

Knowledge Externalities as Commons for Innovation: A Critical Analysis of Public Expenditure on Education

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Abstract

This paper studies how knowledge externalities are commons and enhance innovation. Through analysis of public and private expenditures on education of OECD countries, it shows that public expenditure on education is not committed to collect market failure as stipulated by almost of studies about knowledge spillover, knowledge externalities, and social learning processes. Based on context of knowledge as common resource and the complexity of knowledge externalities, the paper urges that: i) Knowledge externalities are complex common resources, hence public expenditure is done in form of public policy to solve social dilemmas related to these externalities, and ii) Public expenditure is allocated on education not only by the factor of positive externalities generated, but also by being complex commons constituent of peer production and learning society that are important for innovation.

Keywords

Knowledge Spillovers, knowledge externalities, knowledge as a common resource, knowledge externalities as commons, social learning.

1. Introduction

The major justification of government expenditure on education by traditional economists is embedded in its characteristic of creating knowledge externalities which are public goods¹ and thus, government intervention is necessary to correct their market externality (Pigou,1946), (Bator, 1958), (Buchanan J., 1962 & 1966) cited by (Lin, 1976). However, even if this approach has been important socio-political tool for knowledge creation and transfer, it does not explain much about mutual public and private participation in the processes and mechanisms of knowledge creation and diffusion that have much in common with end use of knowledge and knowledge externalities. Thus, to study this problem, this paper considers the nature of knowledge externalities in the context of duality of knowledge functions that state that knowledge externality to individualism knowledge ownership is a bad whereas to social or collective ownership is a good.

It bases its analysis on current studies of knowledge creation and diffusion such as E. Ostrom and C. Hess who give a step forward to consider knowledge as commons and their important contribution is dual functions² of knowledge (Ostrom & Hess, 2006). This helps to have a new context of knowledge externalities as commons that explain much better the reason why of government intervention in form of expenditure rather than that of market failure which prejudices innovation context. This context helps to answer a question of: focusing on knowledge externalities as commons for innovation, what makes public and private expenditures³ co-allocation on education? The hypothesis of this research is that both public as well as private expenditure are equally concerned with education finance.

¹ This means that there are no exclusion and subtract abilities in knowledge externalities consumption. They are open and nonsubtractable resources.

Hence, these benefits cannot be governed by market cost-benefits system. Thus, public expenditure is advised.

² knowledge is a commodity and a social constitutive force and base for innovation.

³ Private spending on education refers to expenditure funded by private sources which are households and other private entities. This indicator is shown as a percentage of GDP, divided into primary, primary to post-secondary non-tertiary and tertiary levels. Private spending on education includes all direct expenditure on educational institutions, net of public subsidies, also excluding expenditure outside educational institutions such as textbooks purchased by families, private tutoring for students and student living costs. Private spending includes expenditure on schools, universities and other public and private institutions delivering or supporting educational services (OECD, Private spending on education, 2022).

To study the complexity of knowledge externalities as common resource, E. Ostrom's Social-Ecological System framework is used. The use of this framework showed that a problem of knowledge externalities as commons is a complex problem that need collective action for better outcomes. In this case, government and private participations are done.

The main conclusion of this study is that knowledge externalities are complex commons, hence public expenditure on education are provided because of complexity problem of these resources. The paper is divided into four main parts: introduction, knowledge externalities and public expenditure on education, knowledge externalities as commons for innovation, methodology, discussions, and conclusion.

1.1 Objectives

This paper has got two main objectives: i) to show that knowledge externalities are complex common resources, and their management needs a collective action rather of both government and private expenditures, and ii) to determine that public expenditure is mainly allocated on education because of knowledge characteristics and function of creating a learning society that is a constitutive force for the society which is imperative for innovation.

2. Literature Review

2.1 Knowledge externalities and public expenditure on Education

The problem of knowledge externalities has been presented as a problem of external economy constituency that must be internalized by government intervention. In this context, knowledge externalities are two-fold contextual phenomenon. First, knowledge externalities generate a competitive gain to knowledge users without bearing a face-value cost⁴. Second is that knowledge generators bear a competitive loss if they are not protected (Gehring, 2016). Thus, to solve this problem, government system of incentives: either by a full protection of creative knowledge through Intellectual Property Rights System (IPR), or/and incentives in terms of funds and subsidiaries is necessary to compensate efforts of individual property rights for innovation development.

