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*Two Decades of Research on Innovation Paradoxes: A Review and Suggestions for  
Future Research*

by

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## Abstract

Innovation paradoxes refer broadly to a family of anomalous observations highlighting that outstanding innovation efforts, including investments in them, lead to either insignificant or undesirable economic outcomes in terms of wealth, employment and competitiveness. While such paradoxes have been recorded and investigated since the late 1980s, there is still not a published review paper, or chapter, on the subject in the extant literature. This paper fills this gap, by reviewing the empirical literature of two of the most popular innovation paradoxes in innovations studies, that of the European Paradox and of the Swedish Paradox. The results show that, despite key differences in terms of both conceptualisation and unit of analysis, empirical research in both paradoxes has processed along similar lines, leading to a four-fold typology of explanations. Lastly, the paper discusses some important observations relevant for innovation theory, research and policy, as well as it discusses directions for future research.

**Keywords:** Innovation paradoxes, European paradox, Swedish paradox, Literature Review

**JEL Codes:** 030, 038,039

## 1. Introduction

Innovation paradoxes consist of a family of anomalous observations highlighting that outstanding innovation activities, or investments in them (however both of these are defined and measured) lead to either insignificant or undesirable economic outcomes in terms of wealth, employment and competitiveness. In other words, an innovation paradox highlights that innovation may not always be beneficial for the economic entity under consideration, be it a nation, a region or a sector. In this broad sense, the essence of an innovation paradox lies in the tension between expectation (theory) and observation (practice).

More specifically, following the writings of the old-master of all innovation scholars, that of Joseph Schumpeter (1942;1934), innovation theory in general, and the economics of innovation in particular, maintain that innovation is, for although various reasons (e.g., productivity growth, competitiveness, knowledge spillovers, entrepreneurship, and variety in the economic system that leads to sectoral expansion and diversification), the engine of capitalist economic progress and human progress (e.g., Castellacci, 2007; Grossman and Helpman, 1994; Romer, 1990; Nelson and Winter, 1982). This assumption has, over the past four decades or so, inspired not only numerous empirical studies, but it has also prompted the introduction of numerous innovation policies across the world. For instance, the great majority of innovation policies is grounded on the assumption that investing in innovation activities (especially in research and development (R&D) activities) is equivalent of boosting the growth and competitiveness of the economic entity under consideration (e.g., Gackstatter et al., 2012; Archibugi and Coco, 2005); with the Lisbon Strategy in general, and the 3 per cent R&D expenditure of gross domestic product (GDP) target in particular, being among the most prominent examples.

However, several empirical observations (e.g., Fragkandreas, 2013; Edquist and McKelvey, 1998; Jones, 1995) have illustrated over the past two decades or so that this is not always the case; or better it is not in the manner suggested (e.g., “scale effects”, i.e., an increase devoted in the resources of innovation should increase the growth rate of the economy) by the mainstream endogenous strand of the economics of innovation (e.g., Castellacci, 2007; 2005; Grossman and Helpman, 1994; Romer, 1990). Given the inconsistency between the scale effects assumption and empirical observation, it is, by no means, surprising that innovation paradoxes are the subject of an extensive empirical research; for instance, a random search on Google Scholar with the term “innovation paradox” yields 1,100 results, searched on 11<sup>th</sup> January 2015. The very existence of such paradoxes, therefore, illustrates the inherent limitations of the scale effects assumption; an assumption central not only to the mainstream strand of the economics of innovation (e.g., Castellacci, 2007; Romer,

1990), but also to numerous innovation policies across the globe (e.g., Gackstatter et al., 2012). Because of this, scientific research on innovation paradoxes has attracted not only the attention of policy-makers, but also their financial support.

Given the increasing interest of both innovation scholars and policy-makers on innovation paradoxes, as well as the policy implications that stem from research on such paradoxes, one may rightly expect to find a few review publications on the subject in the literature. Unfortunately, there is a significant deficiency of meta-analytical contributions on the subject. In fact, and despite two years of research on innovation paradoxes, no such review contribution has been published so far<sup>1</sup>. This neglect carries some crucial implications for not only our understanding of the nature and causes of innovation paradoxes, but also of several research-informed innovation policies that seek to address the causes that bring about the innovation paradox under consideration. To put it simply, our understanding of the nature and causes of such paradoxes looks - at least to an outsider – quite fragmented and conformational: it is mostly based on the results of individual studies, most of which, and as will be shown through this paper, offer not only competing explanations for the occurrence of an innovation paradox, but also contradictory policy suggestions.

The paper provides an extensive survey on the literature of two of the most popular innovation paradoxes in innovation studies, that of the European paradox and of the Swedish paradox. Despite referring to different units of analysis (i.e., nation and a union of nations), both paradoxes under consideration highlight that outstanding innovation activities generate little economic returns, especially in terms of promising innovations, employment, wealth and international competitive advantage. In other words, both paradoxes demonstrate “...*the disappointment of economic growth that did not seem to respond to high levels of investment in knowledge...such as human capital, R&D and patents, as well as broader aspects such as creativity*” (Audretsch, 2009a: 250). By reviewing the literature on innovation paradoxes, the paper attempts to identify a few common theoretically-informed and empirically-verified (or grounded) explanations. In doing so, the paper aims to extend and deepen in a meta-analytical manner our understanding of the nature and causes of the paradoxes under consideration. In addition, the paper identifies a few unaddressed research issues and gaps that merit the attention of both innovation scholars and policy makers. All in all, the paper aims to make a meta-theoretical contribution to the literature on innovation paradoxes, meaning also that one of the secondary purposes lies in the ability of the paper to offer a 'compass' to the relevant literature to both newcomers and seasoned researchers interested in learning about or investigating innovation paradoxes.

This paper is structured as follows. The next two sections review the empirical literatures on the European and the Swedish paradox. The penultimate section identifies a few empirically-verified or ground explanations, common to both literatures under consideration. Lastly, the final section summarises the main findings

of this paper; it also provides suggestions, and discusses some important observations and issues that merit the attention of both innovation scholars and policy makers.

## **2. European Paradox**

As mentioned in the introductory section, innovation paradoxes consists of a several anomalous observations illustrating the tension between innovation theory and empirical research; or better they illustrate the existence of a gap between expectation and observation. With a certain degree of arbitrariness, one may identify several innovation paradoxes in the social scientific literature (for a selective list of innovation paradoxes, see Table 1). The present section reviews the relevant literature of one of the most popular innovation paradoxes in the literature of innovation studies, that of the European Paradox.

