EXTERNALITIES IN EDUCATION, SCIENTIFIC KNOWLEDGE AND SCIENTIFIC RESEARCH

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ABSTRACT

This paper explores how different activities of the State: the outcomes of education, scientific knowledge and research, and technology are interdependent with both positive and negative externalities of society and market structure. It discusses specifically the significance of education, the information wealth of a global knowledge society and the dilemma of the economics of knowledge, which, at the same time have important implications for private investment and intellectual property protections of the new knowledge. This paper aims to examine the complex interactions between the market's role and State intervention in order to achieve two goals: satisfying monetary interests and maintaining balance between technological innovation and productivity gains. Additionally, governmental policy tools play a crucial role in providing equal access to education, open-source knowledge, and research and development opportunities, which allows both society and inventors to benefit from new technology.

KEYWORDS

Education, Scientific Research and Development, Access to Knowledge, Economics of Knowledge, Role of the State

1. INTRODUCTION

This paper is organised as a review of several research papers related to economics studies under the STS perspective. The paper has been written in order to offer a coherent, yet critical analysis of the importance of education, scientific knowledge and technology development as these have been largely interrelated within society and market structures. Focusing on externalities related to education and evaluating aspects of scientific knowledge as an economic good are going to be the main perspectives on which our examination has been based. Externalities connected to education along with externalities related to technological development reveal both problems and chances for a better future-oriented in the greatest equal accessibility to scientific knowledge's positive outcomes. Further, research has pointed out how beneficial education can be for society, but, at the same time, there is substantial evidence to support that what may constitute a benefit for one jurisdiction, maybe, in fact, a cost for another one. The governmental strategies in regulating the intertwining relationships between the public and the private sectors in scientific research can also be crucial for the generation of economic values and the development of scientific progress.

As such, this paper is going to be divided into six sections of analysis. The first part is about general externalities related to education and it proposes the state intervention case in regulating education. The second part is about specific externalities and how they may translate into benefits or costs. The third part introduces us to three properties of knowledge as an economic good, to the benefits and problems arising from the openness of knowledge that is stressed as a knowledge dilemma between the private or social returns in the domain of knowledge production. The fourth

part bridges with the third part, supplementing further the impact of inequality on receiving knowledge. The fifth part investigates the relationships between scientific research, the private and public sectors. The sixth part investigates how externalities and public goods interact from a technology point of view. At the end of the present paper, we have written some general concluding remarks along with critical comments that arose and were proposed by all of us after our collective research had been done.

2. EXTERNALITIES AND PUBLIC PROVISION OF EDUCATION

2.1. Externalities Related to Education

A crucial question arising for someone studying economics is what externalities are about and how externalities are related to the grand functioning of the market. Externalities' evaluation appears to be rather divergent from one study to another one. Yet, a definition of their presence within the economy must be given in order to evaluate this presence. An indicative definition could be: "we are in the presence of external economies whenever the decision of an agent depends on and is influenced by the decisions of others" (Coelho & Oliveira, 2011). In the previous definition given, "others" can be interpreted as the users, producers, patent holders, the state, all the stakeholders, even the market or society itself in general.

The fact that externalities can be visible in economies is indirect proof of the almost invisible, intricate nexus of interdependencies that both exist within society and sustain implicitly the power relations and the structure of the market within society. In the case of accepting an evaluation of their meaning, externalities can be viewed in general as market failures (Bator, 1958). Nevertheless, externalities may offer a chance for societal progress. Especially externalities related to Education bear a clearly positive effect on society and as a result, even if they should be treated as market failures, they could be viewed as being able to be directed towards the optimum benefit for society.

Education's societal outcomes are unavoidably and greatly influenced by the intricate nexus of interdependencies within the market and social structure. This means that education is strongly linked to externalities. Education's externalities are mainly positive ones (Coelho & Oliveira, 2011). However, some kind of negative externalities can be detected: the exclusion of the non-qualified individuals of the new information societies or the migration of the highly qualified from the developing to the developed countries (Coelho & Oliveira, 2011). These kinds of negative externalities related to education are what – among others - pose under serious doubt the belief that education's outcomes are always good ones or that education is a pure public goodby itself.