In the context of full protection by IPRs, knowledge is treated as private economic goods that assignment of IPRs system aims a full-face value payment to the users (Gehring, 2016). In this view, knowledge externalities constitute external economy which is seen as injustice from knowledge users without bearing a corresponding cost. Even if this approach has dominated conventional wisdom, it is proved that too much ownership of creative knowledge destroys economy by stopping innovations and raising costs of living and a facilitated access to sources of knowledge to for example developing countries is advised (Heller, 2008; Stiglitz & Greenwald, 2014). This is in the context that users are also sources of innovation (Hippel, 1988). As far as knowledge externalities are concerned, society in general is referred to. This provides a sense of thinking twice when a policy of full IPRs protection is proposed, because whatever protection is, additions to knowledge pool are necessary and this according to conventional economists, government intervention through incentives and subsidies is the best approach.

However, to bring justice to knowledge externalities external market constitutive by government intervention through funds and subsidiaries has been for longtime used as a metaphor tool to deal with major economic and complex problems like that of knowledge externalities. The complex problem of knowledge externalities is linked to knowledge itself where it has a dual functions—as a commodity and as a constitutive force of society (Ostrom & Hess, 2006), and this causes knowledge externalities to be present into two-folded phenomenon-as private goods to which IPRs are necessary and social constitutive forces where open access is required to maximiser their use. This highlights the complexity of this resource, and state intervention through public expenditure to collect any inefficiency of knowledge externalities is in the context of solving complexity problem. Generation of this problem is explained as follows:

2.2. Knowledge externalities in the context of economic goods:

Knowledge externalities as economic goods comes from an approach of considering knowledge as commodity by which appropriation of knowledge is a source of innovation, creativity, and income. This leads to the consideration that externalities among knowledge providers and beneficiaries must be solved out by the governance intervention (Stiglitz & Greenwald, 2015, pp. 118-119). The government intervention is advised because private sector is unwilling to incur costs of production of goods with public dominion without paying the cost of production (Musgrave, 1999). However, this is a simple representation of knowledge learning process and related benefits as it is observed in the Figure 1, education generates positive externalities to which according to Mankiw N.G, government must internalize them by funding education by taxes from negatives externalities taxes. This seems to be a simple solution as far as complexity problem of externalities is concerned.

⁴ This is the cost that must be beard by knowledge beneficiaries to avoid free-ride problem.

In the context of competitive economy, aggregate principle is used, and the problem of externalities is considered as the problem of market failure where government intervention is required (Cornes & Sandler, 1996). However, according to Breschi and Lissoni, this is a simple solution to a complex problem of knowledge externalities, as it narrows the concept to embrace a wide variety of knowledge transmission systems and mechanisms while keeping diffusion process bounded in space (Breschi & Lissoni, 2001). Moreover, this view is not satisfying as far as the counter-systems and counter-mechanisms of knowledge diffusion are concerned (Cornes & Sandler, 1996). This makes knowledge externalities to be more social than economic good and hence market regulation system is a partial and simple solutions.

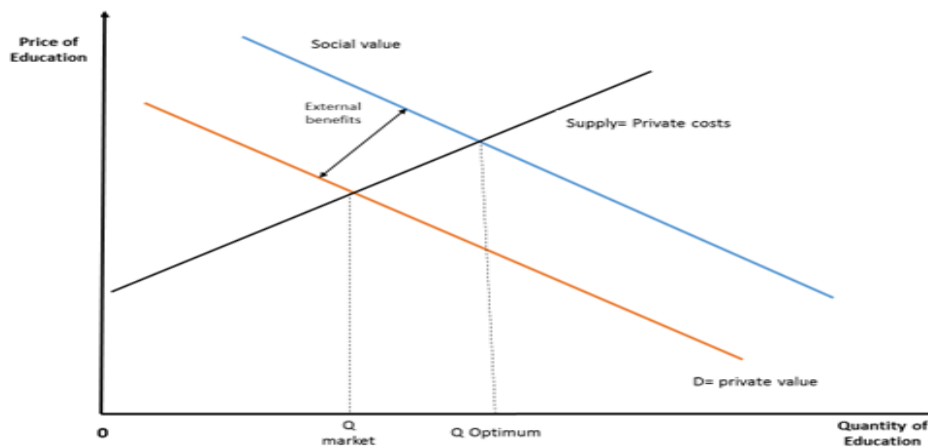


Figure 1.- Knowledge externalities driven market forces. Source: Mankiw, 2006.