According to the Green Paper on Innovation (European Commission, 1995), the European Union (EU) suffers from a series of weaknesses; among others, the first of these refers to investments in R&D activities. It is argued, in particular, that compared to United States (US) and Japan, the EU invests on average less in R&D activities (see also the discussion in Archibugi and Cocco, 2005). The second weakness refers to the lack of coordination in terms of R&D activities, programmes and strategies across Europe. However, the greatest of all weakness is, according to the Green Paper, the *European paradox*, i.e., the inability of the EU to transform “...*the results of technological research and skills into innovations and competitive advantage*” (European Commission, 1995:5).

**Table 1 – Selected innovation paradoxes**

<b>Name</b>	<b>Description</b>	<b>Main Source</b>
European paradox	The Europe paradox refers to the inability of the European Union in terms of transforming its scientific excellence into innovation, competitive advantage, wealth and employment.	European Commission (1995)
European regional paradox	The European regional paradox refers to the observation that some of the most innovation-intensive regions in Europe do not only grow at a slower pace, but they also present lower income per capita and employment statistics than the national average under consideration.	Fragkandreas (2013)
“Scale effects” paradox (also known as Jones critique)	The scale effects paradox refers to the observation that while the number of scientists engaged in research and development (R&D) in advanced countries has grown dramatically over the last 40 years, the growth rates of advanced countries have either exhibited a constant mean or even declined on average.	Jones (1995)
Regional innovation paradox	The regional innovation paradox refers to the apparent contradiction between the comparatively greater need to spend on innovation in lagging regions of Europe and their relatively lower capacity to absorb public funds earmarked for the promotion of innovation activities.	Oughton et al. (2003)
Solow paradox (also known as IT-paradox)	The Solow paradox is based on Robert Solow's observation “[y]ou can see the computer age everywhere but in the productivity statistic”. In other words, investments in generalised purpose innovations (e.g. the computer) and related technologies do not pay-off.	Solow (1987)
Swedish paradox	A generalised version of the paradox refers to the observation that outstanding investments in R&D and innovation-related activities generate little economic return in terms of competitiveness, growth and employment.	Ejermo et al. (2011); Edquist and McKelvey, 1998)

The underlying observation of the European paradox raises two important questions (European Commission, 2003): the first one pertains to the efficiency of the European scientific system, i.e., “[d]oes the European science system fail to produce the kind of research upon which advanced industrial economies have become increasingly dependent?” (p. 413); and the second one relates to the European industrial base, i.e. does the European industry “...lack the ability and/or absorptive capacity to use the knowledge produced in the science sector effectively?” (ibid.). These two questions, therefore, imply that an answer to the European paradox lies in the domain(s) of either/both scientific base or/and industrial base.

The first scientific study to cast some light on the matter was that of Tijssen and van Wijk (1999). Specifically, the authors examined in a comparative fashion (e.g., US and Japan) the scientific performance of the EU in terms of scientific publications and citations in three leading technological fields, that of computers, data processing, and telecommunications. The findings do not only confirm the leading position of the EU in these fields, they also identify a serious weakness on the part of

the European information, communication and technologies (ICT) industry. In particular, the study shows that the European ICT industry lacks the necessary abilities with regards to developing and commercialising the results of promising scientific research (see also Dosi et al., 2006: 1456-1460).

However, the European Commission (2007; 2003) has argued on several occasions that it is not only the European industry that fails to take an advantage of promising research activities, but also the European academic system. In particular, it is argued that, compared to that of the US, the European scientific system fails to transform the results of publicly-funded research activities into wealth and employment-generation innovations. As the EC puts it in one of its reports “[o]ne important problem is how to make better use of publicly funded R&D” (European Commission 2007, p. 7). According to the same report, one of the main reasons for this inability is that “[c]ompared to North America, the average university in Europe generates far fewer inventions and patents...”, and this “...is largely due to a less systematic and professional management of knowledge and intellectual property by European universities” (ibid.).

The above conclusion has triggered several policy responses in the form of institutional reforms across Europe (Jacobsson et al., 2013; Geuna and Rossi, 2011). Since the late 1990s, several European countries (e.g., Austrian, Denmark, Finland, Germany and Norway) have either modified or replaced the traditional inventor ownership model of academic patent rights (i.e. the so-called professor's privilege) by which the sole owners of publicly funded research discoveries are the researchers), with a US-inspired institutional ownership model (i.e. the so-called 'Bayh–Dole Act' model) by which publicly funded research results are owned by the scientific institutions. In other words, the widespread belief that EU under-performs in the commercialization of publicly funded research has been followed by the relevant policy response, that of transferring the ownership of intellectual property rights to scientific institutions.

However, several studies (e.g., Lawton Smith et al., 2013, Jacobsson et al., 2013; Conti and Gaule, 2011; Conti and Gaule, 2011) indicate that the belief of an inefficient European academic system is to a large extent flawed. Conti and Gaule (2011), for instance, seek to find out whether the US technology transfer offices are more productive, in terms of both licence agreements and revenue, than the European offices. The findings show that EU technology transfer offices are as productive in terms of license agreements as the US offices. However, the EU offices seem to earn significantly less from licenses than the US offices. Conti and Gaule (2011) put forward two hypotheses for this observation: (i) US offices place greater emphasis on revenues than EU offices; and (ii) US offices employ more experienced in business employees than the EU offices. Regarding (i), Conti and Gaule found that the EU offices place the same degree of attention as the US offices do; regarding (ii), they found that their proxies on experienced staff had a positive and statistically significant



impact on revenues, suggesting that the US offices hire more experienced employees in business than the EU offices.

Recent empirical studies (e.g., Herranz and Ruiz-Castillo, 2013; Bonaccorsi, 2007; Dosi et al., 2006) indicate that the European paradox has nothing to do with the presumed inabilities of the European academic-scientific system. It rather has to do with some important methodological issues. Dosi et al. (2006), for instance, argue that the European paradox is nothing more than the outcome of mis-calculating and reporting the relevant data regarding scientific performance. In particular, they show that, after adjusting the data for the population, “...*Europe’s claimed leadership in terms of number of publications disappears*” (Dosi et al., 2006: 1454). In addition, Dosi et al., found that, after controlling for both originality and impact of scientific publications (e.g., citations), the US is still well ahead in both indicators<sup>2</sup>. As they put it, the evidence is “...*far from supporting any claim to European leadership in science. On the contrary, one observes a structural lag in top-level science vis-à-vis the US, together with (i) a few sectoral outliers in physical sciences and engineering, and (ii) a few single institutional outliers (such as Cambridge in computer science and a number of other disciplines).*” (Dosi et al., 2006: 1455).