For education to be a pure public good, two criteria must be met: non-rivalry aspect and non-exclusion aspect of its functioning. Education is not a pure public good because it does not fulfil the second criterion of the non-exclusion aspect. Education, according to Coelho and Oliveira (2011), should be rather viewed as being a semi-public good because, at the upper parts of educational progression, namely at universities, a strict pattern of explicating exclusion appears: the fees needed to be paid. As long as this exclusion is applied to society members, a problem of inequality about accessibility capability appears to arise. Not everyone is able to pay so as to make ever-continuing progress. Thus, education being a semi-public good renders inequality being measured in terms of accessibility. How far education's positive outcomes can be accessible by all the members of society is a question without an easy answer.

2.2. The Intervention Case: Why the State should Regulate Education

Given the fact that education may finally fail at not sustaining inequality in terms of accessibility among society members, the State intervention proposal appears to be an explicit belief in the importance of equality being secured for all the members of society. This remark renders clear the fact that "how far can go the provision of education by the state ends up being a matter of financial resources available and – obviously – an ideological issue that results from a more or less liberal view about the way we understand the activity of the state in the economy and in the society" (Coelho & Oliveira, 2011).

As long as accessibility has been the major problem that education still comes up against, the state should explicitly adopt a supportive policy for the "less privileged" facing accessibility impotence (Coelho & Oliveira, 2011). "Less privileged" means either those who have not a solid economical background or those who cannot easily have full realisation of their potentialities gained through education. Both categories have to do with "lack of means" for someone either to realise his own capacities or to integrate effectively in the competitive economy (Coelho & Oliveira, 2011). This discrepancy between the less privileged and the highly privileged is what appears to be sustained socially and economically as an aspect of the inequality that pervades society's members.

For the state to ensure equal opportunities of access to education by the "less privileged" a kind of positive discrimination might be needed (Coelho & Oliveira, 2011). According to Coelho and Oliveira (2011), especially in the local settings of education's regulation, the state should play a more strongly supportive role in organising this favouring stance. In either case of the regulation (general or locally-oriented intervention) various forms of assistance might be offered directly by the state: through the finance system, construction of the educational infrastructure, strategy to prevent monopolisation of the education market in certain areas of science or through the law (Coelho & Oliveira, 2011).

Market's role detected in the reproduction of its functional system seems to be rather impotent to reduce the problems that stem from externalities existing within the education world. Because of the semi-public good nature of education and the presence of externalities in the production and consumption process in the education market, the market in general can be driven to solutions that might not be socially efficient (Coelho & Oliveira, 2011). That's why the state can and should be justified to intervene explicitly and directly. The State Intervention Case is of course justified only if the universal access to the benefits of education is regarded to be a central issue demanding attention and raising questions about the whole, intricate nexus of power relations that persistently exist among the State, the Market and the Society.

3. EXTERNALITIES IN EDUCATION

Many people choose to pursue an education for personal reasons: for example, an educated individual is more valuable in the labour market, hence the attractive prospect of a higher salary while others may derive personal satisfaction from the fact that they can become more knowledgeable in a field that interests them. However, it's not only the individual, or their immediate familial circle that may benefit from this decision. W. W. McMahon (1987) presents a comprehensive list of benefits that positively impact societies whose members become educated: these societal benefits are referred to as externalities and while there may be negative externalities (such as smarter criminals), it is McMahon's opinion that these costs are largely outweighed by the benefits.

McMahon does acknowledge that measuring these external benefits is a daunting task, however, he is quick to point out that before any accurate measurement is made, one should, at the very least, observe them in order to establish that they do, in fact, exist. He then goes on to present some of the pitfalls that we may encounter when measuring external benefits, such as the possibility of treating a private benefit as an external one or ignoring certain externalities altogether.

