



Conceptualizing evolutionary governance routines: governance at the interface of science and technology with knowledge-intensive innovative entrepreneurship

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Abstract

The two main purposes of this article are: 1) To propose a conceptual model for governance at the interface of science and technology with knowledge-intensive innovative entrepreneurship and 2) To develop propositions and propose a future research agenda on evolutionary governance routines. Our proposed conceptualization of governance depends upon an understanding of how different ways of developing rules and norms to interact and make decisions collectively are created and maintained, including two sub-processes. One process is to develop advanced knowledge and the second process is where entrepreneurs transform that knowledge developed as the public good and privatize it through value creation. We propose that a main task for this type of entrepreneur is to manage their engagement in the overall governance in such a way as to be perceived by others as continuing to contribute to the collective action problem. The article provides definitions and propositions in relation to the conceptualization, as well as interesting trajectories for future research.

Keywords Science · Technology · Innovation · Governance · Routines · Knowledge-intensive innovative entrepreneurship

JEL classification O31 · O32 · O33 · O38

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1 Introduction

Out of the vast literature on organizational routines in general, this article contributes to the specific stream of evolutionary economics literature about routines. This literature has identified key characteristics in patterns of routines: specifically, routines represent patterns of behaviour, which can be seen as collective behaviour involving multiple actors, and where activities which become routines can be analyzed as demonstrating cognition as well as habits (Becker 2004; Pentland et al. 2010; Lazaric 2011; Winter 2013). This stream of literature includes some interesting contributions in relation to innovation and entrepreneurship (Cantner 2016; Cantner et al. 2016; Niosi 2018).

Explaining entrepreneurship is currently an underdeveloped topic within evolutionary economics – and the closely related theory of the firm in terms of knowledge and capabilities – but an evolutionary perspective offers great potential for understanding entrepreneurship, as argued by Sidney Winter (Winter 2016). From a review of initial contributions, Salter and McKelvey (2016) detail how this approach can contribute to understanding entrepreneurship, with regard to the particular role of routines and capabilities, and in relation to knowledge creation and its utilization by value creation as realized through innovation and entrepreneurship.¹ Schumpeter (1943) was one of the first economists who highlighted the role of innovation in the economy. He identified that innovations, or new combinations, can consist of a) new goods or new qualities of a good; b) new methods of production; c) opening of new markets; d) new sources of raw materials; and e) new organization of an industry – e.g. industrial dynamics. Schumpeter further argued that the entrepreneurs play a key role, due to their focus upon value creation more generally (Schumpeter 1943). In this tradition, Malerba and McKelvey (2018a) have recently proposed a theoretical definition used for the current article: “Knowledge-intensive innovative entrepreneurial firms are new learning organizations that use and transform existing knowledge and generate new knowledge in order to innovate within innovation systems”. This definition of knowledge-intensive innovative entrepreneurship (KIE) is also in line with the more general insights from an evolutionary economic perspective, namely that developing, diffusing and using new knowledge is crucial, and endogenous, in changing the economy, also known as restless capitalism (Metcalf et al. 2006). This is also known as a distributed innovation system. For this article, we are only considering the narrow case of specific KIE firms in all sectors, which depend upon science and advanced technologies. The reason for doing so is that this restriction allows us to draw upon existing literature to inform our understanding of governance routines related to the development of science and technology.²

¹ This article focuses upon routines rather than capabilities in collective action problems.

² We recognize that this stream of KIE literature discusses a broad spectrum of knowledge as relevant, and indeed, a key point is that knowledge may be of many types – design, low tech, creative industries, etc. We focus upon KIE ventures dependent upon the development of science and advanced technology because this enables us to draw upon existing literature for the conceptualization. Note that these KIE firms may be found across all sectors (and not restricted to only academic entrepreneurship or only to R&D intensive and high tech sectors).

Our aim is to specify the role of the entrepreneur in such a distributed innovation system, involving multiple actors and diverse knowledge, routines and capabilities – and we do so by defining different governance routines, from an evolutionary economics perspective. Therefore, the two main purposes of this article are: 1) To propose a conceptual model for governance at the interface of science and technology with knowledge-intensive innovative entrepreneurship and 2) To develop propositions and propose a future research agenda on evolutionary governance routines. Our specific conceptualization of evolutionary governance routines provides a way of analyzing the processes, whereby individuals and organizations develop rules and norms to interact and make decisions collectively, both for developing advanced technologies and for engaging in KIE. Our proposed conceptualization of governance thus depends upon an understanding of how different ways of developing rules and norms to interact and make decisions collectively are created and maintained, including two sub-processes. One process is to develop advanced knowledge and the second process is where entrepreneurs transform that knowledge developed as the public good and privatize it through value creation.

