Generality of purpose: Linking creativity and technology

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1 Basic question

Twenty years ago, the term 'general purpose technology' was coined by the economists Timothy Bresnahan and Manuel Trajtenberg. Due to their impact on economy-wide innovation processes, the economic impact of general purpose technologies is tremendous:

> "Whole eras of technical progress and economic growth appear to be driven by a few key technologies, which we call general purpose technologies (GTPs). (...) GPTs are characterized by pervasiveness (they are used as inputs by many downstream sectors), inherent potential for technical improvements, and innovational complementarities, meaning that the productivity of R&D in downstream sectors increases as a consequence of innovation in the GPT. Thus, as GPT's improve they spread throughout the economy, bringing about generalized productivity gains." (Bresnahan and Trajtenberg (1992, abstract))

Recently, the European Union stated:

> "Furthermore, firms in the creative industries are increasingly being regarded not merely as users of new technologies that trigger demand for innovative solutions but also as a source of innovative ideas and services (...)" (European Union (2010, 163))

Although the impact of creativity on job creation and growth only recently appeared on the agenda of both scientific analyses and political discussions, its pervasive character is obvious. It is hence self-evident to analyze possible analogies between general purpose technologies and creativity but also to highlight where analogies do not work. We close this short research note by listing some research questions to be addressed in the future.

2 Generality of purpose: technology

As history shows, various fundamental inventions laid the basis for a multitude of innovations, leading to sustained productivity gains, aggregate economic growth and technological development. Kondratieff and Stolper (1935) argued that economic development based on these 'drastic' innovations takes the form of long waves since a single drastic innovation is followed by multitudes of smaller ('incremental') innovations. Prominent examples for drastic innovations are the steam engine during the Industrial Revolution, the information and communication technology (ICT) in the second half of the 20th century or most recently nanotechnologies as a future key technology. Bresnahan and Trajtenberg

(1995) refer to such technologies as general purpose technologies (GPT). This term describes technologies that have *a wide variety of uses*, are inherent of a large *technological dynamism* and *spawn innovations*. The last two features together account for *innovational complementarities*. As potential 'engines of growth' the economic implications of GPTs have been derived by extensive research during the last two decades.

The innovation processes induced by GPTs are as follows: A newly available or improved GPT triggers (incremental) innovations in an (increasing number) of applying downstream sectors. Since this augments the demand for the GPT, firms in the upstream sector have a bigger incentive to innovate. As a consequence, the price of the GPT decreases whereas at the same time the quality increases. The improved GPT enhances productivity in the downstream sector thereby inducing higher innovation activity there. Since upstream sector and downstream sectors are linked, the described dual inducement mechanism of innovation repeatedly takes place as a circular process. Due to the associated feedback mechanisms, innovation processes are complementary along the value creation chain. Finally, as the effects become significant at an aggregate level, the emergence of the GPT affects overall growth. While substantially important in the long run, a GPT's impact might not be significant for actual growth: at first a sufficiently large amount of complementary assets in the application sectors has to be developed. Since in the meantime resources are employed for the insecure R&D process, even a productivity slowdown may be observed in the short run as a new GPT emerges (Helpman and Trajtenberg 1998, Jovanovic and Rousseau 2005).

The pervasive character together with the inherent vertical and horizontal interaction of agents within complex value creation chains incorporate two fundamental externalities underlying the innovation processes: one with respect to the *vertical* relationships between the GPT and the application sectors which is induced by the appropriability problem of innovative returns; the second externality refers to the *horizontal* linkages across the application sectors due to free rider behavior. Altogether, there is too little innovative activity that on top of that arrives too late (Bresnahan and Trajtenberg 1995). Consequently, governmental interventions may be justified from a theoretical point of view, constituting the need for a differentiated set of policies. The organization of coordination, for instance, might be one: Joint expansions of downstream actors would increase the incentive to improve the technological level of the GPT (lower price, higher quality). Eventually, profitability all along the value creation chain increases for all involved actors as the GPT diffuses throughout the economy.