The first group of externalities presented in the paper are those that benefit society at large. The author begins by claiming there is a link between the better functioning of "democracy and democratic institutions" and an educated public. The author seems to treat this as a truism and is content to appeal to authority in order to support it, by mentioning how Thomas Jefferson was of the same opinion. The existence of the next externality is better supported: a more educated public means that the economy is better equipped to deal with imbalances caused by the introduction of new technologies; the author cites Schultz (1975). Another externality presented is the fact that a higher level of education translates to lower crime rates and hence less public expenditure for the penal system. McMahon cites studies showing that prison inmates tend to have a lower level of education and that limited access to schooling is linked to certain types of criminal behaviour, namely crimes against property. Labour market status is also affected by education, which according to Philips et al. (1972) explains youth crime rates (i.e. less educated people are of lower labour market status and hence more likely to commit criminal activities). Finally, running a prison system as expansive as the American one means billions of US dollars have to be spent and that is from a 1982 study; this is equivalent to more than $50 billion in today's money. Education is also linked to lower public expenditure in welfare and healthcare: households of a higher education level tend to be less poor and healthier; McMahon cites many sources that support this particular claim. The author proceeds to point out more externalities: education positively impacts the functioning of capital markets, and educated individuals are more likely to display altruistic behaviour. Finally, there are those benefits termed "non educational": these include babysitting services provided by schools, drivers' education that translates to fewer accidents, school lunch programs for poorer children and the use of school facilities by other organisations.

The next category of externalities is that of "Neighbourhood and Employment-related Benefits": these include better socialisation of children, benefits to the environment and more productive workplaces, something that is contrary to Berg and Freedman's (1977) claim that educated employees may become frustrated by the mundanity of certain tasks. McMahon cites Weisbord (1962) as a counterargument.

Finally, we are presented with spillovers, a different category of externalities. This particular benefit works as follows: people receive an education in jurisdiction A, and then move to jurisdiction B; now, jurisdiction B enjoys the benefits of having these educated people. The fact that these benefits are external in regards to jurisdiction A, is why they constitute an externality. What this means, is that from the point of view of jurisdiction A, this is a cost, and if Weisbord (1964, p.111) is to be believed this can lead to said jurisdiction spending less money on education (the so-called Weisbord effect): after all why spend on it if there are no benefits to be enjoyed locally? This effect may be countered by financial aid (Hirsch and Marcus, 1969).

Spillovers can occur both within a single country or internationally. In the case of the former, we are presented with the case of a St. Louis suburb where 87% percent of a tax increase attributed to education spilled over to other localities (Weisbord 1964, p.53). Money is, of course, only part of the equation: other benefits, such as the ones mentioned above, also spill over to other localities. One way to counter the negative effects of spillovers is by spill-ins, i.e. by having

educated people move into the locality, however, given the Weisbord effect, familiesand businesses are less likely to move to a locality that does not spend on education.

Regarding international spillovers, they are better known as the infamous brain drain, and McMahon emphasises its significance. In keeping with his understanding of how education positively affects society (see: the benefits for society at large mentioned above), he shows that certain countries have historically benefited from the education of people that migrated to them. This is a phenomenon that is ongoing: rich countries are gaining at the expense of poorer ones, whose spending on education becomes a cost when their citizens decide to leave. If the Weisbord effect applies on an international scale, this means that there will be a tendency to see these countries' level of education drop, something that, as we have seen, brings an assortment of negatives such as poverty. McMahon proposes that in order to combat this phenomenon we need to alter immigration policies and provide aid to the nations that need it.

4. KNOWLEDGE AS AN ECONOMIC GOOD AND THE ISSUES OF EXTERNALITIES

What arises is the topic of knowledge as a special type of economic good and the issue of externalities and its relation with knowledge generally and scientific knowledge especially. We have considered previously some general aspects of the notion of externalities.

So at this point to approach the specific issues here, let's consider and explore the basic position that "Knowledge is a special type of economic good". We could ask ourselves some introductory questions: What is or can be considered as a common economic good on the one hand and what as a special on the other? Also, what do we think of as knowledge and scientific knowledge?

We will consider some aspects of these questions and use distinctions also used by Foray & Mairesse (2001). So they say that there is a kind of "pure" codified or "codifiable" knowledge, that is more accessible to anyone (expert or not) on the one hand and tacit knowledge on the other, for which a kind of more complex tools for truly accessing and understanding or some kind of initiation is needed.