Section 2 explores discourses in relevant literature in order to provide our interpretation of how different streams of existing literature can be used to develop the key elements of the two processes in our conceptual model. These two processes are, respectively, the governance of developing new science and technology knowledge, and knowledge-intensive innovative entrepreneurship. Section 3 proposes a definition of evolutionary governance routines for this context, as well as a visualization of our conceptual model. The model is used to propose two propositions, from a dynamic perspective. Furthering this discussion, Section 4 proposes an agenda for future research.

2 Exploring discourses in order to define key concepts and processes underlying evolutionary governance routines

This article now turns to exploring discourses in relevant literature, in order to define concepts and the two sub-processes involving governance. Section 2.1 provides definitions of the underlying concepts of collective action and governance. Section 2.2 and 2.3 address the processes of development of science and advanced technology and the process of knowledge-intensive innovative entrepreneurship, respectively.

2.1 Governance and collective action

Two key underlying concepts are discussed in this section, and each is required for our conceptual model, namely: “governance” and “collective action”. Due to the wide range of different literature involved, we can only discuss a few basic points, and refer the reader to reviews and specialized literature within each stream. The aim here is to take these basic definitions, and specify what we mean – relative to existing literature – to provide initial starting points.

The first concept is “governance” which has very different definitions in different literature. Within Economics, corporate governance is a huge topic in its own right,

with a focus upon the modes of governance inside firms, usually from the perspective of transaction costs.³ Instead of this approach, we draw upon a few relevant definitions from different social science traditions.

Within Political Science, governance focuses upon political institutions. The literature on governance from this tradition sees governance as a way to solve grand societal challenges, given that neither the liberal market approach, nor the traditional top-down government steering approach are seen as good models of effective solutions of societal problems (Jessop 1997; Voss et al. 2006; Loorbach 2010). This view on the governance of political institutions has identified complex decision-making systems, relying upon what is known as polycentric systems, meaning that there are many organizations and/or decision centers involved, that are formally autonomous, but that are in fact linked together by an overarching set of rules, networks and relationships (Polanyi 1951; Aligica and Tarko 2012). Hence, this literature provides an inspiration for understanding what happens when multiple organizations are involved in decision-making, but without a formal centralized decision-maker. More broadly in social sciences, Putnam (1993) has been influential for stressing the importance of civic society, and particularly how civic participation as linked to societal rules and norms help develop social capital within groups.

Specifically, we derive from this literature a starting-point for defining governance. Governance is about understanding the different ways of developing rules and norms to interact and make decisions collectively. Our definition is therefore to use the notion of governance here in order to delineate actions and structures, which are regulating interactions and decisions across multiple individuals and organizations.

The second concept is “Collective Action”. This literature is generally rational choice, and what is known as the collective action problem is often framed in terms of expected negative outcomes, or alternatively frame counter proposals to promote positive outcomes. The most famous negative outcomes are the problems of collective action, tragedy of the commons, and social dilemmas. Within Political Science, Mancur Olson (1965) developed collective action theory, which argued that even though collaboration is necessary in the provision of public goods, the individuals involved have incentives to free ride, making societal decision-making and action difficult to do. Similar problems exist outside government regulation. A classical example within Economics is the tragedy of the commons (Hardin 1968), where one individual or group profits in such a way as to be detrimental to all, with his classic example being overgrazing on common lands.

³ In Economics, ‘governance’ is closely associated with Coase (1937) and Williamson (1996), where a very simplistic representation of their work is that they define different modes of governance, where the firm exists and economizes on transaction costs. We follow (Foss and Mahnke who argue that a more fruitful way to understand governance inside the firm draws upon evolutionary economics inspired theories of the firm involving problem-solving, learning, capabilities and routines (Dosi and Marengo 2000; Coombs and Metcalfe 2000) rather than transaction costs. Foss and Mahnke (2000) distinguish between governance theories of the firm from a Coase perspective and competence theories of the firm from an evolutionary economics perspective. To avoid confusion, we would like to be clear that ‘governance’ as used in this paper does not refer to the definition following Williamson.

