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The International Innovation Policy Network 6CP
40 years of innovation policy research - lessons from the past and future outlook

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1. Introduction

Inevitably this background paper to the anniversary conference of 6CP has become something of a personal account. Both authors worked most of their life in a field which was in the beginning mostly known as research and/or technology policy and only later became called innovation policy. Other concepts and policy approaches were seen as closely linked, like industrial policy, economic growth policy, systemic innovation policy, environmental policy, transitions policy, intellectual property policies, trade policies, market regulation and stimulation, etc. etc. And each of these concepts had its period of popularity. With the change of concepts the focus of the policies also changed (or the other way around) and so changed the focus of our research activities. This paper does not try to cover all aspects of the development of innovation policy and innovation policy research. There exist a wide range of textbooks that try to do this more or less successfully, and specifically with regard to research there is the excellent overview by Ben Martin (2012). The overview tables at the end of this paper are still somewhat explorative" and are only meant for support. Instead, based on our own experiences and our own evaluation of the state of the art, we try to identify a number of issues which we think should be on the agenda for research and policy debate and try to outline a (rather optimistic) view of future directions.

Innovation is a widely used catchword today but actually the concept of innovation itself is not so new. It was already used before 1900, albeit sparsely (Godin 2008). Joseph Schumpeter laid the ground for a widely accepted economic theory of industrial innovation roughly between 1920 and 1940. And very rapidly his thinking translated into a *de facto* form of innovation policy with the establishment of public technological research centres, grouped nowadays under the acronym of RTOs, Research and Technology Organisations. Many RTOs were established just before or shortly after the Second World War with the explicit mission to provide research and development, technology and innovation services to firms and other clients, in order to support their competitiveness and sustainability and thus contributing to economic growth. Often these organisations were established at the same time and as part of the same policy package with other more fundamental university research (funding) initiatives (e.g. TNO and NWO in the Netherlands in 1930, the Fraunhofer Gesellschaft and the Max Planck Society in Germany almost 20 years later). The history of VTT began on 16 January 1942, when the president signed the Act on the Technical Research Centre of Finland. Its mission was “to engage in technical research for the benefit of science and society”.

The authors worked in TNO and VTT respectively from the early days of the growing interest in the economic and societal implications of technology development. Since the mid-70s TNO had its strategy research group, which became an Institute in 1981 (STB or Centre for Technology and Policy Studies). Chris Freeman started the Science Policy Research Unit (SPRU) at the University of Sussex in 1966 with a research programme which built on the works of Schumpeter. Other universities followed in later years. Fraunhofer

ISI is called Institute for Systems analysis and Innovation research. At the time of its establishment in 1972 the first part of the name was “Systemtechnik” but “Innovation” was already there. At the Technical Research Centre of Finland (VTT), VTT Group for Technology Studies was established first as a fixed-term project in 1992, and was granted permanent status in 1995. But even though the concept of innovation was known and used (TNO had its Innovation Advisory project), innovation was still seen as something which largely belonged to the private domain of industry and business. In public policy the key words at the time were science policy, research policy, technology policy and (let us not forget) industrial policy.

The research agendas of most science and technology study groups had many similarities. Their research services consisted of research about the dynamics of technological change and innovation, industrial renewal, assessment of socio-economic and ecological impacts of technological change, performance evaluation and impact assessment of science, technology and innovation (STI) policies (with related STI indicators), and foresight of technological and socio-economic change. The reasons and rationales for government support and intervention in STI is a recurring theme throughout all these research topics. The underlying theoretical of these research topics is largely based on evolutionary (or neo-Schumpeterian) economic thinking, although recognizing the importance of many other economic schools of thought, such as the new growth theory, as well as interdisciplinary research in general.

Vannevar Bush put science policy on the map in the US with his 1945 report titled “Science, the endless frontier”. After the Second World War the US needed jobs for the returning soldiers. Vannevar Bush – as a sort of New Economy advocate avant la lettre - took the premise that what we learn and discover through science is a major and endless source of new economic activities and of wealth. For a few decades “science policy” became the dominant mode of thinking in our field: invest in science to invent, which allows industry to innovate and new markets to grow. It was the period of “big science”, which was inspired by how the atomic bomb was developed during the War and the continuation of the model in the development of nuclear power and space exploration after the war. It is reflected in the name of SPRU – Science Policy Research Unit, but actually under Chris Freeman SPRU became famous not only for its work in the field of science policy but because of its work on technological change.