4.1. The Three Properties

So if we consider "pure" knowledge, we can hypothetically observe three special properties, contrasting with common goods. First, it is difficult to control - non-excludable and generates externalities. That is because it is fluid and portable, so it is difficult to control it and make it exclusive, mainly privately. Also in economic terms, it is a non-pecuniary good. So, it generates "positive externalities". That is, it has a positive impact on third parties. (Foray & Mairesse, 2001). Second, it is a non-rival (as for the users, not the producers) good or "infinitely expansible": Because it is inexhaustible-unlimited as a resource. The use of existing knowledge does not imply the production of an additional copy of the "unit of knowledge". The unit of information/knowledge received by its party is not a copy, but the original good itself. So the users do not have to compete for its use. Also, related to this characteristic, is the fact that the transmission of knowledge is a positive-sum game instead of a zero-sum game. Besides, in economic terms, since the marginal cost of use is nil, knowledge cannot comply with the economic rules of cost-based pricing. Finally, it is cumulative and progressive: because it is not only a consumer good but also an investment good (Foray & Mairesse, 2001).

4.2. Problems Raised from these Observations

These three properties of knowledge as an economic good are ambiguous as for their economic results. Because on the one hand activities concerning knowledge production generally have a high "social return" and are therefore a powerful mechanism for economic growth. But on the other hand, they pose important problems of resource allocation and economic coordination. So, "the main dilemma of the economics of knowledge" is set: Should knowledge be efficiently (in social terms) used once it has been produced or should we give ideal motivation to the private producer? (Foray & Mairesse, 2001) The main implication of the three properties is the creation of a difference between the private and the social return in the domain of the production of knowledge and particularly more social than private returns. Assuming that the production of knowledge generates profits, the recovery of all those profits is in itself a problem because of the difficulty of controlling knowledge. So a share of the profits will be externalised, harnessed by others (Foray & Mairesse, 2001).

The economic problems of public good and knowledge dilemma are very strong in the case of codified knowledge (for which as we saw the 3 properties are very strong). Externalities generate a lack of incentives to the inventors or the "Public Good Problem": In the presence of externalities, inventors as private agents, must expect to receive less than the social returns of their invention. So the net private marginal gain is less than the net social marginal gain (Foray& Mairesse, 2001).

The "knowledge dilemma" could be expressed and analysed in economic terms in the following way: Since the marginal cost of use of knowledge is 0, maximum efficiency in the use of knowledge supposes rapid and complete distribution and hence requires that the price is 0. Since the cost of production of knowledge is usually high, maximum efficiency in the use of resources to create new knowledge requires that the costs of all necessary resources be covered by the economic value of the knowledge created. Or more clearly: "Only the anticipation of a price on use will guarantee the allocation of resources for creation; but only a price that is 0 will guarantee efficient use of knowledge, once it has been produced." (Foray & Mairesse, 2001) So in regulatory terms, we could wonder: "Should we imply restrictions on the use or promote free use of knowledge?" Possible restrictions could be set as a control mechanism and might refer to and concern: the actual use of knowledge (copyright or patent), the transmission medium (pay-TV or tax on the recording), the formatting of the knowledge (coding to prevent copying or free recording) (Foray & Mairesse, 2001).

4.3. Re-examining the Problems Through Another Perspective

If we bring the "knowledge dilemma" as a theoretical problem in the real world, "quantify" it and reexamine it, we will see the dilemma weakened and we can be able to set a degree to the problem of externalities. The core of these reconsiderations is that no kind of knowledge is truly widely accessible even if it is "open source".

So finally, knowledge is not so uncontrollable and non-excludable: It is not reducible to pure "codified" knowledge but has a tacit dimension (know-how, practical experiences, research materials, instruments, tools). So, there is a sort of natural excludability, a way of controlling access and use (Foray & Maires). At the same time knowledge is not so non-rivalry: Even ifthe cost of using is 0, the capacity of knowledge to be used infinitely is limited because costs of accessing, formatting and transmitting knowledge are high. But also learning costs, which are the intellectual investments needed to form a community capable of understanding and exploiting knowledge through "intellectual equipment". Also, related factors and phenomena include the increase or decrease in education and training investments, information overload and the need for

new intellectual equipment (e.g. the increased problem of attention, need for new equipment for selection, screening…) (Foray & Mairesse, 2001). In addition, knowledge is not so cumulative: Because of the barriers in access and use together with the formatting, transmission and learning costs. Another possible reason could be the possibility that it is being kept a secret. Also, there are other specific obstacles that hinder cognitive processes underlying the cumulativeness of knowledge. The absence of a common and agreed type of code, a form of expression and procedure of verification and evaluation. Secondly, the difficulty and impossibility to grasp the temporal dimension. Finally, phenomena of obsolescence and depreciation of the "old" knowledge and paradigm weaken the cumulative process (Foray & Mairesse, 2001).