However, in counter to these claims, the research by Elinor Ostrom and colleagues – as well as research inspired by her – proposes that actors can develop their own common pool resources, reliant upon norms and institutions.⁴ The Ostroms showed that more complex metropolitans had systems of relationships between local government units, public agencies and private businesses that “create important economic opportunities and evoke self-regulating tendencies” (Ostrom and Ostrom 1965: 135–136). A classic example was water rights in California (Ostrom 1972), where their research on ‘social dilemmas’ showed how diverse actors can avoid negative outcomes, by developing and monitoring voluntary agreements over common resources. In contrast to what might be expected, these complex, polycentric systems of governance outperformed the less complex ones (Ostrom et al. 1978). In her later work, she focused on identifying the members, rules and norms that needed to be developed and put in place to regulate access to information and resources (Ostrom 1990), including science as a common good (Hess and Ostrom 2007). The rules and norms both promote the development of a common resource but must also include monitoring activities to avoid free riding and associated tragedies of the commons. Although this stream of research is based upon rational choice, rather than evolutionary economics, it does provide inspiration to study the problem of collective action.

Specifically, from this literature, we derive a starting-point for understanding collective action which leads to a public goods. In short, this literature suggests that the problems of collective action and social dilemmas may potentially be mitigated by defining members of the group, by enforcing monitoring mechanisms, and by developing rules and norms to promote the development of a common resource pool. Our definition is to use the notion of collective action problems, in order to help outline the alternative ways that governance routines may play out in practice, and specifically which arise in relation to knowledge creation and its utilization through value creation.

2.2 What is the problem of governance of science and technology?

This section specifies what problems are involved in the governance of science and technology, and how those problems may be solved (McKelvey 2014). As introduced above, our more general definition is that governance helps delineate actions and structures, which are regulating interactions and decisions across multiple individuals and organizations. So what does that mean in relation to the development of science and technology?

The literature in the economics of science and technology addresses the norms, incentives and institutions of individuals and organizations involved in producing and diffusing new knowledge. Dasgupta and David (1994) initiated a stream of research that focuses on the differing incentives, of scientists involved in open scientists, which differentiates their incentives from firm developers involved in commercial inventions. This dichotomy in incentives between different types of organizations involved in developing new science and technology is mirrored in the modern organizational theory literature on ‘hybrid logics’, which has developed an analysis of where and

⁴ In other words, multiple individuals can engage in collective action, which provides benefits to all defined as being within the group setting the rules, and thereby avoid tragedies of the commons and similar negative outcomes.

why universities and firms develop new routines and capabilities to work together, or fail to do so (Perkmann et al. 2019). Another approach to the same issue is for universities to change their behavior, and engage in “academic entrepreneurship”, so that public knowledge can be even more effectively privatized in commercialization activities such as patents and start-up companies (Perkmann et al. 2013). Another approach is the Triple Helix, which suggests that policy, universities and firms collaborate (Etzkowitz and Leydesdorff 2000).

During especially the 1990s and early 2000s, and based partly on earlier work, a large literature emerged which considered information and especially digital information as intangible common pool resources. Hess and Ostrom (2007:3) propose to look at “knowledge as a shared resource, a complex ecosystem that is a *commons* – a resource shared by a group of people that is subject to social dilemmas” and provide a rich oversight of contemporary research across many disciplines. Because we are concerned with economic issues, one relevant set of research about commons is the stream which considers the act of invention as a collective action problem (Allen 1983; Gächter et al. 2010; Allen and Potts 2016). This literature addresses core issues of collective action, such as how to develop institutions to enable intangible common pool resources of information and knowledge. A related but slightly different stream has focused upon institutions and especially intellectual property rights, which are often studied in relation to their effect on the further development of science and technology. The concept of the tragedy of the anti-commons has been applied to scientific activities, and particularly to research in medicine and bio-sciences (Heller 1998; Heller and Eisenberg 1998; Murray and Stern 2007). The basic theoretical argument was that an increasing number of patents and intellectual property rights would be blocking other, future users, and thereby restricting future products innovations and scientific progress. However, countering this claim, in an empirical study of this phenomenon, Walsh et al. (2003) found that even though patenting in biotechnology has increased, especially for research tools, that this had not impeded drug discovery, and they thereby argue that there has not been a tragedy of the anti-commons in bio-sciences. Another stream of literature has tackled the incentives for individuals to continue to freely develop and diffuse new knowledge – for example in the context of open source software or science. The open source software debates address how intellectual property rights may be negatively affecting progress due to the incentives and processes underlying open source software (O’Mahony 2007; O’Mahony and Ferraro 2007; Langlois and Garzarelli 2008). This research asks whether, and why, communities continue to contribute with new software, if someone else privatizes and capitalizes upon the open source software. By tackling a set of related problems, these streams of research demonstrate that science and technology can be analyzed through the notion of *commons* including an analysis of the collective action problem and also that the development and diffusion of science and technology can be subject to both positive and negative outcomes.