Fairly soon thinking about “science policy” became complemented with thinking about “technology policy”. There were several reasons: a) in which fields do we invest to develop new “big technologies” (like nuclear and space), b) which are the new growing fields of technology (in view of signs of decline in traditional industries) and c) during the 1970s resistance against the environmental and human risks of new large technology projects grew, which was manifested e.g. in the establishment of Office of Technology Assessment in the United States in 1972.

In this period 6CP was established in 1975. A number of people from around the globe felt a need to create opportunities for mutual learning between international peers in policymaking, research and industry. 40 years ago the debate about innovation policy focused on (in the words of Thierry Gaudin):

1. How to create new business opportunities through large scale mission driven technological projects (“grand projects”)?
2. How to best support SMEs as important drivers of innovation, jobs and economic growth?
3. How to develop the “technological culture” which makes sure that new developments are well-embedded in society?

Over the 40 years of 6CP existence these three points have lost nothing of their importance and urgency. But at the same time, since 1970s, after four eventful decades and wide-ranging worldwide changes since the establishment of 6CP, a lot has been learned about how to tackle these questions. The first 6CP workshop with “innovation policy” in its title was held in 1976: *The current international economic climate and policies for technical innovation* (November 1977).

A brief organisational history of 6CP

6CP started as a network of people wanting to collect evidence about the need and effectiveness of innovation policies and to learn from each other. It started with representatives of 6 countries (UK, Netherlands, Germany, France, Sweden and Canada), which explains the name. They met once or twice a year in a workshop or conference which was decided in a steering committee and prepared by one of the members. Funding was taken care of by de members’ home organisations. The prime goal was always to bring together a good mixture of researchers, policy makers and industrialists. As innovation policy started to receive more interest in government circles, the involvement of ministries grew and in several cases they became the prime participants and funders. Around 1995 around 13 countries were officially involved as members and many other participated. But in the following years the mutual learning networking of governments was increasingly taken over by in particular the OECD through its STI-division and the European Union with the establishment of ERA-nets and mechanisms like OMC. Around 2005 it became clear that government priorities had shifted to these new intergovernmental networks and activities. And in particular for university based researchers several academic networks with a focus on the presentation of academic research had been established. As a consequence the 6CP-steering committee decided on a return to the people network which 6CP was at the start, aiming at an open exchange of views and at being at the front of developments in the field.

2. The concept of innovation and innovation policy: towards growing complexity

The widely accepted methodology for collecting statistics on R&D and Innovation is set forth in the Frascati Manual, prepared and published by the OECD, and Oslo Manual published jointly by the OECD and Eurostat. The first Frascati Manual (officially known as The Proposed Standard Practice for Surveys of Research and Experimental Development) dates from 1963. The updates of these manuals reflect how the scope of the innovation concept and the underlying innovation activities and related policy-making has broadened continuously over the years. It gradually started to cover service, social, organisational, behavioural and intangible innovation. Gradually the concept of invention as a single act has been extended to learning and discovery as more systemic characteristics of innovation (Lundvall (Ed.) 1992, Elg 2014, Foray et al, 2009). And the meaning of the concepts of learning and discovery has broadened from scientific discovery to entrepreneurial discovery, from scholarly learning to community based learning, or from scientific learning to policy learning. These and many other conceptual changes in the field reflect what is probably the most striking change of the field over the past 40 years: the spread of “innovation-thinking” and the growth of the number of institutions and people in all sectors of government and society with “innovation” in their task description. This has now almost come to a point where we could ask if the concept has not lost its purposeful meaning. And in the end talking about innovation in terms of learning and discovery has a tautological feel about it.