4.4. The Emergence of a Knowledge-Based Economy, Increasing Externalities, Risks and Evaluations

There is a twofold phenomenon (as a part of a long tradition of technical progress in relation to knowledge and the economics of knowledge) that is characterising the emergence and development of the knowledge-based economy: The long-term trend relating to the huge increase in resources devoted to the production, transmission and management of knowledge and investments in education. Furthermore, we are facing the advent of new information and communication technologies. (I.C.T.) In this kind of economy knowledge externalities are more powerful than ever (Foray & Mairesse, 2001).

These developments seem to be regarded as ambiguous by Foray and Mairesse (2001): both positive and negative. Negative, mostly because they argue that this will have a negative implication as for the private (investment) incentives, which they evaluate as crucial to the operation of knowledge production and economic coordination. Also, they state the importance of the protection and compensation for the producers of the new knowledge. Although they are concerned in relation to the issue of whether an economy should or not reward knowledge creation only in terms of monetary values alone or maybe use additional "honorary values" (Foray & Mairesse, 2001).

On the other hand, increased knowledge externalities are treated as positive, because the free, open and rapid circulation of knowledge between heterogeneous populations of researchers and entrepreneurs is the condition for optimum use of a non-rival good. In this way: the coordination between agents is facilitated, the risk of duplication between projects is reduced, the probability of later discoveries and inventions is increased and finally, the risk of not exploiting the potential of knowledge is decreased. Also, these high "social returns" are considered a powerful mechanism in economic growth (Foray & Mairesse, 2001).

5. KNOWLEDGE AS A GLOBAL PUBLIC GOOD

In our days, due to technological development, the creation of a global knowledge society and access into this information world emerged and became vital for people's lives. This capacity to access this information world that was afterwards linked with open access has given many opportunities to facilitate the productivity sector on the one hand, as well as individuals on the other. However, the existence of inequalities divides how and to what degree one can receive this information wealth.

As we first see the definition of "public goods", which pointed with non-rivalry of consumption where everyone can use the same information simultaneously without barriers, and second with non-excludability where everyone can have actual access to it, we question then if knowledge qualifies and can be described as a public good. About the first criteria the answer is unanimously

positive because one can freely use the information without restricting others from its use too, but for the second one opinions conflict. There are many examples, mostly in the technological sector (printed information or electronic journals which provided only to a close group), where knowledge has dual roles, by being free or being excluded. Following the first version, everyone can have access into the global knowledge society, so as into the intellectual property that is created, as well with the aspect of copyrights, patents or other information tools. Howbeit, in the second version, where knowledge acquires new legislation, the accessibility is more limited in order to satisfy monetary-economic purposes and to foster innovation productivity which motivates the reproduction of information as well the inputs (Schiltz 2007).

So the previous dilemma of whether information wealth must be free or excluded according to the requirements, we are guided to the openness of access and sources provision. Considering the access to knowledge as a value that should be plentiful and not scarce, as also as a gift economy and not a market product for incentives, leads us in a more advantageous position to remove potential barriers. Most access barriers dependent on existing inequalities which remain in place are the "filtering and censorship barriers" (Schiltz 2007) where inventors or government can limit the accessible content, the "language barriers" where the most dominant language can be restrictive to groups, the "handicap barriers" where people in need with specific peculiarities can be excluded and final "connectivity barriers" where the infrastructure of each place can work negatively on the accessibility of information.

Open Access (OA) and Open Source (OS) (Schiltz 2007) can abolish barriers across borders and population groups. Characterizing knowledge as a universal public good with non- excludable benefits any discrimination between people can be vanished, leading not only to cultural development but also to scientific and technological improvement combining the collaboration of both public and private actors. Moreover, a significant impact on human development can be noticed in many social, political or economical issues where the productivity, market conditions or the exploitation of various facilities can be achieved only with adequate information or accessible data.

In conclusion, these two critical tools can play a distinct role in the scientific work or other sectors concerning education, research, agriculture, health or technology, endorsing the development of countries and motivating the innovation and productivity market which must focus on user's purpose and not on developer's, creating a new framework of thinking with international intellectual property regimes.