Looking at a more aggregate and public policy perspective, the issue of the overall governance of research and innovation systems has been addressed in a somewhat different literature within public policy and in science and technology studies. The notion that science is a public good, subject to imperfections, has long been a reason to justify government investment into science policy (Archibugi and Filippetti 2015), and

more recently innovation policy (Borrás and Edquist 2013; Edquist and McKelvey 2000). The question remains of how governance works within science and technology. Borrás and Edler (2014:14) define this type of governance as a situation where “societal and state actors intentionally interact in order to transform science, technology and innovation systems”. Here, governance includes all forms of regulation of activities leading to the production of scientific knowledge, including collective self-regulation as well as regulation involving the market and government (Borrás and Edler 2014). In terms of governance failure, they predict that whether the outcome is positive or negative depends on mechanisms regulating interactions amongst the different actors involved, and one type of governance failure is the lack of institutions and networks. Studies of medical innovation in particular have used the theoretical and empirical concepts of innovation systems and governance in order to explain the interrelated development of science, technology and innovation involved in medicine (Metcalf et al. 2005; McKelvey et al. 2018). Medicine is particularly interesting, due to the presence of many positive and negative outcomes between actors as well as due to the extensive involvement of government in funding science as well as the importance of commercial actors.

From this literature, we extract and interpret the following four points as the key elements relevant to our conceptual model:

- 1) **“Collective Action for Science and Technology”** describes the interactions amongst heterogeneous public and private actors, which are involved in developing, diffusing and using new knowledge for science and advanced technology. These interactions can be described as polycentric system, involving many organizations and decision centers, that are formally autonomous. Universities (and research institutes) are involved as well as public policy and firms.
- 2) **“Norms, Incentives and Institutions”** help to regulate the interactions amongst these individuals and organizations. Private and public organizations often differ with regard to their rationale for investing and benefiting from the development of new science and technology. During the collaboration, norms, incentives and institutions are developed, which enable heterogeneous actors to collaborate.
- 3) **“Monitoring”** is necessary, so that the organizations involved are rewarded for following the collective norms and punished for breaking the accepted norms. Monitoring also enables the individuals and organizations involved to assess whether the overall system is heading towards positive or negative outcomes.
- 4) **“Public knowledge”** is the result of the collective action for science and technology, and affected by norms, incentives and institutions through monitoring activities. Public knowledge requires capabilities to interpret and absorb external knowledge, and even though some types of research results can be protected through intellectual property rights, knowledge in general will diffuse and become public due to particular characteristics.

Taken together, these four elements and the relationships between them constitute the first process within our conceptual model (Fig. 1).

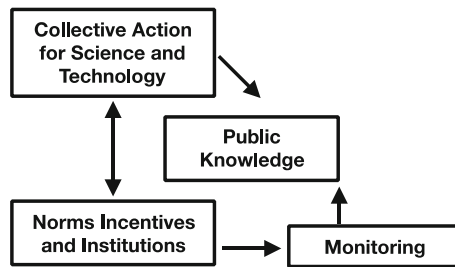


Fig. 1 Process of Governance of Science and Technology

We propose this definition of governance for science and technology:

Governance for science and technology involves a type of collective action problem, based upon actors involved in science, technology and innovation. These governance routines aim to promote positive outcomes and to avoid negative outcomes. This collective action problem requires interactions involving heterogeneous organizations, and especially between university and industry, in order to organize the sets of routines involved in the development of science and technology.

2.3 What is the problem of governance of knowledge-intensive innovative entrepreneurship?

This section specifies what problems are involved in the governance of knowledge-intensive innovative entrepreneurship, and how they may be solved. This process involves a series of collective action problems, which are important when knowledge becomes a privately held resource, through entrepreneurial activities.

To develop our understanding of this type of governance, we take as our starting point that developing science and technology alone is not enough to impact the economy, but instead individuals and organizations must engage in innovation and entrepreneurship in order to stimulate change in the economy, and they do so through routines and capabilities.