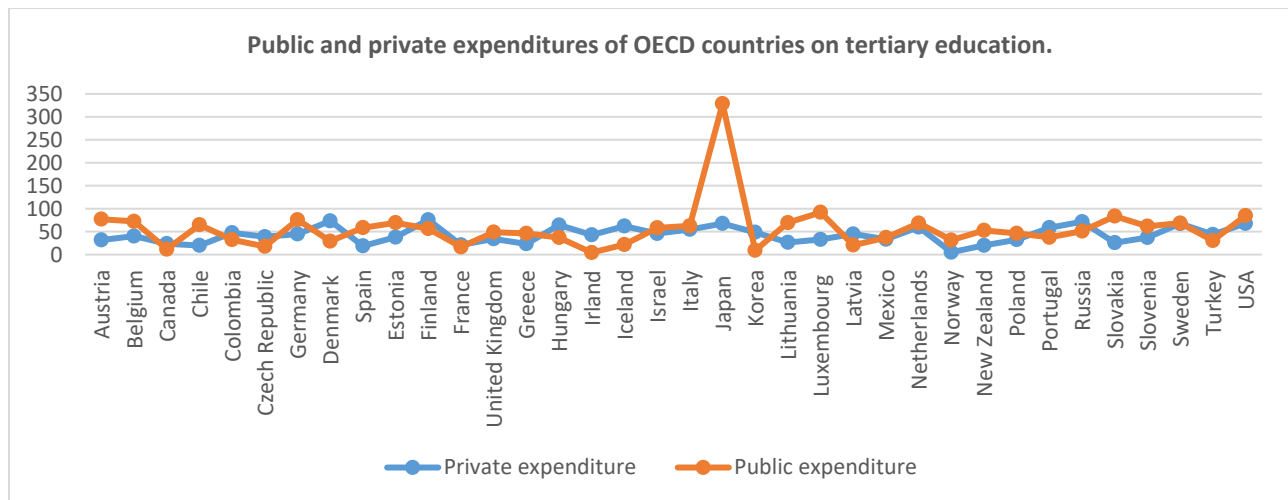
Knowledge externalities play a big role in a social learning society. To understand well this role, it is necessary to associate this idea with R&D spillovers which is current reflex and common outcome of knowledge diffusion and creation of innovations (Stiglitz & Greenwald, 2015). Innovations are not possible if there are no local interactions of knowledge spillovers (Ropera, et al., 2017). These local interactions canalize local knowledge flows that are derived from pure knowledge externalities and from complex set of inherently local transactions and interactions in form of pecuniary externalities that drive to productivity growth (Gehring, 2016). The local and cross-countries knowledge flows form a pool of knowledge that is commons. The collective action for knowledge generation and spillover has been manifested by a private and public intervention-no single country that can evidence only public or private expenditure. This can be evidenced by the case of OECD countries where the main cause of government and private expenditures on education is economic growth and social development (OECD, 2021). The public expenditure counts 86% for primary to tertiary educational institutions whereas private sources count 16% and 1% from international fund (OECD, 2020). According to OECD, public expenditures are most sources of funding on primary to tertiary educational institutions in OECD countries, although private funding at the tertiary level is very important. This can be observed in the following Table 1.

Table 1: Public and private expenditures of OECD countries on tertiary education. Source: Proper design according to data of OECD, 2022.

Country	Private expenditure	Public expenditure	Total expenditure
Austria	32	77	109
Belgium	40	72	113
Canada	24	12	35
Chile	20	65	85
Colombia	47	32	80
Czech Republic	39	18	57
Germany	45	76	120
Denmark	73	29	103
Spain	19	59	77
Estonia	38	69	107
Finland	76	56	132
France	21	17	38
United Kingdom	34	49	83
Greece	23	46	69
Hungary	64	37	101
Ireland	43	4	47

Iceland	62	22	84
Israel	46	58	104
Italy	55	62	117
Japan	68	329	396
Korea	48	9	58
Lithuania	27	69	96
Luxembourg	33	92	125
Latvia	45	21	65
Mexico	33	37	70
Netherlands	60	69	128
Norway	5	31	37
New Zealand	20	53	73
Poland	32	46	79
Portugal	59	38	96
Russia	72	51	123
Slovakia	26	84	109
Slovenia	37	62	99
Sweden	67	69	136
Turkey	44	31	74
USA	68	85	153

According to this Table 1 private expenditure accounts on average 42.86 million of USA dollars whereas public expenditure is 56.49 million. A detailed comparison is given in the following Figure 2.