3 Generality of purpose: creativity

More recently, aside from technological innovations and based on the nowadays popular theses of Florida (2002), the economic impact of *creativity* on job creation and wealth generation has become a basic issue within both scientific analyses and political discussions. Creativity is indeed an important ingredient to innovations: According to the reasoning of Schumpeter (1912), innovations are always a result of new combinations of already existing knowledge, skills, ideas, processes and materials. The overall competence needed to enable these new combinations is known as creativity. Sternberg and Lubart (1999, 3) define creativity as 'the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints)'. Following this reasoning, creativity – no matter if it refers to technology or not – generates economic value by the hybridization of existing knowledge and thus is relevant in almost every field of personal and professional life (see also Gassman and Zeschky (2008)).

The unifying feature of the underlying *creative class* is that their actors' capabilities are based on various skills and talents that are neither per se restricted to one single field or technology nor to non-technical (e.g. cultural) contexts. Creative people have a potential for wealth and job creation through the generation and exploitation of intellectual property. The corresponding 'creative class' hence includes aside from artists or bohemians also scientists, engineers, lawyers or economists.[1]

Recent studies summarize various attributes of firms and actors of the creative class (see Georgieff et al. (2008)): most of them are small and medium-sized enterprises, there are many start-up firms and self-employed people. Due to their small size, the actors provide only parts of complex value creation chains. They are members in various networks and inter-sectoral cooperations. Their knowledge and technological endowment is mostly based on media as well as on information technologies. The majority of work is realized in flexibly arranged teams and is based on individual projects. Hence, local conditions such as labor markets or the economic, political and institutional framework are essential.

Moreover, creativity crosses borders of conventional classification systems and induces interdisciplinarity: "[...] when new work is added to older work, the addition often cuts ruthlessly across categories of work, no matter how one may analyze the categories" (Ja-

[1]Following Cunningham (2001), the concept of creative industries is indeed broader than the existing concepts of cultural industries that embrace 'arts', 'media', or 'culture' and their focus on the potential for job creation, wealth, and business value. The European Union (2010, 165) concludes in this context: "Dealing with creative industries is therefore not exactly the same as dealing with cultural industries. Cultural industries are considered by some as an 'adjunct' of the creative sector and vice versa." Thus, "[. . .] the broader perspective by the European Commission Green Paper (European Commission, 2010) includes both creative and cultural industries, therefore reconciling both economic and cultural objectives."

cobs (1969, 62)). Coherently, Amabile (1996), referring to the development of creativity, hypothesizes creative competence as a confluence of creativity-relevant skills across different fields, field-relevant knowledge and skills, and motivation. The pervasive character of creativity is thus obvious. But in contrast to GPTs, creativity is not necessarily linked to a certain technology but the concept is much broader. We expect that as in the case of GPTs its main contribution to overall welfare generation arises from the impact of creativity on innovation.

4 Linking Creativity and Technology

Bresnahan and Trajtenberg (1995) state that most GPTs are rather to be seen as 'enabling technologies' that open up new opportunities instead of offering complete, final solutions. The same applies to creativity. So far, the argumentation suggests to search for analogies and differences between GPT and creativity in particular in the context of their respective impact on innovation processes. It sees to be promising to start with GPTs since there already exist various analyses that focus on the economic implications of GPTs and derive policy implications. In doing so one has to be clear about the extent to which drawing analogies is really helpful as well as to investigate possible limits. Starting point of the discussion are the aforementioned key characteristics of GPTs and their application, if possible, to creativity (compare Table 1 for an overview):

defining element	GPT	creativity
1. pervasiveness	generality of purpose	talent, know-how, skills
2. innovation spawning/ technological dynamsism	enabling technology	fundamental importance of recombination for innovations
3. innovational complementarities	dual inducement mechanism along the value creation chain	possible complementarity to (technological) knowledge and high degrees of cooperation

Table 1: Origins of the analogy between GPT and creativity

- *pervasiveness*: Generality of purpose provides the potential for pervasive use of a certain technology across a wide range of industries. Such technological characteristics are, e.g., rotary motion (steam engine), binary logics (ICT) or the manipulation of atoms at the nanoscale (nanotechnology). The pervasive character of creativity consists of the competence to create something new out of existing knowledge/ideas in various contexts and thus to become effective at almost any point of the value creation chain.[2] The Department of Culture, Media, and Sport (2000) who was among the first to address the economic impact of creativity highlights the pervasive character of creativity and its overall importance: ‘Creativity will make the difference - to businesses seeking a competitive edge, to societies looking for new ways to tackle issues and improve the quality of life.’