Similarly, several studies (e.g., Herranz and Ruiz-Castillo, 2013; Albarran et al., 2010; Bonaccorsi, 2007) have collected and analysed extensive bibliometric data with regards to the performance of the EU science base; for example, Herranz and Ruiz-Castillo (2013) analysed 3.6 million articles which were published in the period between 1998 and 2002 period in 219 fields. While, on the one hand, the findings of these studies confirm that the European scientific system outperforms that of the US in terms of total publications, these studies show that the European scientific system: (i) under-performs in both new and fast-growing scientific fields (e.g., ICT, biotechnology, medical sciences); (ii) has, in comparative terms, a poor citation performance in the majority of the fields under consideration; as well as that (iii) it is highly specialised in slow-growing and mature scientific fields (e.g., physical sciences, engineering and mathematics). In a nutshell, these studies raise serious doubts on the assumption of a world-leading European science, thus also to the first axis of the European paradox.

Although the findings of the above studies have shed some light on the nature of the European paradox, especially with regards to the input side of the paradox, they, nevertheless, raise a few important questions. For instance, *why does the European science base excels mostly in mature (slow-growing) scientific fields?* As well as, *how can the EU take an economic advantage in the fields that its scientific system excels?*

Regarding the first question, Andrea Bonaccorsi’s work (2011; 2007) offers some interesting insights. Bonaccorsi (2007) argues that a deeper understanding on the question why the European scientific system excels mostly in mature scientific

fields, requires a shift in our analysis; from analysing contemporary science, technology and innovation (STI) policies to the history of scientific institutions in Europe. In particular, Bonaccorsi argues that the European scientific system suffers from some “...*serious deep-seated institutional features that make it difficult to adapt to new search regimes*” (p.9). Such institutional rigidities seem to be rooted in the post-War II period, in which Europe was well prepared to face the infrastructural challenges posed by the then promising scientific fields such as chemistry, physics, mathematics and engineering. According to Bonaccorsi (2007), the institutional infrastructure of the EU (especially of France, Germany and Italy) was unprepared to face the challenges posed by the advent of new technologically-oriented scientific fields (e.g., ICTs, medical and life sciences), fields characterised by continuous radical technological change than by incremental change. To substantiate the above claims, Bonaccorsi (2011) provides a comparative historical analysis (e.g., US, United Kingdom, Germany and France) of a science-based industry, that of information technology (IT). Based on an analysis of the curriculum vitae of the top 1,000 computer scientists in these countries, Bonaccorsi (2011) finds that it was only in the US that the institutional setting was germane to the development of a competitive science-based IT industry.

Regarding the second question, David Audretsch's work (2009a;2009b) and colleagues (Audretsch and Keilbach, 2008) on entrepreneurship offers some interesting insights. Audretsch (2009a) argues that fostering the creation of a knowledge-based entrepreneurial economy offers a promising resolution to the European paradox. In particular, Audretsch and Keilbach (2008) point out that the mainstream approach to economic growth (e.g., Romer, 1990) leaves not only the question of commercialisation of scientific knowledge largely unaddressed, but also it gives the impression that there is an automatic link between investing in scientific knowledge and economic growth. As they argue the significance of socio-cultural factors – the 'knowledge filter' as they call it - may hinder the commercialisation of new scientific knowledge. Audretsch and Keilbach (2008) maintain that entrepreneurship overcomes the knowledge filter by transferring knowledge from the scientific domain to the economic domain. Therefore, “*entrepreneurship is the missing link between investments in new knowledge and economic growth*” (Audretsch, 2009a: 92). On this basis, it is argued that entrepreneurship constitutes a promising solution to innovation paradoxes (e.g., Audretsch, 2009a; 2009b; Audretsch and Keilbach, 2008). To substantiate their claims, Audretsch and Keilbach (2008) develop a production function model, and assess its explanatory power in 440 German counties (Kreise). The results suggest that “...*not only is entrepreneurial activity greater in regions with higher investments in new knowledge, but that also those regions with more entrepreneurship exhibit higher growth*” (p.1698).

Having examined the literature of the European paradox, four main explanations seem to emerge:

1. *Empirical validity explanation.* The underlying observation of the European paradox is mostly an outcome of methodological problems, especially with regards to measuring scientific performance.
2. *Academic and scientific base explanation.* The European academic-scientific system fails in comparative terms (e.g., US) to translate the results of scientific research into wealth and employment-generating innovations.
3. *Knowledge filter and entrepreneurship explanation.* The European paradox is caused by social-cultural factors - the knowledge filter – that hinders the commercialisation of promising research results. Therefore, and due to its ability to overcome the knowledge filter, entrepreneurship is a promising way forward.
4. *Industrial base explanation.* The European industry fails, for various reasons (e.g., lack of investments in R&D, establishing networks with science, etc.), to take an advantage of scientific research.

The next section introduces and reviews the empirical literature of the Swedish paradox. It starts with a brief introduction to the Swedish paradox, followed by an extensive review.

### **3. Swedish Paradox**

The Swedish paradox emerged out of a debate in the Swedish-speaking literature in the late 1980s (for an overview, see Jacobsson et al. 2013: 875-876). This debate was initially prompted by the observation that the relation between R&D investments and aggregate economic output statistics (e.g., growth per capita) was weak. Since then, different interpretations of the Swedish paradox has been proposed (for an overview, see Ejermo and Kander, 2006:9-11). Nevertheless, as emphasised elsewhere (Ejermo et al. 2011; Bitard et al., 2008; Jacobsson and Rickne, 2004:1356), all versions of the paradox lead - in one way or another - to the same conclusion: outstanding investments in innovation activities generate little economic benefits in terms of high-tech products, exports, productivity, growth and employment. In other words, all versions of the paradox highlight “...a mismatch between very high values on indicators of inputs into innovation and low values on output indicators...” (Bitard et al., 2008: 240). In this generic sense, the Swedish paradox describes the inefficiency of the Swedish economy in terms of transforming innovation inputs into innovation and economic outputs.