Here we focus upon one type of entrepreneurship, KIE, where a Schumpeterian view of the entrepreneur is one of the theoretical building blocks. In modern literature, this Schumpeterian perspective has led to the more general observation about the importance of the entrepreneur in enacting change and stimulating economic growth (Foster and Metcalf 2012; Metcalfe et al. 2006; Cantner 2016). More generically, the Schumpeterian entrepreneur creates innovative opportunities, as opposed to the Kirzeirian entrepreneur which simply discovers opportunities. Buenstorf (2007) defines Schumpeterian entrepreneurs as grasping opportunities and mobilizing knowledge resources. In exploring said opportunities, the entrepreneur plays a particular role in taking risks and in using knowledge and resources to transform ideas into innovations, e.g. novelty of economic value (Carlsson et al. 2013; Becker et al. 2006).

The emerging stream of literature on KIE takes a similar starting point, and aims to conceptualize one specific type of entrepreneurship, where new firms are dependent upon knowledge and innovation to compete, and may be found in all sectors of the economy (Malerba et al. 2016; Malerba and McKelvey 2016; Malerba 2011).

Knowledge-intensive innovative entrepreneurship has a specific empirical and theoretical conceptualization, and this emerging KIE literature provides evidence of why

this type of entrepreneurship constitutes an important and specific type of entrepreneurship (Malerba and McKelvey 2018a, b, 2019). Although many processes and characteristics are similar to entrepreneurship in general, KIE firms face faster processes of change because they are particularly dependent upon external relationships to access knowledge (and resources) as well as to identify innovative opportunities, while at the same time trying to compete with less tangible business offerings (McKelvey and Lassen 2013). Note that we do not assume that all science and technology become innovations (e.g. not all knowledge moves to knowledge intensive entrepreneurship),

Our view is that a more nuanced understanding of this type of KIE entrepreneurship can be developed through a richer understanding of the importance of routines in relation to entrepreneurship. Specifically, one can explore how and why the key characteristics of routines represent patterns of behavior, and analyzed through cognition as well as habits (Becker 2004; Pentland et al. 2010; Lazaric 2011; Winter 2013). Part of this literature specifically links routines and entrepreneurship draws upon earlier traditions, including the role of teams in the evolution of organizational routines (Lazaric and Raybaut 2005). Entrepreneurial action is seen as key aspect of change, and this done by focusing upon how the founder entrepreneur is able to influence values and the knowledge involved (Aldrich and Yang 2014; Lazaric 2011).

Specifically, we derive from this literature that evolutionary routines are relevant to knowledge-intensive innovative entrepreneurship, and especially in relation to the development of science and technology. Our proposal is to use the existing definition of KIE, and specify that KIE firms use their capabilities in order to develop knowledge into innovations on the market and also rely upon innovation system relationships to complete. More specifically, we propose that KIE entrepreneurship can be better understood and analyzed, by focusing upon the particular role of routines and capabilities, in relation to knowledge creation and its utilization through value creation. In other words, this article contributes to the KIE and evolutionary routines traditions, but we wish to slightly shift the focus away from the founder entrepreneur per se and instead shift focus to the sets of routines involved. Sets of routines are involved, when entrepreneurial action involves recurrent interaction patterns, which help organize this KIE process and to transform the potential entrepreneurial action into an actual one when they are able to use the result of the collective action problem – namely the development of science and technology – in order to transform that knowledge into private returns, through entrepreneurship.

From this literature, we extract and interpret the following three points as the key elements relevant to our conceptual model:

- 1) **“Public Knowledge” linked through arrows to “Monitoring”**. These two elements have been introduced in the previous model, but remain important. KIE is dependent upon a range of available public knowledge being created and diffused, by heterogeneous individuals and organizations.
- 2) **“Public Returns”** refers to a series of different public returns to the creation and diffusion of science and advanced technology, including the continuing creation of open science. This may take many different forms, and range from knowledge spill-overs, to knowledge specialization of clustering in specific regions and industries, to information available quite widely through open science.
- 3) **“Private Returns”** refers to a series of private returns to the development of knowledge, and here we are particularly concerned with KIE. The idea is that some

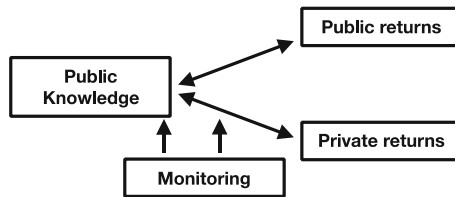


Fig. 2 Process of Governance of Knowledge-Intensive Innovative Entrepreneurship

entrepreneurs can use the public knowledge created through collective action, and can use their routines and capabilities in order to innovate and thereby benefit.