- *innovation spawning:* As a GPT diffuses it penetrates more and more value creation chains. Analogously, within today’s knowledge societies, creative work and innovative concepts become increasingly important at different stages of value creation. Less apparent, but nonetheless of major importance, (scientific) creativity crucially determines innovations in high technology sectors thereby pointing out the interdependencies of creativity and technology.[3] Independent of the concrete context, this also spurs innovation in downstream firms. Altogether, individualized solutions that are inherently creative (in contrast to standardized processes) are increasingly in demand.

- *circular innovation processes/innovational complementarities:* In contrast to GPTs, creativity is not necessarily linked to a certain technology field and complementarities are less obvious. Due to the high degrees of cooperation within creative industries and due to the associated feedback mechanisms, the underlying innovation processes are nevertheless frequently also interdependent. This is mainly the consequence of the aforementioned characteristics of actors within the creative class.

The argumentation so far has identified several analogies between creativity and general purpose technologies. However, it is not possible to adopt the concept from the technical to the non-technical perspective one to one. While creativity is an indispensable prerequisite for both technological and non-technological innovations, the reverse implication does not hold. This becomes especially obvious in cultural contexts. Besides, it is not reasonable to expect a temporary overall productivity slowdown as was discussed in the context of GPT.

A first and careful summary may be drawn according: The impact of creativity on innovation within scientific and non-scientific contexts potentially may be disentangled in the following sense. The more radical an innovation is, the more scientific creativity is

[2] Exceptions where creativity is less important for value generation are standardized work flows. The underlying employment possibilities are increasingly substituted by automated processes.

[3] Compare for the generation of nanotechnological innovations for example Heinze et al. (2009) or Cohendet and Pawlak (2009).

needed. Creativity and most probably the associated spillovers exhibit large technological dynamism (European Commission 2010). For most value creation chains, non-technical creativity (in contrast to knowledge as an asset) becomes the more important the more downstream (and hence the closer to the final product market and commercialization process) a sector is.

However, the relationship basically also works the other way around namely from technology to creativity: Science and technology more and more play a role in contemporary art, such as molecular sciences influencing fine arts and music. This also provides a possible locus of spillovers. But the interaction in these contexts are far less obvious. On top, they are even less in the focus of scientific analysis.

5 Research questions

As argued so far, despite some limitations it is nevertheless reasonable to compare creativity and GPTs in order to assess their respective roles as key drivers within complex innovation processes. The approach at hand might also serve as a starting point for economic policies that are based on theoretical considerations. This argument becomes especially appealing if seen in the light of a recent study that has been conducted for the European Commission (see KEA European Affairs (2009, 151)). The overall tenor of the study is that within the European Union there is a bias to support financially R&D, technology and technological innovations at the expense of those innovations that are based on multi-disciplinarity, creativity, and arts. We argue that due to the pervasive character of creativity this line of support should be analyzed more carefully. In doing so we especially suggest to follow some main research questions:

1. *theoretical underpinning:* Building a consistent theoretical approach that in analogy to the models of Bresnahan and Trajtenberg (1995) or Helpman and Trajtenberg (1998) are based on sound micro-foundations. This helps understand complex interdependencies of various actors as a consequence of optimizing behavior. Besides, the theory also allows for the derivation of differentiated policy instruments.

2. *indicators:* The pervasive character makes allocation of creative activity to already existing categories and classification systems difficult. Although some progress has been made it is still not possible to derive the impact of creativity on job creation, growth and welfare out of official statistics. In this context a lot may be learnt from general purpose technologies and the way the feature of pervasiveness is dealt with there, e.g. via constructing concordance matrices or introducing new classes in existing classification systems. Some obvious difficulties arise from the aforementioned

characteristics of the members of the creative class, e.g. the small firm size and the corresponding fact that there is no duty to report innovation activities.

3. *embedding within innovation systems:* Despite the characteristic of pervasiveness, creativity as well as general purpose technologies always become effective within existing economic, social, cultural and scientific contexts. This implies that the final impact is crucially context or region specific.

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