But at the same time we have to acknowledge that the spread of innovation thinking is a sign of the profound change from an industrial economy and society to a knowledge driven economy and society. And when we go deeper into the fields of innovation research and innovation policy we find that over the years a very diverse wealth of topics has been addressed, most – if not all – related to this change from industrial society to knowledge society. Each of the topics had its own logic. In this paper we will address some of these and try to find out why they became important in the research and policy agenda. From the small series of "cases" we then attempt to derive a clearer picture of the future of the field.

The thinking about *the public-private relationship* or about how much public intervention in innovation is good, allowed or needed has gone through changes over the 40 years. 6CP addressed the issue implicitly and explicitly in several conferences or workshops (latest in 2009, Elg and Leijten 2010). At the very least we can see a broad movement from large scale public intervention ("grand projects"), to a very generic hands-off approach with a focus on "market failure" thinking (neoliberalism), and more recently again returning to stronger interventionist thinking (Mazzucato 2013, Block 2011, Atkinson 2012, etc.) in which the role of longer term government investments in new technologies again being stressed. The changes in thinking also affected government policy itself, and very often also revealed internal contradictions within governments (e.g. the "classical" examples of ministries of economic affairs vs. the science ministries or innovation oriented ministries vs. finance ministries. In recent years the changes have translated into a growing focus on demand driven approaches, on public-private collaboration and on "grand challenges". These changes are certainly of importance, but the actual prioritisation and shaping of such policies proves to be challenging.

> *An interesting example of a mixture of "grand projet" – grand challenges approach is the European Human Brain Project, which was launched in 2013, planned to take 10 years, bringing together more than 100 research institutes and more than 7000 person year effort. The project has a clear technological focus on mapping, measuring and simulating the brain and aims at developing a full scale model. Soon after its launch however the project goals were contested by a sizable group on cognitive scientists which felt that their approach(es) have no place in the project. If the contestation trickles down in the project it may lose its distinct focus.*

During most of the history of 6CP "*sustainability*" has been an issue, starting from an environmental policy perspective which aimed at creating a cleaner/healthier living environment but gradually encompassing much "larger" goals in concepts such as "sustainable economies" or "sustainable/resilient cities". Of more recent date is a focus on "transitions", based on the recognition that some changes need radical transformation of the techno-economic base (e.g. from coal, oil and gas based to renewable energy systems). The relationship with innovation policy has been (see 6CP conference 2002 and workshop 2011) and still is weak, maybe because sustainability is often approached from a "planning" perspective (Giddens 2009) and innovation from a competitive "opportunities" perspective. The alternative would be the development of a challenge and demand-driven approach to innovation, but this is going slow and not very successful, mainly because politicians prefer the relative certainty of environmental planning above a more open innovation oriented approach (Montalvo and Leijten, 2015). Moreover, solutions for long-term complex challenges require multidimensional "horizontal" actions of various policies which has proved to be difficult in practice. We have seen how so-called demand driving subsidies have led to disruption of what seemed to be thriving innovation systems and clusters (wind, solar), or how transition oriented policies do not take into account the speed of diversifying technological developments (e.g. renewable energy), etc. This shows again that we will need a much better understanding of both theory and practices of complex challenge and demand driven approaches.

3. The need for a new focus on technological change?

The nature and dynamics of technological change also has been a regular topic in 6CP agenda. Technological systems have become increasingly complex and, as ubiquitous ICT or nano, they are characterised by interdisciplinary, generic and pervasive aspects enabling shifts from scale to scope economies. Enterprises cannot mobilize all resources and competencies needed in innovation and today these abilities depend increasingly on external sources, networks and collaboration. When a bulk of new knowledge originates from external sources the traditional corporate lab model will vanish. Innovation is becoming "systemic" and it is increasingly difficult to see where an innovation originates. Innovations are combining technology with intangible conceptual service and business innovations, and are increasingly emerging in less science driven trial and error processes and joint experimentations. Fights about IP are growing due to blurring and converging borderlines of science, innovation and valorisation and acquisition. But at the same time IP is opened up to and shared with collaborators. A growing role of "big data" will aggravate this trend. What is for example the future outlook when for instance Google and/or IBM (big data) are massively entering the healthcare field? These factors have a profound impact on the innovation institutions, and have played a role in the wider competitive battles and other power struggles between the institutions.

