classes of assets related to patents and technologies: the patent titles themselves, and the rights to use patents (licenses of various types). There is no statistical system providing a reliable and comprehensive estimate of transactions involving such assets´(Guellec and Meniere, 2014: 16).

[13]Drahos(1996) argues that Intellectual Property instruments allow to consider their registry -e.g. a patent- as a commodity in the same way as a material product is. He calls abstract objects the products of intellectual activity, and considers that they represent value in the same way as materials objects do. This approach challenges the classic Marxist interpretation of use value and value. It is not the purpose of this article to go over this discussion; however, we should meditate if an immaterial object, such as a patent, which is an individualized product not feasible of reproduction, can have value on its own, separated from the final material product, even having a price on its own –e.g. patent.

[14]There is no recognized method of determining the value of patents (Madiès et al., 2014: 14). One study claimed that a third of European patents are not exploited(Gambardella et al., 2007).

[15]For example, the European Commission monopoly laws, No. 772/2004.

[16] These entities, which are actually financial companies, are known as PAEs (Patent Assertion Entities), and the Federal Trade Commission began an investigation of them in late 2013(http://www.ftc.gov/news-events/press-releases/2013/09/ftc-seeks-examine-patent-assertion-entities-their-impact).

[17] According to the American Intellectual Property Law Association (AIPLA) the cost of litigation for the average patent is 2.6 million dollars, a rise of 70% since 2001.

[18]In a letter to the United States Congress in November 2013, sixty university professors of patent law wrote "Despite our differences, we all share concern that an increasing number of patent owners are taking advantage of weaknesses in the system to exploit their rights in ways that on net deter, rather than encourage, the development of new technology" (Allison and et al, 2013).

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