Taken together, these four elements and the relationships between them constitute the second our conceptual model (Fig. 2).

We propose this definition of governance for KIE:

Governance of knowledge-intensive innovative entrepreneurship involves the set of routines used by the entrepreneur to transform public knowledge into private returns.

3 A conceptual model of evolutionary governance routines

This section details our conceptual model, including the definition (sub-section 3.1), the visualization and discussion of the conceptual model (sub-section 3.2), leading to two theoretically-based propositions (sub-section 3.3).

3.1 Definition of evolutionary governance routines

Our conceptual model of evolutionary governance routines brings together the two models proposed in the previous section, in order to introduce a more dynamic perspective over time with possible pathways. The first process for governance of science and technology includes a definition of a set of routines, which are used for the further creation and diffusion of scientific and technological knowledge. The second process for governance of knowledge-intensive innovative entrepreneurship includes a definition and set of routines involves the diffusion and use of science and technology by entrepreneurs through innovations to impact the economy.

We propose this definition of evolutionary governance routines at the interface:

Evolutionary governance routines involve routines that 1) stimulate the creation and diffusion of scientific and technological knowledge while 2) allowing entrepreneurial action to privatize returns by transforming collective knowledge into private knowledge and while also 3) preserving the incentives for heterogeneous actors to continue to participate in the development and application of further advances of scientific and technological knowledge.

3.2 Visualization and explanation of conceptual model

Figure 3 provides the visual representation of our conceptual model for evolutionary governance routines. On the left hand side, we find the model for governance of science and technology. On the right hand side, we find the model for the governance of knowledge-intensive innovative entrepreneurship. The key elements are contained within the boxes, as well as arrows, which suggest impact from one element to another. Given that each element has previously been introduced, the explanatory text focuses upon interactions and interfaces, and also includes additional illustrations of what this type of governance means in our context.

On the left hand side, four elements are represented in Fig. 3, namely “Collective Action”, “Norms, Incentives and Institutions”, “Public Knowledge”, and “Monitoring”.

“Collective Action” is the element at the top left hand side. In this context, the collective action entails the process of developing science and technology. Developing science and technology can be seen as knowledge production, which requires collaboration between public and private actors, and collaboration often occurs in network structures as well as in more complex polycentric systems such as innovation systems and ecosystems. We have established that the actors involved are often heterogeneous and need to find a way to self-organize their collaboration. The different organizations involved may have different incentives and sources of financing, such for example that a research projects may be financed by both public and private sources. Moreover, customers and users may be important sources of knowledge within an ecosystem, and networks may link organizations. Hence, specific illustrations of what collective action may mean in this context include university-industry interactions, customer and user driven innovation, and networks. The collective action problem is how to organize interactions for the development of science and technology.

“Public Knowledge” results from “Collective Action” as represented in the left-middle top part of Fig. 3, and therefore there is a dark arrow, going both directions. In this element, we are focused upon the outcome, that is, the public nature of knowledge developed and useful to create spill-overs and positive knowledge spill-overs. Public knowledge thus refers to the actual knowledge developed, and can lead to both direct and indirect pathways during diffusion. Indeed, we are making an assumption that in distributed innovation systems, that the individuals, networks and organizations have some capabilities in order to monitor, understand and use newly developed scientific and advanced technical knowledge.

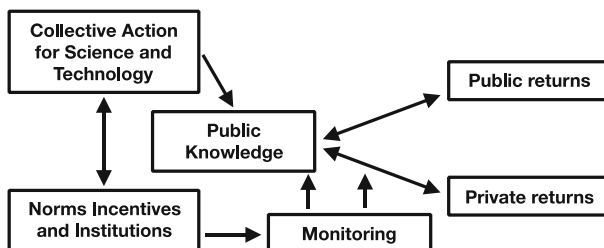


Fig. 3 Conceptual Model of Governance at the Interface of Science, Technology, and KIE

Moreover, “Collective Action” is also in turn strongly and mutually influenced by “Norms, Incentives and Institutions”, which is the element found on the bottom left hand side of Fig. 3. This element should be seen as having a moderating influence on whether and how collective action does, or does not, take place. This highlights the possibility of establishing self-regulating norms and institutions, which help keep actors committed to collective action as well as regulate the benefits to participants and enforce sanctions to free-riders. Hence, the specific illustration of this element can include things that promote norms, incentives and institutions such as previous collaboration experience, goals with knowledge production, formal agreements and trust between partners.