Since the late 1990s, a considerable number of studies have attempted to explain the underlying observation of the Swedish paradox – mostly due to the political implications that emanate from it (e.g., Jacobsson et al. 2013). This has

gradually culminated into a noteworthy empirical literature, from which six empirically-examined explanations seem to have hijacked the interest of both innovation scholars and policy-makers. These are briefly as follows:

1. *Sectoral allocation of R&D activities.* Most of R&D expenditures are conducted by government-funded organisations; or by multinational enterprises (MNEs); or by private firms which grow fast but not as fast as their R&D investments.
2. *Knowledge transfer problems and entrepreneurial inabilities.* Knowledge generated through R&D in either/both scientific organisations or/and corporate departments and organisations stays with the borders of these organisations.
3. *Technological Lock-in problems.* The Swedish economy is heavily dependent upon the innovation abilities of a few successful Swedish MNEs. These firms are specialising in non-high-tech and slow-growing sectors of the contemporary economic landscape, thus their decisions to invest in high-tech innovation strongly affect the economic specialisation of the country.
4. *Globalisation of production:* The Swedish economy is dependent upon the activities of a few large Swedish MNEs. These MNEs invest heavily in innovation within Sweden, but they produce the results of R&D activities in other countries. In other words, “...much of the return on Sweden's R&D investments is captured abroad, rather than domestically” (Bitard et al., 2008: 265).
5. *Inefficient innovation system:* The national innovation system of Sweden fails, for although various reasons, to transform resources devoted to innovation into wealth and employment-generating innovations. In other words, the national innovation systems suffers from weaknesses that lead to low efficiency.
6. *Theoretical perspective.* There is no paradox, it is all a matter of theoretical perspective. For instance, if the proportional logic of scale effects is replaced by a more nuanced theoretical perspective, there is no reason to expect a strong link between innovation inputs and economic outputs.

Starting from the first explanation, descriptive empirical evidence provides no support to the claim that R&D activities are mostly conducted by government-funded organisations. For instance, 74 percent of the total R&D expenditures in Sweden are conducted by the business sector (Chaminade et al. 2010: 14). In addition, the business sector has increased its share in the total amount spent in R&D activities over the past four decades (e.g., Marklund et al., 2004), of which 83 per cent is carried out by large firms employing more than 500 employees (Bitard et al., 2008). Ejermo and Kander (2006) show that high concentration of R&D activities in a few large firms is one of the most persistent and distinctive features of the Swedish economy. This, as argued elsewhere (e.g., Bitard et al., 2008; Marklund et al., 2004; Henrekson

and Jakobsson, 2001; Edquist and McKelvey, 1998), can be attributed to both micro (e.g., firm-specific) and macro (e.g., historical, political and institutional) factors, both of which will be discussed shortly.

While the above studies confirm that most of R&D activities are conducted by the business sector, the explanation that government-funded R&D activities are not efficient enough has been quite popular in the political discourse of the Swedish paradox (e.g., Jakobsson et al., 2013; Granberg and Jakobsson, 2006; Hellström and Jacob, 2005; Jacobsson and Rickne, 2004; Henrekson and Rosenberg, 2001). Jakobsson et al. (2013) attribute this belief to the policy discourse surrounding the European paradox. In particular, they argue that the underlying observation of the European paradox has given the impression that the European academic-scientific system, including that of Sweden, lacks the abilities to commercialise government-funded R&D results (see also, the discussion in Goldfarb and Henrekson, 2003). This, and in conjunction with the Swedish economic crisis in the early 1990s, triggered significant discussion with regards to the institutional and organizational changes that are required to increase the efficiency of government-funded R&D activities. In this context, the presumed inabilities of the Swedish academic sector has been a recurrent theme in policy discussions, reports and empirical studies (Jakobsson et al., 2013; Granberg and Jakobsson, 2006).

However, several empirical studies (e.g., Jakobsson et al., 2013; Lawton Smith et al., 2013; Bitard et al., 2008:245-247; Jacobsson and Rickne, 2004) demonstrate that such beliefs rest not only on questionable empirical grounds, but more importantly, they are to a large extent erroneous. Jacobsson and Rickne (2004), for instance, demonstrate that the supposed inefficiency of the Swedish academic system is mostly an outcome of methodological problems. In particular, they show that the conventional way of measuring academic R&D expenditure skews the rankings in favour of a top position on the part of Sweden. It is argued that most ranking exercises neglect the significance of R&D efforts conducted by government and non-governmental research institutes, the 'extended academic sector' as Jacobsson and Rickne (2004: 1361) call it. Taking into account the contribution of the extended academic sector, Jacobsson and Rickne (2004) illustrate in a comparative fashion (e.g., EU and OECD countries) that the R&D expenditures of the Swedish academic system are average in terms of monetary input (e.g., measured as a percentage of GDP) and above average in terms of output (e.g., scientific publications per gross domestic product). Therefore, Jacobsson and Rickne (2004) argue that the Swedish academic system appears to be efficient, not inefficient as believed.

However, a recent study sheds new light on the question of sectoral allocation. In particular, Ejermo et al.'s study (2011) departs from the observation that most of the R&D efforts in Sweden are conducted by firms. Specifically, their study seeks to investigate whether the underlying observation of the Swedish paradox “...is a consistent feature across all sectors of the economy, or specific to either fast-growing

or *slow-growing sectors*” (p.669). Ejermo et al. (2011) distinguish between growing and declining sectors, and analyse their long-term R&D patterns in relation to their added value for a sixteen year period, between 1985 and 2001. The results show that “...*the paradox occurs only in fast-growing manufacturing and service sectors*” not in the slow-growing sectors as argued elsewhere (e.g., Edquist and Mckelvey, 1998). However, Ejermo et al. seem to neglect the possibility that slow-growing sectors of the Swedish economy outsource an important part of their innovation and production activities to fast-growing sectors, as well as that fast-growing sectors outsource an important part of their production activities abroad, through for instance global production networks (e.g., Chaminade et al., 2010). Nevertheless, Ejermo et al.'s study has made an important contribution to our understanding of the sectoral dimension of the paradox.

The second explanation, that of *technology transfer problems and inabilities*, has also received considerable attention from both innovation scholars and policy-makers. Once again, the Swedish academic system has been at the centre of both scholarly and policy attention. Henrekson and Rosenberg (2001), for instance, compared the incentive structure for commercialising academic research in Sweden with that of the US. The study results indicate that the Swedish incentive structure provides far less encouragement than that of the US. Goldfarb and Henrekson (2003) attribute this observation to three factors: (i) the top-down nature of the Swedish academic system; (ii) the lack of competition among universities in terms of funding and personnel; and (iii) to an academic environment that seems to discourage researchers from commercializing their ideas. This, as they argue, comes in stark contrast with the institutional setting in the US, which is characterized by (i) a “bottom-up attitude” in the sense that universities are wholly responsible for designing their own strategies, (ii) competition among universities for research funds and personnel, and (iii) an attitude that encourages commercialisation and entrepreneurship.