Source: Proper design according to data of OECD, 2022.

Figure 2, A detailed comparison of Public and private expenditure of OECD countries

According to the above Figure 2, only a country that is marking a difference is Japan, otherwise general equally distributed. However, the trend of private funding is growing. For example, from 2012 to 2017 this trend increased with 0.5 % on average (OECD, 2020). This shows that public as well as private sectors are consent of socio-economic importance of knowledge externalities and the main raison of this, is not because of market failure as it is mentioned by most researchers, but the participation of each party to foster knowledge generation and better management of knowledge externalities economies without separating their economic and social benefits⁵. One of these benefits is the innovation. This relationship is shown by a triadic patent family⁶ from OECD countries as following Table 2.

⁵ The knowledge has dual functions: as a commodity and as a constitutive force of society.

⁶ A triadic patent family is defined as a set of patents registered in various countries (i.e., patent offices) to protect the same invention. Triadic patent families are a set of patents filed at three of these major patent offices: the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO). Triadic patent family counts are attributed to the country of residence of the inventor and to the date when the patent was first registered.

Table 2. triadic patent families of OECD countries

Country	Total Patents value	Country	Total Patents value	Country	Total Patents value
Austria	407	United Kingdom	1703	Mexico	22
Belgium	413	Greece	23	Netherlands	1008
Canada	623	Hungary	37	Norway	118
Chile	12	Ireland	105	New Zealand	71
Colombia	6	Iceland	3	Poland	70
Czech Republic	44	Israel	522	Portugal	38
Germany	4652	Italy	856	Russia	113
Denmark	304	Japan	17938	Slovakia	9
Spain	289	Korea	2730	Slovenia	12
Estonia	5	Lithuania	5	Sweden	763
Finland	291	Luxembourg	26	Turkey	52
France	2164	Latvia	3	USA	13551

Source: Proper design according to data of OECD, 2022.

According to this Table 2, total expenditure on Education in OECD countries is highly correlated with the registered patents (0.77 correlation coefficient). This shows how societies in these countries benefits from education expenditure. As a criticism to conventional economist position on knowledge externalities as public goods, Mankiw states that it is not enough existence of the externality for government intervention, in a small group where cooperation is possible, externalities' incidences are possibly solved out without government intervention (Mankiw, 2006, p. 205). The state intervention is advised in those complicated situations of knowledge externalities which can be compared to tragedy of the commons (Musgrave, 1996). This is a common characteristic of complex resources where the social dilemmas are uncertain and complex (Ostrom, 2011).

The government intervention through institution arrangements and new principles of collective actions are advised as alternative to generate efficient outcomes (Cornes & Sandler, 1996, p. 7). This is the same as J.M. Buchanan in what he says that government intervention must not only be in terms of public expenditure but more as institutional arrangements that highlights situation action with private sector (Buchanan & Musgrave, 1999). According to Stiglitz and Greenwald, this is because, the government intervention to positive externalities is very complex (Stiglitz & Greenwald, 2015), thus, Cornes and Sandler recognize probable inability of solving the problem of the knowledge externalities by saying “ Knowledge externalities are highly related to the noncooperative game theory that is more relevant to externalities and public goods, in which individuals seeking to maximize their own utility often ignore both the beneficial and detrimental side effects that their optimizing behavior will have on others” (Cornes & Sandler, 1996, p. 18). This is related to the fact that the knowledge externalities as impure public goods (Ibidem). According to E. Ostrom, these goods are called collective goods and the provision of them require complex delivery arrangements (Ostrom & Ostrom, 1978; Ostrom, 1983). The policy of the government intervention must the provision policy rather than production policy (Buchanan & Musgrave, 1999). Hence, considering the complexity nature of the knowledge externalities and their social dilemmas that only government intervention is effectively and efficiently unable to solve, knowledge externalities deserve further consideration as complex commons whose problems related to their use are solved by using complex framework, theories, and models, instead of advising simple solutions based on simple systems of state intervention like public expenditure in education.