“Monitoring” is an important element in the collective action problem, and found in the middle of Fig. 3. The element of “Monitoring” is crucial in interactions between the processes of Governance for technology and Governance for knowledge intensive entrepreneurship. By monitoring, we mean routines that ensure that the norms, incentives and institutions which enable the collective action are enforced. The element of “Monitoring” expresses the need for individuals and organizations involved in the collective action to also find ways of ensuring that later benefits are somehow distributed amongst the diverse actors who are individually and collectively committed to developing the public knowledge. As expressed in the governance literature, our interpretation is that monitoring tries to avoid problems of inappropriate behavior, such as free-riders, exploiters and unintended knowledge spill-overs. Hence, we propose that monitoring emerges from the norms, incentives and institutions through the enforcement (or breaking) of agreements and trust. The illustration of this element focuses upon positive feedback mechanisms as well as punitive behavior such as exit from collaboration. Likely, monitoring includes various attempt to align expectations (and incentives) with outcomes.

In the middle and right hand side of the Figure, “Public Knowledge” and “Monitoring” are clearly linked to “Public Returns” at top right and “Private Returns” at the bottom right of Fig. 3. The element of Public Returns refers to science and technology, which have been developed and remain open to use and common knowledge resources. This means that these public returns provide new advances in science and technology, which link and enrich later Collective Action in the phase of governance for technology. This link relies upon the resulting knowledge remaining public and available, implying it is in public domain through prior art, scientific publications, widely held industry knowledge, copy-left and similar ways of diffusing science and technology. The element “Private Returns” refers to an assumption that the knowledge intensive entrepreneurs can create opportunities, based upon the diffusion and use of science and technology, by introducing innovations. When they do so through property rights and utilizing that knowledge in an innovation for profit, then some parts of what were formerly public becomes a privately held resource.

3.3 Propositions from the conceptual model

Figure 3 provides a visualization of the interface between science and technology with knowledge-intensive innovative entrepreneurship. The propositions that we derive from it can be thought of in terms of feedback loops, which run from the right-hand side and back to Public Knowledge and Monitoring.

3.3.1 Proposition 1

When public returns to public knowledge are achieved and recognized, then we mean that broader societal impact of science and advanced technology are recognized such as knowledge spill-overs, networks and societal impact. This condition always reinforces the positive norms, incentives and institutions for public actors to continue engaging in collective action for science and technology. There should also be wider impacts on the heterogeneous individuals and organizations involved in science and advanced technology. We assume that public bodies, usually government but also foundations, thereby helps support the governance of science and technology. Given the public investment to knowledge as a public goods, private actors also have incentives to participate, and they do so in order to obtain new knowledge. In this situation, governance routines will usually stimulate all involved parties to continue in the creation and diffusion of science and technology as a common resource pool.

3.3.2 Proposition 2

When private returns to public knowledge are achieved and recognized, then we mean that there is a privatization of new scientific and technological knowledge through activities constituting knowledge-intensive innovative entrepreneurship. The KIE firm uses its routines and capabilities in order to create private returns such as profits and to survive in the industry.

However, we propose that only some specific conditions help to reinforce the positive norms, incentives and institutions for public actors to continue engaging in collective action for science and technology. There will be a continuing positive outcome, if and when this specific type of KIE firm contributes back to the public knowledge as well. They have an incentive to do so, because they are explicitly dependent upon public knowledge in the form of science and advanced technology, in order to be able to translate that knowledge into innovation and later, survive and obtain profits.

Note that there is also possible negative outcome, due to monitoring activities. If the KIE entrepreneur exploits the system in such a way as to illicitly gain private returns from the public knowledge, then the collective action can break down, e.g. all involved stop contributing to the creation and diffusion of science and technology.

Therefore, we propose that a main task for this type of KIE entrepreneur is to manage their engagement in the overall governance in such a way as to be perceived by others as continuing to contribute to the collective action problem. More specifically, the KIE entrepreneur must ensure that other members perceived them as continuing to contribute to public knowledge and also as following norms, incentives and institutions related to publically available science and technology.

These two propositions are thus based upon a further reasoning, based upon feedback loops on the right of Fig. 3 and back to the center. The two propositions are thus built upon the underlying notion of the self-organizing processes underlying the variety and selection of routines underlying governance, and which can also lead to positive and negative outcomes.

4 Future research agenda

Given the early state of this research on evolutionary governance routines, many avenues for future research are viable, to link literature on evolutionary routines to innovation economics and entrepreneurship. The proposed conceptualization – including two propositions above – open up three interesting trajectories for future research.