However, several studies raise some serious doubts about the validity of the above claims. Jacobsson et al. (2013), Granberg and Jacobsson (2006), for instance, argue that the results of some studies have given rise to a set of dominant false beliefs in Sweden. One of such beliefs, in particular, depicts scientists as anti-social, self-sufficient ‘hoarders’ of scientific knowledge, who are also generally uninterested in sharing the benefits accruing from their research with the rest of the society. In a nutshell, as Hellström and Jacob (2005) note, scientists are often depicted as recalcitrant, and therefore “...*in a need of management*” (p.444). Such a belief, however, finds very little support in the empirical research to date. Granberg and Jacobsson (2006) refer to the results of several empirical studies showing that scientists in Sweden are quite active in diffusing scientific knowledge. Similarly, Bitard et al. (2008:250) refer to the findings of a few empirical studies showing the close connection between science and industry in the field of biotechnology in

Sweden. Lastly, Swedish scientists seem also to be quite active in writing publication with both national and international colleagues (Bitard et al., 2008; European Commission, 2003).

Furthermore, the results of recent empirical studies indicate that the Swedish academic system performs exceptionally well in terms of academic entrepreneurship, i.e., “*the variety of ways in which academics take direct part in the commercialization of research*” (Henrekson and Rosenberg, 2001: 207). Lawton Smith et al. (2013), for instance, found in a comparative study that researchers at the Chalmers University in Sweden are more active in creating spin-off firms than their counterparts at the prestigious Oxford University in the UK. In particular, they found that 75 spin-off firms were created at Oxford and 271 firms at Chalmers University in the period under consideration (e.g., 1997-2009). Similarly, Jacobsson et al. (2013) found in a study on academic entrepreneurship that the birth rate of such firms was higher for the period between 2003-2010 in Sweden than of that in US and in the UK (for more details, see Jacobsson et al., 2003: Table 2). In a nutshell, the results of the above studies show that the Swedish academic system performs exceptionally well in terms of academic entrepreneurship.

Since the examination of the inabilities in the academic system add very little that is new to our knowledge of the causes of the Swedish paradox, several studies have suggested that the causes of the paradox lie mostly in the domain of economy than in that of academia and science. Ejermo and Kander (2006), for instance, note that despite the low barriers to entrepreneurship, trade and competitiveness, as well as the high level of investments in innovation, Sweden seems to be unable to diversify its economic structure (for a similar observation, see Bitard et al., 2008; Marklund et al., 2004; Edquist and McKelvey, 1998). With regards to the latter, the predominance of large industrial groups has remained intact over the past four decades: only one out of the fifty largest firms in Sweden was created during the past four decades (Ejermo and Kander, 2006:18). This, as argued elsewhere (e.g., Ejermo and Kander, 2006; Edquist and McKelvey, 1998), is in itself a strong sign of weak competitiveness and entrepreneurship. Bitard et al. (2008) argue that, despite the high survival rate and the increasing birth rate of both high-tech and knowledge intensive business services (KIBS) firms, Sweden still lags behind in the creation of new firms and in the contribution of these firms to the restructuring and renewal of the economy (see also the discussion in Marklund et al., 2004: 22). Moreover, the results of the Third Community Innovation Survey show that Swedish firms cooperate less often in the process of developing an innovation with other firms and organisations (e.g., universities, consultancies, etc.) than their counterparts in Europe - a pattern that seems to be consistent across all sectors of the Swedish economy, except the KIBS sector (Bitard et al., 2008:250). Lastly, Swedish firms seem to be less active in terms of financing research activities at scientific institutions (Bitard et al., 2008: 250; European Commission, 2003: Figures, 3.1.4-5). For example, firms and non-profit

organisations financed only 11 percent of the total budget of universities in 2010 (Chaminade et al. 2010: 7). The above discussion, therefore, indicates that the Swedish paradox could be an outcome of entrepreneurial, networking and knowledge transfer problems and inabilities, especially on the part of firms.

Returning to the predominance of MNEs, two related explanations have been proposed with regards to our understanding of the causes of the Swedish paradox. The first explanation refers to *lock-in problems* and the second one to *globalisation of production*. Edquist and McKelvey (1998), for instance, show in their seminal publication that, despite investing heavily in R&D activities since the 1950s, the Swedish economy is mostly specialised in non high-tech products, except the case of telecommunications which is mostly due to the activities of a few firms such as the Ericsson Group (Chaminade et al., 2010:4). Subsequent contributions (e.g., Bitard et al., 2010; Marklund et al., 2004) have not only confirmed this observation, but also extended it further. For instance, Marklund et al. (2004: Figure 9.2) show that a significant portion of business R&D activities in Sweden are conducted by MNEs in the telecommunications, automotive, pharmaceuticals, engineering and machinery industries; most of which have a foreign ownership structure. Bitard et al. (2008) point out that “*the dominance of MNEs has contributed to the Swedish paradox by diminishing commercialization of research results and maintaining a disproportionately high allocation of R&D resources to low- and medium-technology sectors with little potential for growth*” (p.262). In addition, Marklund et al. (2004) cite empirical evidence showing that Swedish firms display “*...a rather low rate of value-adding innovation... in terms of genuinely new products*” (p.21), as well as that the Swedish industry is considerably more competitive in adopting existing product innovations than in creating new ones. For Marklund et al. (2004) the latter indicates a competitive economy in the sense of being capable of adapting to new technological changes through imitation and process innovation. For others (e.g., Chaminade et al., 2010; Bitard et al., 2008; Edquist and McKelvey, 1998), however, it is a symptom of lock-in problems, that is, of heavy concentration on low and medium-tech sectors of the contemporary economic landscape.

Edquist and McKelvey (1998) argue that the high specialisation of Sweden in low and medium-tech sectors can not only be attributed to micro (firm-specific) factors, but also to macro (political and institutional) factors. Following David Teece's (e.g., 1988) early contribution on core capabilities, Edquist and McKelvey (1998) argue that, on the one hand, it is reasonable that Swedish MNEs invest heavily on low and medium-tech products, since they possess the necessarily capabilities to produce competitive products on their respective markets. On the other hand, however, it is quite questionable that sizeable and resourceful profit-seeking firms do not consider investments in high-tech products as an opportunity to diversify their product range, thus also to enhance their competitiveness. Edquist and McKelvey (1998) argue that such behaviour has not only to do with firm-specific factors (e.g., strategies and



decisions), but also with macro factors such as economic policies. In particular, they argue that one of the most important policy tools for boosting the exports and competitiveness of the Swedish economy has for a long time been based on devaluing the national currency, the Swedish Krona. This, and in conjunction with several economic policies that gave little incentives to firms in terms of developing and exploiting new product innovations, have made it - especially during the 1980s and 1990s – “...more profitable to export the same old products, produced in the same old way” (p.142) than developing new products and production techniques. Therefore, Edquist and McKelvey (1998) conclude that certain macro-economic factors and policies in the 1980s and 1990s have reinforced further the significance of MNEs in the economy (see also the discussion in Marklund et al., 2004: 54-57; Henrekson and Jakobsson, 2001).