2.2.3. Knowledge externalities as common-Pool resources

In principle nothing can prevent raising and increasing of knowledge externalities since we live in much more integrated world. This integration makes domestic and cross-countries knowledge-based transactions to more than ever produce externalities (Gehring, 2016). Thus, a context of knowledge externalities as commons is majorly founded in their nature of being derived from knowledge dual functions and being two-fold phenomenon. From this view, knowledge externalities are characterized by difficulty to exclude potential beneficiaries who do not bear costs of knowledge production and diffusion (Cornes & Sandler, 1996), and the subtract ability in use since there is unexplicit motivation to contribute to common knowledge pool (Stiglitz & Greenwald, 2015).

The nonexplosion characteristic states that, there is no limit to use resources, and this generates a free ride in use and causes knowledge externalities to resemble to public goods. This is the same as Leather, in what he says that knowledge externalities either tacit, stick or from a more complex set of inherently local transactions are inevitable to any community

as generate local knowledge (Lehrer, 2007). Even if knowledge externalities are increasing as much as we live in integrated world, however knowledge externalities are subtractable due to lack of motivation to contribute to common pool knowledge. Subtract ability in use characteristic relates knowledge externalities to private goods (Ostrom, 2005, pp. 24-25). There is a tradeoff between knowledge flows contribution for public use and their blockage for individual interests that forms prisoners' dilemma (Dixit & Levin, 2017). There is a problem of contribution, dissemination, monitoring, and benefits realized. These characteristics make management problem of the common pool resources to be complexity problem that needs a good understanding to get better solutions (Hakizimana, 2017).

To understand knowledge externalities as commons and that their problem is a problem of complexity, E. Ostrom Social Ecological System framework as it is shown by Figure 3 is used. The use of this framework is related to complex ecological system context of knowledge (Ostrom & Hess, 2006, p. 3). It helps to analyze interactions of generation and use of these resources that is not a problem of funding and appropriation. To understand well this process, we may refer to what S. Levin says that fragility of any system is caused by the fragility⁷ of its services (Levin, 1999, p. 15). This leads to the social dilemma according to tragedy of the commons of Garrett Hardin (Ostrom, 1990) that means, knowledge is not a problem, the problem is its services which are in this case knowledge externalities.

The SES framework enables to organize analyses of how attributes of the resource system, the resource units generated by that system, the users of that system and the governance system jointly affect and are affected by interactions and the resulting outcomes achieved at a particular time and place. In this context, the SES framework is a multi-level where each of the above categories is a system of interrelated variables. The framework also enables to organize how these attributes may affect and be affected by small or larger socioeconomic, political, and ecological settings in which they are embedded.

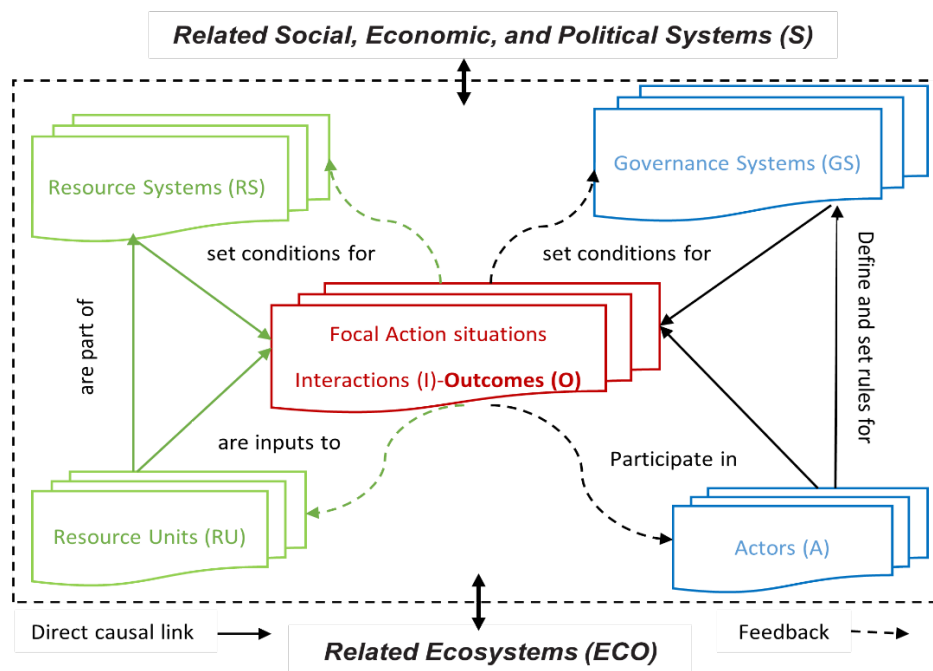


Figure 3.- Ostrom SES framework. Source: M.D. Cox & E. Ostrom, 2014.