A first trajectory of future research is to empirically test the conceptual model and propositions above, and enriching the extensive research which focuses primarily on the university activities (Perkman et al. 2013; Etzkowitz and Leydesdorff 2000). By empirically testing, empirical research could verify and analyze whether empirical evidence does indeed support the two propositions about different pathways of development, and the research should do so by tackling the predictability of processes and outcomes. Different types of research designs can be employed. Detailed case studies can be useful to make more fine-grained predictions, such as developing case studies of collaboration for science and technology, in order to identify key events related to both successful and failed collaboration in terms of the model. A relevant case study would thus be use the model to analyze the processes whereby the European Union science and innovation policy has promoted both collaboration amongst public and private actors as well as private returns (through patents, start-up companies and the like) and societal impact of science. Quantitative studies such as surveys can also be employed to examine whether the heterogeneous actors involved actually do share norms, incentives and institutions for the collaboration *per se*. For example, a survey of KIE entrepreneurs within a traditional industry like paper and pulp or agro-food could use specific questions as indicators of how they perceive their norms and incentives and specifically analyze how well their norms do, or do not, align with collaborative partners. This could enable a better empirical understanding of specifically the establishment and maintenance of the governance routines, as well as how and why the interaction between different involved actors is based upon mutually reinforcing social structures, norms and behavioral patterns underlying routines. We suggest that this empirical research should in particular address the interface between governance of science and technology with governance of KIE.

A second trajectory is to consider specific changes over time, within the model, and then relate to both propositions above about positive and negative outcome. As an illustration of the understanding that could be gained through case studies, research has shown that the underlying norms, incentives and institutions can rapidly change at certain periods, as documented in McKelvey (1996) for the use of biotechnology (recombinant DNA) to make pharmaceuticals. Molecular biology and genetic engineering were fields which stimulated many of the early start-up companies in universities. However, initially in the late 1970s, many university scientists were critical of privatizing science developed within medical schools, and commercialization was seen as negative for ‘open science’. A few years later, start-up companies like Genentech were successful, and many of the previously critical university scientists became academic entrepreneurs, and the criticism died out, when genetic engineering became

commercially successful. This suggests that research is needed, which explicitly explores the speed and direction of change in norms, incentives and institutions, and also how they may be influenced by public policy.

Moreover, this second trajectory of research would also require conceptual work, which we would propose requires both engaging further with the conceptualization of entrepreneurial routines (Aldrich and Yang 2014; Lazaric 2011) as well as knowledge-intensive innovative entrepreneurship (Malerba and McKelvey 2019). It seems that a vital question for this type of research is to explore the time and place when routines are stable, and when and why they may change. In terms of governance for KIE, the illustration above also suggests that a particular puzzle is that “Private Returns” may be viewed as a positive and/or negative outcome, depending on the underlying norms, incentives and institutions at a specific time and place. One suggested empirical approach would be find a stable long-term example of collective action for science and technology and analyze what happens when existing partner – which was not previously engaged in entrepreneurship – starts engaging in KIE entrepreneurial action and what happens to the other partners. Another approach would gather data on the private and public returns related to a specific type of collaboration project, and try to simulate a ‘tipping point’ of the system between the positive and negative outcomes.

A final trajectory of research is to further develop the links between our conceptualization of evolutionary governance routines back to broader but core evolutionary economics topics, including ideas such as alignment. Hence, one way to empirically tackle this issue is to focus upon the institutions. Previous research has shown that institutions can affect the underlying norms, incentives and institutions (Cantner et al. 2016) but needs to be supplemented with a detailed understanding of the micro foundations (Winter 2013). For this future research, one could use case studies of an institutional shock, to examine what happened afterwards in a particular case of collective action resulting in KIE. Moreover, while a conceptual model is presented, more conceptual work could be done as well as simulations. The initial story told here as an evolutionary interpretation reads approximately: new scientific and technological knowledge continues to be developed (variety creation) through collective action. Some results continue to remain public knowledge and provide public returns through the new body of knowledge (science and technology) while other results are translated through innovation and entrepreneurship into private returns. The two propositions suggest that these two pathways could be further developed theoretically, relating to literature on different types of evolutionary selection processes. Hence, future research should return to fundamental issues about the role of routines in helping or hindering the ongoing emergent properties of the economy (Cantner 2016; Metcalfe et al. 2006), and specifically the link between knowledge-intensive innovative entrepreneurship and economic growth.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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