Since the innovation potential of Sweden is heavily dependent upon the activities of Swedish MNEs, this opens up the possibility that the Swedish paradox can also be caused by the production activities of such firms. Edquist and McKelvey (1998) are among the first to propose that the paradox is partly caused by the globalisation of production. In particular, they argue that Swedish MNEs tend to conduct most of their R&D activities in Sweden, while the end product of R&D efforts are produced elsewhere. As Marklund et al.,(2004) point out Swedish MNEs “...find Sweden considerably more attractive for R&D activities than for production...” (p. 13). In other words, Swedish MNEs “...have made Sweden a knowledge producer without domestically translating that knowledge into economic value” (Edquist and McKelvey, 1998: 140). This, as Bitard et al. (2008: 262) note, has created great concern in Sweden, since the ongoing off-shoring and outsourcing of more sophisticated forms of production activities abroad threatens the innovative capacity of not only the supplying industries, but also “...what by international standards is a quite advanced Swedish structure of subcontracting SMEs” (Marklund et al., 2004:14). In a nutshell, “...there is substantial support for the hypothesis that the Swedish paradox can be at least partly explained by globalization, in the sense that R&D carried out in Sweden increasingly bears fruit in terms of innovations in other countries” (Bitard et al., 2008, p. 262).

Another popular explanation, which complements to a large extent all the previous explanations discussed so far, is that of the inefficient innovation system<sup>3</sup>. In particular, Edquist and McKelvey (1998) are among the first to argue that the Swedish paradox can be best understood as the outcome of structural problems in the innovation system of Sweden. The underlying argument is that the Swedish system of innovation had, for several decades, provided relatively little incentives to firms in terms of investing in and developing high-tech products and services. On the contrary, as Edquist and McKelvey (1998) show, there was a significant scarcity of innovation incentives in the 1980s and 1990s which seems to have contributed to the heavy specialisation of the Swedish economy in low and medium-tech sectors, as well as to

its heavy dependence upon the innovation and production activities of a few Swedish MNEs. Bitard et al. (2008) examine at length the extent to which the Swedish paradox is an outcome of an inefficient national system of innovation. Following Edquist (2005), the analysis concentrates upon some of the key activities (or functions) of the system, especially upon the abilities of the innovation system to develop, use and diffuse innovation. Five main sets of activities were examined: knowledge inputs to innovation (e.g., R&D activities); competence building (e.g., training and education); demand-side factors (e.g., formation of new markets); provision of constituents (e.g., entrepreneurship, networking, interactive learning, and institutions); support services for innovation (e.g., incubating, financing and consulting activities); and innovation policies related to the above activities. The findings illustrate that the Swedish innovation system is strong with regard to R&D and competence building, but weak in many other activities such as new firm formation, provision of venture capital, incubation support, formation of new markets and labour market flexibilities. In other words, the Swedish innovation system is strong on some activities related to the development of innovation, and rather weak on many other activities related to the development, use and diffusion of innovation (Edquist, 2010; Bitard et al. 2010). However, as argued in Edquist (2010), such structural weaknesses that lead to inefficiencies and lock-in problems represent not only problems but also unexploited opportunities that innovation system-inspired policies should tackle.

One of the less popular explanations for the Swedish paradox is that of *theoretical perspective*. In particular, Ejermo and Kander (2006) maintain that the underlying observation of the Swedish paradox - that of high R&D investments, low and modest high-tech production, exports and growth - rests on a proportional-mechanistic rationale informed by the scale effects assumption propagated in the early endogenous growth theory models (e.g., Grossman and Helpman, 1994; Romer, 1990). Once such assumptions are replaced by a more complex theoretical understanding that acknowledges some of the mechanisms (e.g., inventions, innovation and entrepreneurship) through which R&D is transformed to economic growth, there seems to “...no sound reason to expect a strong proportional relationship between the level of R&D in a country and its growth performance ” (Ejermo and Kander, 2006:32). In other words, “[w]ith lower and more realistic expectations, no paradox will exist” (Ejermo et al., 2011: 665). However, and independently of the theoretical perspective, the Swedish paradox seems to highlight that the Swedish innovation system needs to invest a significant amount of resources in R&D in order to achieve the same levels of competitiveness and welfare that other small national innovation systems in Europe (e.g., Denmark, the Netherlands, Norway) achieve with far fewer resources devoted to R&D (see, for example, Figure 7.2 in Bitard et al. 2008). In this sense, the Swedish paradox constitutes not only an unexploited opportunity, as some innovation system scholars argue (e.g., Edquist,

2010), but also an interesting contrastive regularity that deserves our research attention.

#### **4. An Explanatory Typology**

How have the innovation paradoxes under review been theorised and explained? Based on the above review, an answer to this question could be given in different ways. However, it seems that the various explanations identified throughout the present review form in an inductive fashion a typology of four main explanatory categories; from which several explanations (e.g., hypotheses) can be drawn (for more details, see Figure 1). These four explanatory categories are as follows.