Knowledge as complex ecosystem is a resource system to multiple actors that generates resource units, and it is characterized by no exclusion and constructability by use faces a social dilemma.

The above SES framework is decomposed into second tier variables in the purpose of analysis of complexity embedded into systems like that knowledge externalities.

⁷ A system is fragile when there is no sustainability of resource generation and use.

Table 3: Second-Tier Variables in Framework for Analyzing SES.

Social, Economic, and Political Settings (S) S1-Economic development. S2-Demographic trends. S3-Political stability. S4-Government settlement policies. S5-Market availability.	
Resource System (RS), and Resource units (RU)	Governance System (GS)
RS1- Sector (e.g., education and Knowledge externalities) RS2- Clarity of system boundaries RS3- Size of resource system RS4- Human-constructed facilities RS5- Productivity of system RS6- Equilibrium properties RS7- Predictability of system dynamics RS8- Storage characteristics RS9- Location RU1- Resource unit mobility RU2- Growth or replacement rate RU3- Interaction among resource units RU4- Economic value RU5- Size RU6- Distinctive markings RU7- Spatial & temporal distribution	GS1- Government organizations GS2- Non-government organizations GS3- Network structure GS4- Property-rights systems GS5- Operational rules GS6- Collective-choice rules GS7- Constitutional rules GS8- Monitoring & sanctioning processes Users (U) U1- Number of users U2- Socioeconomic attributes of users U3- History of use U4- Location U5- Leadership/entrepreneurship U6- Norms/social capital U7- Knowledge of SES/mental models U8- Dependence on resource U9- Technology used
Interactions (I)	Outcomes (O)
I1- Harvesting levels of diverse users I2- Information sharing among users I3- Deliberation processes I4- Conflicts among users I5- Investment activities I6- Lobbying activities	O1- Social performance measures (e.g., efficiency, equity, accountability) O2- Ecological performance measures (e.g., overharvested, resilience, diversity) O3- Externalities to other SESs
Related Ecosystems (ECO) ECO1-Climate patterns. ECO2-Pollution patterns. ECO3-Flows into and out of focal SES	

Source: E. Ostrom, 2007.

According to the Table 3, the SES framework contains 42 variables whose interactions affect the outcomes. These variables are applied to any SES and in this work, the variables that interact and affect the outcomes of knowledge externalities generation and use are selected from total variables contained into SES framework.

The subtract ability happens in the context that, through the social networks and in the competition environment, potential users and competitors want to use new knowledge as core competence. The more knowledge is used without incurring corresponding expenses, a free ride occurs and hence the abandon in know creation and expenditure occurs too. Thus, any resources which share these characteristics fall into social dilemma and to solve it, institutional arrangements through collective action is advised (Ostrom, 1990). This conception is found on the dynamic interactions of knowledge externalities diffusion and its limitations in space. The maximization of the benefits is related to social network externalities (Ostrom & Hess, 2006, p. 94), hence knowledge externalities are impure public goods because of no exclusion or costly to exclude potential users whereas they are not free available to all potential users. They are shared among those who have competences to use them (Antonelli & Gehringer, 2015). Because of competition effects, this generates negatives externalities to potential users (Ropera, et al., 2017), hence for example new firms which can access external knowledge are the ones which are more innovators (Raspe & Van, 2011). This happens in interactive process of the knowledge generators and receivers which is predominant locally rather than internationally (Gehringer, 2016). They are driven by incentive structures with local to global tendencies (Cornes & Sandler, 1996, p. 6). This is the same as S. Levin, when he says that most commons resources evolve to global commons exhibiting patterns behaviors that reflect in Garrett Hardin's Tragedy of the Commons which urge to think globally and act locally (Levin, 1999). Thus, knowledge externalities become complex.