6. SCIENTIFIC RESEARCH, PRIVATE AND PUBLIC SECTORS

Scientific and technological knowledge is an incremental process, where long-run new discoveries could contribute unintentionally to other bodies of knowledge and promote a speedy future generation of discoveries and practical inventions (David, 1998). In the modern economic analysis of R&D, firstly, it is important to acknowledge that information (knowledge) is an economic commodity, which shares the characteristics of expansiveness (2), allowing it to be used simultaneously by several buyers without depleting its values. Although it would incur the initial costs of its generation and fixed costs of training potential users to access the information, the marginal costs of knowledge can be extremely low when the scale of use increases. Secondly, another property of information regards its instant "transactional spillover" effect. In economics principles, for a reputable seller to gain the trust of their customers, it is expected naturally to share basic information about his or her product to prove of its reliable knowledge. Such trading of knowledge, however, even a slight disclosure of its possession could imperil the exclusiveness of knowledge as a potential buyer could acquire significant commercial advantages from even general information about an invention. Given the dual properties of "non-rival usage" and

"costly exclusion" of information, it is argued by the economists „ideas tested and reduced to codified scientific and technological information" (David, 1998, p.3) therefore cannot be based on the competitive market framework as knowledge has significant attributes of "pure public good" (David, 1998, p.3).

The notion of "basic research" refers to the fundamental and exploratory scientific inquisitions, in contrast to commercially-oriented R&D, basic research does not base on the competitive market's price system since it has potential difficulties in directing the scientific outcomes and rate of financial return (David, 1998). Usually, its resulted activities are protected by intellectual property rights (public patronage), as a societal form of investment for creators to generate some forms of profits by imposing restrictions on the users. Noticeably, exploratory research as a pure public good can also be carried out by private R&D-intensive firms, where they view it as a long-term business strategy to be better positioned at the frontiers of science and penetrating their competitors' emerging innovations. As seen, there can be complementary relationships for the private sector by publicly-funded open science activities. From historical accounts, one could observe that basic science research has significant social rates of return contributing to the overall „knowledge infrastructure" (David, 1998, p.5), previous fundamental scientific knowledge could also provide some „pre-specified technical objectives" (David, 1998, p.7) due to its „cumulative indirect effects" (David, 1998, p.5) that can be both time and cost-saving in the long-run. The „new economics of science" (David, 1998, p.5) therefore, refers to the generation of economic value from commercially exploitable and mission-directed innovations, which are considered to be the „by-products" of open-ended research and keeping the R&D firms profitable by increasing the corporate net worth. It is important to point out that, due to factors of commercial pressures and size of the firm, private sectors can be asset-restrained and seek an optimal balance between exploratory and practical commercial applications. Further, another complementary relationship between basic and applied research is the network of universities for training scientific expertise. As the nature of research knowledge is embodied in people, scientific expertise remains tacit and is regularly transmitted through communications and demonstrations. Researchers could tighten the linkage of the latest technology and its commercial values of inventions, therefore enhancing the R&D of the private business sector based on a "user-supplier" interaction within its budget specification. Thus, the phenomenon of circulation of researchers from the academic sphere into „industrial research organisations" (8) is seen as „technology transfer", an interactive model of coupling of research conducted under the commercially-oriented industrial R&D and publicly-funded work of academic scientists.

The successful integration of different capabilities between private and public sectors has offered „an attractive route towards successful innovation" for member states (David 1998, 15) and consequently, the notion of „wealth creation" with examples of „state-directed, mission-oriented" scientific programs, both civilian and the military has been prevalent in the West. Also, the public sector would have more capacity to monitor the international science and technology frontiers, especially concerning scientific activities that are tied to „national economic priorities" that may improve international competitiveness and concern the national economic security. Subsequently, The notion of „national innovation systems "suggests that „responsible governments should design, and support where necessary, to enhance their countries' economic performance" (David, 1998, p.10). Specifically, David (1998) presents to us the establishment of the „Technology Foresight Programme" in the UK, where it primarily aims to identify the potential competitive advantage of the nation, rewarding grants to research contributions that correspond to priority areas designated by the programme. Secondarily, such a program also has a „process-oriented" function in facilitating mutual understandings between the academic community, industry and Government Departments. Although without compromising the scientific and technological works performed by national laboratories and public institutes in the short-term, David (1998) points out the danger of over-emphasising the economic-instrumentalist