But somehow the nature of technological change seems to have become a neglected issue in innovation (policy) research. Partly this is of course the result of the neoliberalist focus on generic support measures which almost equal innovation policy and growth policy. And partly it is the result of the fact that academia still has major problems with interdisciplinarity, which makes that academic innovation (policy) research has become a special corner in management studies, economics, sociology, etc. There is a clear need for a new focus on understanding the nature of technological change and its implications. Against this background the value of strategies with regard to entrepreneurship, venture and other forms of risk-bearing capital, IPR, tax-measures, etc. needs to be evaluated.

The key challenges with regard the dynamics of technological change in the future are: (a) how innovation strategies and behaviour of firms will change in view of the changing nature of technology (e.g. governance of global value chains, open innovation and collaboration modes, crowd sourcing of knowledge etc.), (b) how universities and research organisations change their strategies from disciplinary oriented science and technology developers to wider innovation drivers (Mode II/III, internationalisation, etc.) and (c) how public policy and funding moves "closer to the market", to identification of challenges and demand, to priority setting, and to cross-border policy strategies.

All in all there seems to be a growing need again for "old fashioned" technology and innovation analysis and for technology assessment (with its focus on how technology interacts with society). Not that it is absent, because in environmental technologies, in ICTs and in nanomedicine for example, a lot of such research work is done. But we have the impression that the focus of such work is more on feeding the political debate than on understanding the dynamics of the technology and innovation in interaction with its economic and societal context.

Nonetheless, we see also examples of arising needs towards “old fashioned” concrete technology and innovation studies related to increasing needs to display industrial and socio-economic impacts of STI policies. The background is in the fact that increasingly fierce public economy pressures to carry out concrete assessment and identification of impacts of STI policies on the levels of industries, economy and society. Accordingly recently few studies have been made on impacts of policies on a level of individual innovations (Hyytinen et al. 2012; Loikkanen et al. 2013). Such impact studies provide however the existence of systematically collected and analysed data, such as SFINNO in Finland and SWENNO in Sweden, which are so far rare.

4. Globalisation, regionalisation and unequal development potential

Globalization and the dynamics of knowledge and innovation have become key drivers of industries and of knowledge-economies (e.g. Squicciarini and Loikkanen (Eds.) 2008). The concept of globalisation refers to several trends like global markets, global sourcing, global competition, global science, and global innovation networks and platforms. Globalisation is mainly driven by the search for competitive advantages by companies and builds largely on applications of ICT which both require and incentivise global standards which in turn incentivise global innovation platforms. Multinational enterprises play a major role in R&D globalisation and at the institutional level a major driver is to be found in trade and trade agreements. Global IPRs are challenged by pressures of democratizing and opening science and innovation worldwide. The globalisation comes with drivers for globalisation of research and innovation, which also has an impact on the role and behaviour of the innovation institutions.

Globalisation puts innovation policy in the middle of international competition policies. It is a continuously and dynamically changing phenomenon and conclusions and policy suggestions drawn today are not necessary valid anymore tomorrow (e.g. what happened to the BRICS?). The position a company, a research organisation, a country, region or city wants to take in global innovation systems has become a compulsory part of strategic behaviour. And even when one decides on a local strategy, the global dynamics may interfere at any moment. A particular challenge is the development of global research and innovation funding mechanisms, because traditional national public funding procedures seem to have difficulties to cope with the dynamics of globalisation and thus also with societal challenges which have a global reach (see Montalvo and Leijten 2015).

Globalisation of STI has been dealt with extensively in several former 6CP events including exploration of options for innovation policy. The events show that innovation policy research has come to a good understanding of the phenomenon and new issues, such as the relationship between innovation policies and trade policies are recognised well in time. But closely linked to globalisation there are a number of issues relating to inequalities which very well might become key in the near future and probably do not receive sufficient attention. Three types of inequalities are and have been important for the development of innovation systems:

(a) The “success breeds success” and other agglomeration phenomena are giving rise to a “peaks and valleys” distribution around the world (Florida 2005). A further look at innovation indicators shows considerable differences between countries in Europe, between states in the US and even between regions in one country or state. Scientific knowledge, a (global) public good, is necessary for socio-economic development, which leads to a debate on how less developed countries and regions fit into the (global) innovation economy, and how their position can be improved through specific STI policies. Given the strength of the agglomeration effects there seems to be no easy way out towards more equal distribution of innovation opportunities and wealth. Last years' 6CP workshop points in certain directions but the dynamics of innovation in relation to (global) economic geography will be an important topic for research and policy debate in the near future. Among interesting questions is whether region-states will gradually replace nation-states which would make global competition among innovation systems all the more fierce in the future (Ohmae 2005).