The complexity of the of knowledge externalities is related to the complex nature of the knowledge commons and the incentive structures of associated with the knowledge externalities. Complexity nature of the knowledge comes from its dual functions- as human needs and an economic good (Ostrom & Hess, 2006), and this causes the incentive structures associated with these resources to be varied and complex than standard economic literature assumes (Ostrom, 2012, pp. 23-24). Hence, local knowledge spillovers follow a complex transactions and institutional arrangements (Suriñach, et al., 2007, p. 5). In accordance with the above, E. Ostrom research program says that complexity problem of common resources is attributable to the nature of resources or the action situation in which incentives and actions towards the use of resources are realized (Ostrom, 2005, p. 117). Thus, complexity of knowledge externalities is related to the complexity of the knowledge itself which fall into social dilemma if not thorough governance institutions.

Knowledge externalities fall into the tragedy of the commons because of lack of the institutions to exclude the potential users which leads to nonoptimality equilibrium, hence, new principles of collective actions have to be established to solve social dilemmas of externalities use (Cornes & Sandler, 1996), instead of staying trapped into social dilemma in which to internalize externalities, government intervention is advised (Ostrom, 2012). This can be achieved through collective action of knowledge externalities’ generators and their beneficiaries and can help in institutional arrangements for correcting nonoptimality created by externalities which is cost effective in of establishing institutions in making social decisions (Ledyard, 1976).

Institutional analysis is possible because, besides of being nonexcludable and subtractable resources, knowledge commons approach is accepted to help solving social dilemmas related to knowledge provision systems and mechanisms, social dilemmas related to knowledge externalities are of the second order. E. Ostrom believes that “the initial problem exists because the individuals are in a dilemma whereby, they impose negative externalities on one another, it is not consistent with the conventional theory that individuals can solve a second-level dilemma when they are already predicted to be unable to solve the initial social dilemma (Ostrom, 2008). Knowledge externalities raise its interest to be studied as commons not only to respond to their problem of public expenditure but also because are among few goods that produce positive externalities (Samuelson & Nordhaus, 2010), and considering the knowledge externalities as commons is an advance for having low cost in public expenditure and achieving optimal maximization of the generated benefits.

3. Methodology

Based on the Hypothesis of: “both public as well as private expenditure are equally concerned with education finance”, the methodology of this article consists of theoretical analysis of different authors on the knowledge externalities, socio-economic benefits of knowledge externalities, and how social and dynamic system of knowledge externalities are diffused. Among biographies revised, E. Ostrom and C. Hess, 2006; Cornes & Sandler, 1996; and Suriñach, et al., 2007 are in the center of the analysis. As far as the public expenditure is concerned, a critical comparison of the public and private expenditure in education of the OECD countries is done to show that public and private sectors are socially and equally concerned with education. Statistical techniques such as hypothesis test using T-test and correlation coefficient were used. The OECD countries were chosen because of the availability of data and a common policy to invest in research and Development as a source of innovations which enhance economic growth. It is a community of countries which tend to have a common policy of generating economic growth founded on learning society.

4. Results and Discussion

The theoretical and empirical analysis of knowledge externalities as commons for innovation based on the critical analysis of public expenditure in education brought the following results:

- i) Comparative criteria of public and private expenditures are given in the following Table 4:

Table 4: Comparative criteria of public and private expenditures

Analysis criteria	Public expenditure	Private expenditure
Sample size	n =36	n =36
Sample mean (\bar{X})	$\bar{X}_1 =56.49$	$\bar{X}_2 =42.86580997$
Variance	2722.63	333.51
Degree of freedom	70	
Significance level	10%	
T-Critical	$\alpha=-1.667, \alpha=1.667$	
T-Calculated	0.1463 this fall into acceptance region.	

Hypotheses	$H_0: \bar{X}_1 = \bar{X}_2$	$H_1: \bar{X}_1 \neq \bar{X}_2$
Conclusion Relationship between public and private expenditure and a triadic patent family.	Don't reject H_0 . There is not enough evidence that public expenditure is different from private expenditure. This is expressed by a positive correlation coefficient of 0.77	

According to the Table 4, the public expenditures on education as well as private expenditures are very important to education. The variation of these expenditures among countries depends on different factors such as education levels or economic level.