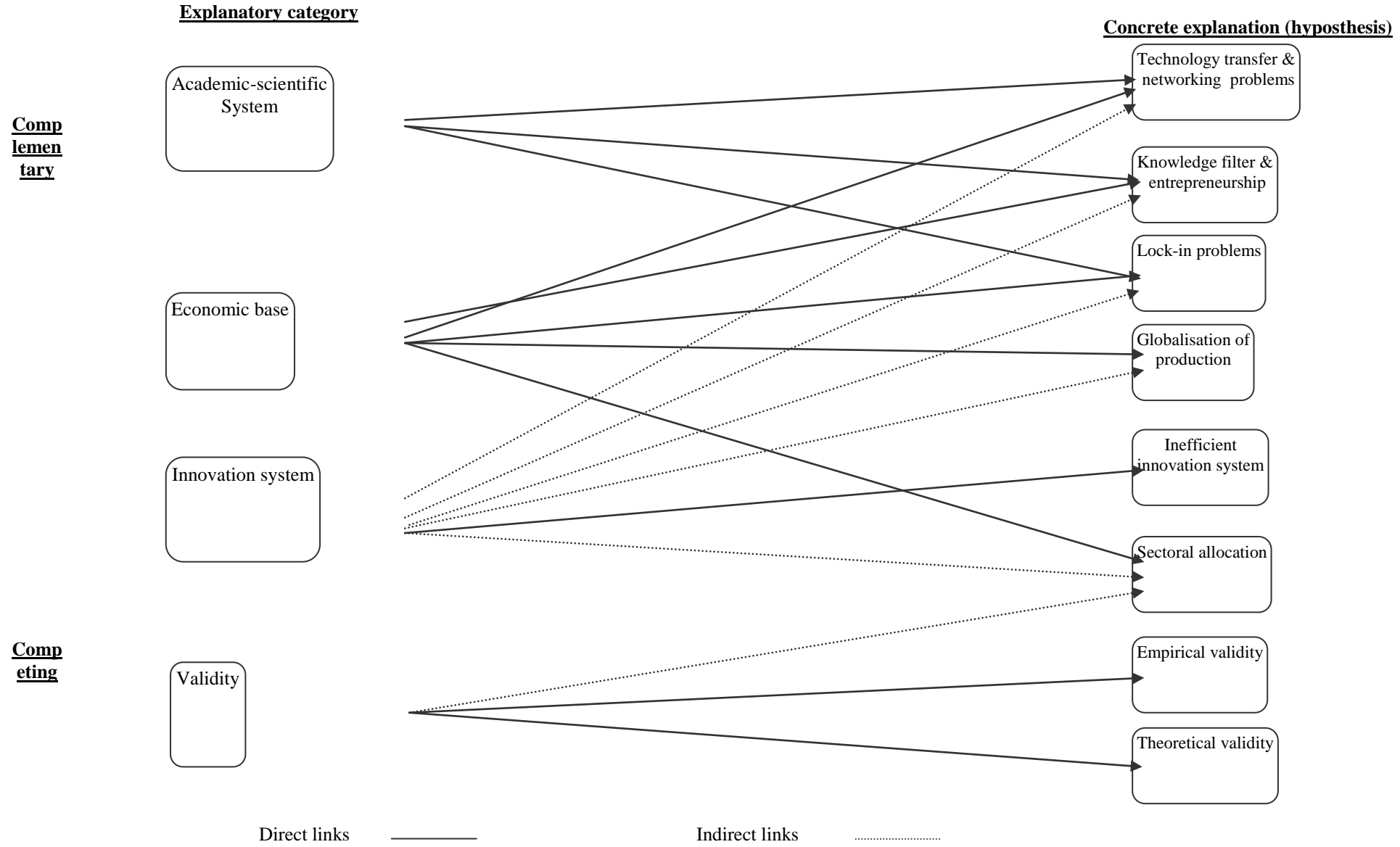
- *Academia-science base explanatory category.* This is one of the most popular explanatory categories in both literatures under consideration. The underlying argument is that an innovation paradox is mainly, or partly, caused by problems and inabilities (e.g., technology transfer problems, entrepreneurship problems, institutional rigidities) in the academic and scientific system. Therefore, explanations belonging to this category seek for answers to an innovation paradox in the government-funded sectors of the economy (e.g., academia and science). However, empirical research in both paradoxes under review has raised significant doubts on the extent to which explanations drawn from this category offer genuine knowledge on the underlying causes of an innovation paradox. In fact, several empirical studies show that the presumed entrepreneurial inabilities of the Swedish academic system are largely fallacious. This, in turn, raises two important questions: 'why such explanation were proposed at the first instance?', as well as 'why policy-makers have taken the validity of such explanations for granted?'. It would be interesting to speculate at length on both these questions. For the purposes of this paper, however, it will suffice to say that the early research on innovation paradoxes (i.e., late 1990s and early 2000s) seems to have reinforced the belief that the European academic-scientific system is not quite efficient in commercialising scientific research and knowledge. It must also be emphasised that the policy discourse on innovation paradoxes has been somewhat slow in incorporating the results of innovation studies that disprove dominant beliefs.
- *Economic base explanatory category.* Since the academic-scientific system has nothing, or at best little to do, with the occurrence of an innovation paradox, empirical research in both paradoxes under review has gradually sought for explanations in the domains of firms and industries. While early research on the European paradox (e.g., Tijssen and van Wijk, 1999) has highlighted the weaknesses of the European industry in terms of developing

and commercialising promising scientific discoveries, it is in the empirical literature of the Swedish paradox that a few interesting explanations have been proposed and advanced over the past decade. Key explanations include: the increasing 'nationalisation' of R&D activities versus the increasing globalisation of production; lack of certain innovation capabilities, especially in terms of investing in new high-tech products; lack of network and technology transfer activities, especially with regards to innovation co-operations; and technological lock-in problems on the part of both firms and industries. To put it simply, explanations falling into this explanatory category propose that an innovation paradox is an outcome of certain activities and inabilities of the industrial base in the economic unit under consideration. Promising it may sound, there has been scant empirical research on the European paradox from the standpoint of this explanatory category. For instance, and given sufficient data availability, it will be interesting to investigate the extent to which the EU economic base suffers from technological lock-in problems, as well as the influence of both micro and macroeconomic factors on such problems.

- *Innovation system explanatory category.* This is one of the most popular explanatory categories in the Swedish paradox literature. The underlying proposition of this explanatory category is that the Swedish innovation system suffers from some structural problems and inabilities, which have led over time to several inefficiencies, especially in terms of providing incentives to firms as well as in terms of transforming the high investments to R&D into wealth-and employment creating innovations. Compared to the rest of the explanatory categories, the innovation systems category seems to be the only one that is - at least a priori - able to combine in a flexible, holistic and interdisciplinary manner (Edquist, 2005) several of the explanations identified in the previous explanatory categories. In addition, the innovation systems explanatory category seems to offer interesting arguments relevant for both theory and policy. While the inefficient innovation system explanation has been proposed and examined in the context of the Swedish paradox since the late 1990s, no study has so far examined its explanatory power in the context of the European paradox. This, perhaps, can be attributed to the absence of a coherent innovation system in Europe (for a discussion on this, see Caracoustas and Soete, 1997). Nevertheless, it would be interesting to examine in a comprehensively comparative manner the Swedish innovation system with another 'innovation paradox-free' national innovation system in Europe (e.g., Denmark, Norway and the Netherlands are some candidates). Perhaps, such a comparative approach may lead to interesting insights, relevant for both theory and policy.