view in exploratory research by the government, where it can curtail the long-term „maturity structure“ of science and technology, and further depriving the creative capacity to respond to unanticipated challenges. Furthermore, he criticises the simplicity of the „science-push“ or „market-pull“ strategy of economic growth, where the former refers to the casual chain that scientific progress could translate directly into technological and productivity gains; and the latter simply reverses the former and implies the causal relationship of feedback from the market would demand more commercial inventions through private innovative activities. For this reason, David (1998) suggests that such linear-modelled assumptions of relationships between scientific research and technological innovations do not consider the inherent dynamics of technological change as a „recurring, circular process“ (p. 17) where the role of technologies could continuously shape the design and productivity of research itself.

Moreover, in the light of market-orientated technological developments David (1998) has further addressed concerns regarding the trend of appropriability of knowledge by universities. Specifically, he demonstrates the case study of the University of Oxford and its regulations over-claiming intellectual property protections on research projects and inventions, even made by their students. From a societal standpoint, the technology transfer through the vehicle of licensing intellectual property and copyright patents (David, 1998, p.9) could offer stronger incentives for researchers, as well as prevent the issue of „free-riding“ by firms on R&D of others and excessive trade secrecy taken as precautionary measures. However, it is equally worrisome that the traditional societal roles of researchers in promulgating knowledge through publications (David, 1998, p.19) have been substituted and institutions functioning more like the profit-oriented corporations with which biding for specified contracts. Thus, David (1998) warns of the risks of closed, proprietary research projects when the universities should have committed their unique roles as an „open knowledge community“ from„ quality-controlled, commercially disinterested sources“ (David, 1998, p.20). Generally, this paper reviews the technology policy-making in the West and its new recognition of „economic instrumentalism“ emerging in the 1980s. David (1998) in the end advocates that a „well-functioning“ science and technology system requires a balance between public and private sectors, where moderate collaborations could improve the collective efficiency in opening up „the mobility of technical personnel and reverse engineering“ (p. 20), however, institutions should also be aware of their unique role contributing to the stock of knowledge rather than driven by monetary interests.

7. TECHNOLOGY, POSITIVE EXTERNALITIES, AND PUBLIC GOODS

New technologies of the last two centuries have radically changed the way we live. The rise of modern capitalism and the start of the industrial revolution led to the enlargement of inventions from the 19th century, which could be explained by the fact that the majority of inventions have, at least partly, a monetary reward drive. The “Technology, Positive Externalities, and Public Goods” (Taylor et al.) chapter, which we are going to review in this part of the paper, investigates the idea that the social benefit of an invention typically exceeds the inventor’s benefit by using some important concepts (positive externalities and public goods in technology, the “tragedy of commons”, and the “free-rider problem) and proposes solutions to tackle this problem in a balanced way that benefit both inventors and the society.

The main topic of discussion in the chapter is how market competition and inventions interact in supported and opposed directions. On the one hand, the discovery of new technology or a new way to produce an existing one can provide a firm with more profits until competitors can achieve similar outcomes. On the other hand, in a case like the production of a new medicine that has a huge initial investment, market competition can harm inventions because the inventor will have invested millions of dollars to experiment with a new product while the competitors can

easily adapt and produce it cheaper afterwards; As a result, a pharmaceutical firm would invest in a new medicine only if it had guaranteed a monopoly and sufficient profit for it.

The most relevant concept to our paper that the chapter introduces us to is the positive externalities in technology, which is defined as "a situation where a third party benefits from the spillover effects of a market transaction by others". In the pharmaceutical firm case discussed above, the less the private benefit (which means more third-party benefit) of a new medicine invention, the less the pharmaceutical firm's investment and vice versa. Apart from the above example, some other positive externalities are presented including vaccination and education. Finally, the opposite concept of negative externalities is introduced, which emerges when specific technologies provide economic benefits, but also commit pollution to the environment.