- ii) The public expenditures on education are not explained by the market failure for knowledge externalities rather the complexity character and social constitutive forces of knowledge externalities call upon government intervention through expenditures on education.
- iii) Government intervention in terms of public expenditure to regulate market failure of knowledge externalities is not theoretically supported, because knowledge as commons is impure public goods which need new principles of collective action.
- iv) The knowledge externalities are commons because, increase of knowledge externalities users generates subtract ability of benefits available to others. Knowledge externalities highly benefit users through favorable network externalities and as far as agglomeration and spatial space are concerned, the most beneficiaries are those users with enough competent. In other words, competition among knowledge externalities users generates negative externalities which is inevitable as far as incentive factor is concerned.
- v) The analysis of the E. Ostrom, 2007, Second-Tier Variables in Framework for Analyzing SES applied to the knowledge externalities case, brought to the determination of the variables that can be applied to knowledge externalities to show that inefficiency, non-equity, and uncountable are results of interaction process of resource system and units, governance system and users. The performance of each unit can be viewed in the following Table 5.

Table 5: Social Ecological System Variables applied to Knowledge externalities performance.

Social, Economic, and Political Settings (S) S1-Economic development. S2-Demographic trends. S3-Political stability. S4-Government settlement policies. S5-Market availability.	
Resource System (RS), and Resource units (RU)	Governance System (GS)
RS1- Sector: Education RS2- Clarity of system boundaries: not clear RS7- Predictability of system dynamics: Not predictable RU4- Economic value: high	GS1- Government organizations: Public institutions GS2- Non-government organizations: Individuals and private institutions GS3- Network structure: High GS4- Property-rights systems: difficult to apply GS5- Operational rules: difficult to apply GS6- Collective-choice rules: difficult to apply GS7- Constitutional rules: difficult to apply GS8- Monitoring & sanctioning processes; difficult to apply
	Users (U)
	U1- Number of users: Many U8- Dependence on resource: High
Interactions (I)	Outcomes (O)
I4- Conflicts among users: High I5- Investment activities: High cost	O1- Social performance measures: no efficiency, no equity, no accountability. O3- Externalities to other SESs: High in terms of innovations.
Related Ecosystems (ECO) ECO1-Climate patterns. ECO2-Pollution patterns. ECO3-Flows into and out of focal SES	

According to the above Table 5, the knowledge externalities as resource system are characterized by unclear system boundaries, unpredictable of system dynamics and high economic value; their governance system is characterized by connected many public and private institutions, property rights system and rules which are difficult to apply; the users of these resources are many and dependence on them is too high. Thus, these characteristics cause existence of conflicts and high costs, hence, the outcomes are poor (lack of efficiency, equity, and accountability). This show that new models are necessary to interactions of resource system and users can generate better outcomes.

- vi) Complexity of knowledge externalities is founded in knowledge, complex social process of learning, and incentive structures associated to knowledge externalities. Because of incentive structures related to these goods that make them to be complex socio-economic goods, new collective action principles are necessary instead of government intervention recommended by traditional economists. This enhances innovation creation.
- vii) Incentive structures within a complex system of knowledge externalities generators and potential users cause these resources to be complex commons resources which needs complex framework, theories, and models in the concept of E. Ostrom Social-Ecological Systems Framework to solve problems related to their use. Thus, there should be a shared co-responsibility of the private and the public sectors to invest in education.

Thus, this article articulates that the affirmation of that government must invest in education because of the positive externalities generated, it is too a generalization, hence, another view of knowledge externality in the context of complex common resources is necessary.

5. Conclusions

In conclusion, to enhance innovation, knowledge externalities are commons which need both public and private commitment. This justifies interest of both public and private expenditures on education. The public expenditure is allocated on education not only because it generates positive externalities, but also knowledge externalities are complex commons driven by social incentive structures. Their complexity problem is embedded in the interactions of resource system, governance system, users that generate poor outcomes. Thus, it is in this context that the intervention of the government as counterpart of the social community is efficient and effective either in terms of the public expenditure allocation on education or more in assisting in institutional design and arrangements.

Acknowledgements

This work was financially supported by the Instituto Politécnico Nacional, México. The authors would like to thank this institution for their support and commitments to this research project. May thanks go also to the referees for their valuable comments and suggestions to improve this research.

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