(b) Another important inequality topic – more closely related to the advance of a technological culture - has been how (groups of) people are included/excluded in technological change (e.g. digital divide, job-loss because of automation, disappearance of the middle class, etc.). On the one hand people in the more advanced economies seem to have adapted to a faster changing world of jobs, work-location and skills requirements. On the other hand a widening income/wealth gap together with increasingly faster disappearance of middle income jobs cannot be seen disconnected from the shape of innovation and technological progress. It may very well lead to feelings of "being left out" and growing resistance to new technologies. The question what innovation actors can or should do in view of such inequalities deserves a higher place on the research and policy agenda.

(c) A more specific issue of inequalities between small and large companies has so far resulted in an almost dogmatic approach toward SME-support in innovation policy and regularly also in research. The supposed differences in abilities to innovate between small and large companies and their expected impacts gave rise to a broadly supported and extensive system of special support actions for SMEs. In the more recent years this line of thinking has been extended to putting very high innovation value on entrepreneurship, start-up firms and risk-capital. At the other end some large companies seem to focus now on spending their revenues on increasing their market share by a mergers-acquisitions strategy and only a limited group of leading ICT-companies (Apple, Google, etc.) seems to invest in a longer term innovation strategy. Recently ITIF has started an interesting discussion about the justification of special support actions for SMEs (Atkinson 2014). It shows there are good reasons for putting this issue in the centre of a debate. The perspective should on the one hand be analytical (What is the influence of size on conditions to innovate?), but on the other hand it should also be discussed how innovative the different players should be, and how equal roles they play in collaboration in innovation eco-systems.

5. Future outlook – snapshots on innovation paradigm change

What might be the future outlook of innovation activities, of innovation policy and of innovation policy research in the era of austerity and thereafter if/when the rebound comes? What are the lessons from the development of the field over the past decades for future scenarios? What is realistically and feasible, and what is potentially disruptive? As industrial and public investments in R&D have been cut during times of recession (not everywhere in the same pace, but in the end the trend seems to be inevitable) we see for instance a growing interest in so-called frugal technology and innovation. Companies want to break the increasing complexity and costs spiral by moving in the direction of frugal technology solutions and the related lower cost paths. Another disruption could be the result of a re-fragmentation of the world which is a real option for geo-political reasons. At the same time as the number of international trade agreements (including the basic rules for competitive behaviour and level playing fields) is growing, we also see a growing search for power positions, which may foster nationalist and protectionist strategies. These may also become a more feasible option in terms of knowledge, technology and economy, as the conditions and skills to innovate have become more evenly spread between countries around the world. The talking about a relatively closed Chinese or European Internet points in this direction.

Innovation policy and innovation policy research does not have a strong track-record when it comes to analysing, understanding and dealing with "power". This can be partly explained by the "opportunity seeking" and competitive thinking in which innovation thinking originates. It leads mainly to calls for "level playing fields" and searching catching up strategies for countries or regions that so far have not managed to be part of the "global knowledge economy". But this relative neglect of power structures in combination with an earlier mentioned neglect of the changing nature of new technologies has meant that innovation research, probably more than innovation policy which usually has to serve economic growth, also has neglected most of the profound changes new technologies have brought to power structures and their societal impacts.

In the following we present selected foreseeable future trends of technological change and innovation policy, generally taking an optimistic position with regard to the new technologies as well as to the potential implications for politics.