The main problem investigated in the chapter is that inventors receive only a portion (around one-third to one half) of the total economic benefit of their inventions; Examples of Whitney's cotton gin, Edison's voter counter and Gould's laser are presented to back this statement. We may notice a paradox here: At first sight, it seems that there are relatively high positive externalities from inventions, which means more benefit for society. But, in the long term, if there is not enough benefit for inventors there will be less drive for innovation that will lead to less benefit for society.

To tackle the above problem a couple of government's policy tools are proposed by the chapter to increase the rate of return for new technology and encourage its development. For the purpose of this paper, we will present them and discuss to what extent they are applied in Greece.

a) Direct government funding of R&D

Many inventors (eg. research centres, firms, individuals) have great ideas, but a lack of money to implement them sufficiently. In these cases, the government can provide direct funding for research and development. In the case of Greece, there are a couple of funds and competitions (co-supported by the European Union) that provide money to universities, firms and start-ups.

b) Tax incentives for R&D

Apart from direct funding, the government can provide tax reductions for research and development. The Greek government recently introduced a relevant law (Νόμος 4712/2020-ΦΕΚ Α 146/29.07.2020) that provides an increased tax reduction for research and development.

c) Protection of intellectual property (patents)

Protection of intellectual property with patents is a useful tool, but it is often imperfect for a couple of reasons (eg. irrelevant in a fast-moving industry, creating temporary monopolies with a high price and low outcome, overused) and thus it should be accompanied by other tools.

d) Jointly work of companies on R&D

Similar laws like the US's "National Cooperative Research and Production Act of 1993" can enable firms to share knowledge, costs and risks and achieve a big invention that could not be

achieved individually. In the case of Greece, this is achieved by European funds that are distributed among many companies to develop a new technology together.

At the same time, the chapter proposes that a balance in the use of these tools is needed:

- Patents should be limited to genuinely new inventions and not extend for too long.
- Firms should be allowed to collaborate, but not to end up in a situation where they do not strive for new technology because they expect their innovation to be shared.
- R&D spending must be balanced against other government spending priorities.

From a technology point of view, and according to the chapter, a public good appears in situations where the positive externalities are so extensive that inventors could not expect to receive any of the social benefits at all. Furthermore, the chapter introduces us to two other concepts": a) The "tragedy of the commons", which is found in situations where one party is mainly benefited, but many parties share the cost (we may highlight here that pollution is an example here, which was also expressed asa negative externality earlier), and b) the "free-rider problem", which is found in situations where people use public goods without making a contribution to paying for it. By expressing the latter concept in terms of the prisoner's dilemma game, it is stressed that if there are many free riders, the public good may never be provided. To tackle the problem some actions are suggested, including alternative ways to make profits (eg. ads in the radio) and social pressures (eg. community activities, fundraising efforts).

Finally, the chapter suggests that positive externalities and public goods are "closely related concepts" and proposes direct government spending on research and development as a solution to increase inventor's benefits without necessarily turning their new inventions into private goods so that social benefits can remain increased too.

8. CONCLUSION

In general, we have gone over an extended examination of how education, scientific knowledge and technology development all together share an intricate nexus of interrelations appearing among society, the state and the market. The paper started by offering the potential to think about the State intervention case in regulating, in general, education for the greatest societal benefit. Despite the fact that such a proposal sounds good, doubts about the efficacy of this proposed solution might be raised. For example: can we easily trust the state for better organising of education's societal outcomes, and how far can this trust be finally an effective one for the good of society? Market's role dynamics within the intricate nexus of interrelations detected everywhere seem to be very powerful and so implicit or explicit that they might finally oblige society and the State to indirectly follow or at least to directly respond and react to this crucial dynamic. Additionally, externalities in the increasingly emerging knowledge- based economy, together with the advent of information and communication technologies, seem to be more powerful than ever. These developments can be regarded as ambiguous about whether knowledge should be a public or private good and how this division affects the openness or closeness of knowledge. Furthermore, we have also understood that the meaning of technological progress cannot be directly translated into commercially exploitable goods, and we have also recognised the danger of over-appropriability of knowledge by private sectors if the State has lost the balance intervening between the public and the private sectors. Finally, we saw that a set of governmental policy tools (eg. investment in R&D) are useful to ensure great benefits not only to the society, but also to inventors of new technologies so that they can keep being motivated to innovate and provide even bigger benefits to society.

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