- *Validity explanatory category.* The previous three explanatory categories offered a set of *complementary* explanations for the occurrence of an innovation paradox. However, the validity explanatory category consists of a few *competing* explanations, in the sense of providing explanations which doubt the existence of an innovation paradox. In other words, explanations belonging to this category argue that an innovation paradox does not exist in the real world. As shown throughout this review, such explanations take the form of either/both *empirical validity* or/and *theoretical validity* explanations. The first set of explanations proposes that an innovation paradox is mostly due to methodological problems and inaccuracies, both of which have to do with measuring innovation inputs and outputs properly. The second set of explanations argues that an innovation paradox is a matter of theoretical perspective, not an outcome of real economic structures and forces. Broadly speaking, one of the key merits of the validity category lies in its ability to draw our attention - prior to the initiation of a detailed empirical study - on the possibility that an innovation paradox may rest on both/either shaky empirical and/or theoretical grounds. However, one of the key demerits of this explanation is that it provides little knowledge and guidance on how to deal with a genuine innovation paradox.

**Figure 1 - A Typology of Explanations**



## 5. Concluding Remarks and Suggestions for Future Research

This paper has provided an extensive review on the empirical literatures on both the European paradox and the Swedish paradox. An important finding concerns the observation that empirical research in the paradoxes under review fall, in one way or another, into a four-fold typology of explanations; from which a number of competing and complementary explanations can be drawn. Another observation pertains to the multi-determined and socially-constructed nature of innovation paradoxes, meaning that the occurrence of an innovation paradox can be determined by multiple forces and factors. However, much of the empirical research reviewed in this paper seems to have underestimated this essential fact. This is, in turn, leaves abundant room for theoretical reflection with regards to examining an innovation paradox from a more holistic theoretical approach that combines explanations from more than one explanatory category. In this respect, the innovation systems category seems to have an advantage, since, and as argued extensively elsewhere (e.g., Edquist, 2005; Lundvall et al., 2003), it constitutes one of the most holistic theoretical approaches currently available in innovation studies.

Another observation pertains to the very essence of an innovation paradox, i.e., the observation of 'high-inputs-low outputs'. As every regularity in the human social world, an innovation paradox is an observation limited to a specific spatio-temporal context, meaning also that is subject of change due to purposeful human behaviour including innovation policies. Therefore, once an innovation paradox has been identified, empirical research must proceed as fast as possible, if it is to make a valuable contribution to our knowledge about the causal factors that may have brought about the contrast in observation. For instance, empirical research can begin by examining the both theoretical and empirical validity issues, followed by a fully-fledged empirical inquiry on the underlying causes of the paradox in question. With regards to the spatio-temporal nature of innovation paradoxes, it appears that the reviewed research has largely neglected the geographical character of innovation activities. This seems to be a crucial omission, given that innovation activities are highly localised and unequally dispersed across the geographical landscape (e.g., Crescenzi and Rodríguez- Pose, 2012; Asheim and Gertler, 2005). This, therefore, opens up the possibility of identifying and investigating at length innovation paradoxes at the regional level (e.g., Frangkandreas, 2013; Oughton et al., 2003).

Another observation relates to an evident lack with regards to discussing on the theoretical perspectives that have been informing both the theoretical and political discourses on innovation paradoxes. Based on this review, it seems that most of the discourse on innovation paradoxes rests on a latent *proportional-linear rationale*, which is, in turn, informed by the mainstream economic paradigm (e.g., endogenous

innovation models) in general, and the linear model of innovation in particular (see also the discussion in Edquist, 2014). This is quite surprising, given that such a rationale has extensively been criticised during the past two decades or so by both evolutionary economists (see, for example, Castellacci, 2007; 2006) and innovation system scholars (e.g., Lundvall et al., 2003) for not only its extremely limited ability to conceptualise the complex and dynamic nature of innovative activities, but also for providing a rather oversimplified and static perspective on the complex mechanisms through which innovation contributes to economic progress. This, however, does not necessarily mean that a mainstream-informed and identified innovation paradox is of little relevance to evolutionary-institutional economic research as some scholars argue. After all, the explanatory power of a theoretical perspective is best illustrated in causal explanatory research. Speaking of theoretical perspectives, it would also be interesting to conceptualise and analyse innovation paradoxes from a (Post-)Keynesian perspective, in particular emphasising the significance of demand sided factors (e.g., Audretsch and Link, 2012; Edler and Georghiou, 2007)<sup>4</sup>. This, in turn, may cast light not only to several so far unaddressed demand-related causal factors of innovation paradoxes, but it may also illustrate the inherent limitations in innovation policies, especially of those which aim to tackle an innovation paradox by addressing only the supply side factors of it.

Lastly, another observation pertains to the quality of data collection techniques and analysis that have been employed and used in innovation paradoxes research. In general, the extant research on innovation paradoxes has so far been exclusively utilising quantitative methods. For instance, none of the reviewed studies has recorded the views of the key innovation agents (e.g., business associations, policy-makers, labour unions, entrepreneurs etc.) with regards to the underlying causes of both European paradox and Swedish paradox. This seems to be a crucial omission, given that innovation activities are social activities based on the actions and interpretations (e.g., meaning) of innovation actors. In this sense, quantitative methods are inherently limited when it comes to recording meaning, as well as when it comes to examining the influence of contextual factors. Therefore, future research may also consider employing in a triangulating fashion both quantitative and qualitative methods such as combining interviews, documentary analysis, network analysis and statistical analysis. For instance, network analysis can be used alongside statistical analysis, interviews and documents for assessing the explanatory power of a proposed explanation (e.g., network, technology transfer problems, globalisation of production, etc.). Methodologically speaking, therefore, a more pluralistic approach to investigating innovation paradoxes may also help us sharpen our appreciation of the nature and causes of innovation paradoxes.



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## 7. Notes

1. To anticipate a possible critique, research in innovation paradoxes (especially in the Solow paradox) has been the subject of a few stock-taking exercises (e.g. Macdonald et al., 2000). However, none of these attempts has been published in innovation-related journals, as well as none of these contributions reviews the empirical literature from the standpoint of innovation theory. This, however, does not mean that the findings of such reviews have no relevance to both innovation theory and research.
2. However, Dosi et al. draw no comparison with Japan. This, perhaps, may be attributed to data availability issues. It will be interesting to see whether Japan outperforms Europe in this respect, or otherwise.
3. An innovation system can be understood as consisting of “...*economic, social, political, organizations, institutional and other factors that influence the development, diffusion and use of innovations*” (Edquist, 2005: 182).
4. The author is indebted to Professor Jesper Jespersen for bringing this point.

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