Future trends of new social technologies

We would not be surprised if in a few years from now, when thinking about it in terms of Kondratieff-cycles and a Schumpeterian approach, the current crisis may be seen as an important phase in the development of an ICT-dominated technology paradigm, or better, of a control and management systems ICT-dominated era.[1] Many of the developments which have contributed to the current crisis only have been possible because of the rapid growth in the use of ICTs as technologies of control and management, for example in enterprise resource planning, international finance, computerized trading, marketing, customer relations management, logistics, etc.[2] The patterns of growth and development of companies, other types of organisations and the networks between them have very much depended on this group of ICT applications, which are mostly built to maximize exploitation of resources (including human resources).

But it appears as if somehow limits have been reached with these centralised ICT-based control systems and the number of people advocating other types of coordination mechanisms seem to be rapidly growing[3]. On the one hand the control systems have given companies the means to react much faster to changes in the market (as in the present crisis), but on the other hand they seem to reduce real strategic flexibility and agility because they only "control" a limited set of parameters. Of course these technologies have benefited citizens and consumers, and national economies, but in general they better supported

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[1] Writing at the very start of the dot-com bust Freeman and Louçã tend to see developments in financial and stock markets as part of the wider institutional and social changes associated with the ICT-revolution.

[2] Nearly everything that moves can be tagged with an RFID chip. So it is possible to tag the fish in fish farms with RFID chips to be able to follow them on their way to the consumer. Googling on the topic reveals a whole world of this kind of initiatives. This is of course the ultimate control-thinking which is suitable and possible even necessary for interactions between fully anonymous producers, intermediaries and consumers in a mass-marketplace. We should expect that systems which build on trust and communities thinking will have very different characteristics.

[3] The growing movement around transitions thinking which is clearly reflecting this trend has its origins for one part in innovation (policy) thinking and for another part in environmental activism (see Grin, Rotmans and Schot 2010).

specific company strategies in extending the scale (and scope) of operations while at the same time reducing costs. Electronic banking is a good example because it makes it possible to deal with very large numbers of differentiated clients on the one hand and transferring part of the costs of the service to the clients themselves (a computer and internet connection and the time to handle the transactions). The complex systemic impacts of such developments were mostly applauded as service innovations in innovation thinking. Critical analysis has been an exception.

Like the main techno-economic systems which characterised previous waves, ICT, conceived broadly and including mobile communication, digital media, etc., will not disappear. On the contrary, these technologies will continue to grow and spread throughout the economy and daily life, just as trains and electricity have only grown in importance. But somehow ICT, digitalisation and internet of things, manage to transform itself much faster than the earlier major techno-economic systems. It can for example be argued that the characteristics and functionality of train-systems only changed with the rather recent introduction of high-speed trains and possibly about one hundred years earlier with the introduction of urban metro networks. Electricity will change profoundly with the imminent introduction of smart grids and related changes in the scale of networks and power generation.

For some time now new technologies and functionalities are developing in ICT and surprisingly enough these new functionalities have many resemblances with the complex interactions between many actors which are characteristic for the “invisible hand” of market coordination: WEB 2.0, social networking, peer-to-peer computing, grid-computing, etc. all somehow build on the free interaction of individuals and their (mobile) ICT appliances. The versatility of the systems but also the fragmentation is growing rapidly with the growth of the “app-economy”[4]. The new technologies which aim for an exchange of “values” on equal terms and symmetric information seem to be preferred and have some similarities to a traditional (non-anonymous) market place. This makes it clearly distinct from the atomistic anonymous market which as a vision or “ideal” dominated the past 25 years. The new systems resemble the ancient marketplace where everybody knows each other and where trust is likely to be one of the major “rules of the game”. But compared to “traditional” market coordination these new mechanisms are much more complex and do not limit themselves to the localised coordination of supply, demand and prices of goods and services. They also allow coordination of much more complex behaviour and interaction, including the building and rapid spread of shared visions, preferences, and “cultures” or group decision making.

Could it be that a non-anonymous “market” for ideas and preferences is going to be built on top of the market for goods and services? In other words, are our individual and collective ideas and preferences becoming more important as steering mechanism of society, partly helped by the increasingly rich and easily accessible technological environments? Can the reductionist mechanisms of policy making and politics be complemented with bottom up processes of defining needs, wants and preferences, which not only serve as guidance for the production of goods and services, but also give direction to innovations and thus to shaping the future?

Although ICTs have to be seen as the major driving force, developments in other areas of technology like materials and life sciences show similar trends which support the development of new modes of coordination and governance. Most new technologies have the character of highly versatile tools (ICT,

[4] The global application economy is estimated to grow 27 percent annually and account for 33 percent of the combined app services in 2016 when the share of handset markets is estimated to be 67 percent (Pappas 2013).

genomics, nanotech, etc.) and there is a tendency of these tools to become very cheap. As a consequence the tools become available for everybody. Personal computers and mobile phones are good examples of how this inspires ordinary users to become inventors. "Personal Genomics" is moving in the same direction, with – as a first step – (nutri-) genetic screening tests or personal genetic tests (to establish susceptibility for certain diseases) being on offer at the Web for anything between €100 and €1000. Although interest seems to be rapidly growing in it still highly uncertain how people will actually use such tests. But such an experimental or discovery phase is normal in very early stage applications of generic technologies. The number of low-cost readily available "personal manufacturing" machines (3D-printing) is rapidly growing. And FABLABs or Makerspaces, where everybody can at low cost experiment with the new technology, are nowadays to be found in most cities. There is a growing number of easily accessible platform initiatives which integrate design, production, and marketing (e.g. Local Motors, i.materialise). In the field of energy we can see an explosion of the number of promising research and innovation directions with a focus on small scale user controlled appliances and related services.

Somehow this (optimistic) information age discourse is showing increasing overlaps with the transition discourse which was mentioned earlier. Both discourses foresee a fairly radical change in structures and governance of the major techno-economic systems which shape our working and living environments. Precisely because of the close connection which these discourses see between the development of techno-economic systems and the ways in which these systems are governed, they deserve a lot of attention in innovation policy research. But not in their usual disconnected ways (the goal driven environmentalist transition discourse and the new technological opportunities driven information age discourse). Both approaches may learn a lot from each other. And innovation policy will benefit from integration of the two in a single new rationale.

It is developments like this that generate an environment in which we need to build ideas and visions of what we want the technology tools to do. This environment is very different from the classical mass-production dominated market place where we voice our preferences by buying (or not) and in doing so help to coordinate supply and demand. And it also seems to lead away from the tendency toward more and more specifically target advertising and product/service offers.

After description of the positive ICT-technologies driven scenario above we must however ask ourselves: a positive scenario for whom? These promising opportunities do not reach all citizens of the globe in equal ways, as digital divides still do exist. For example at the end of 2012 around 450 million people worldwide still live out of reach of a mobile phone signal, high mobile-cellular penetration rates do not imply that everyone owns or is using a mobile phone, and household access to a telephone is still not the norm, in particular not in many less development countries (ITU 2014).

Future trends of innovation policies

As already said, there is a move towards a very comprehensive approach of innovation, including economic growth, quality of life, new political and policy processes (governance), etc. With the extending scope it encompasses an increasing number of rather intangible processes. But in comparison with technological product or process innovations, the more intangible processes pose enormous challenges to get empirical performance evidence and indicators. The more comprehensive the approach to innovation gets, the more stakeholders will need to be involved in innovation processes. Some analysts like Eric von Hippel and

Josephine Green see a move toward "democratization of innovation".[5] It means that increasingly we all become innovators and have to decide individually and collectively about the kinds of innovation that we need and want. And this needs to be done in structures which are capable of handling considerable complexities. Traditional IPR thinking is even seen as an important barrier toward "democratization of innovation", as Boldring and Levine (2008) conclude their analysis, intellectual monopoly is not necessary for innovation and as a practical matter is damaging to growth, prosperity and liberty (Boldrin and Levine 2010).

More than ever the needs, wants and preferences of users, consumers, co-creation by users and producers as well as public policies will become the key drivers of innovation (e.g. Prahalad and Ramaswamy 2004). At the micro-level it are individuals or communities identifying and voicing certain needs and sometimes also develop solutions. At macro-level the identification of collective societal and in several cases global challenges is increasingly seen as important driver for innovation and as a means to create new economic growth. Entrepreneurship policies need to be supportive for new kinds of entrepreneurs. They will increasingly come from the ranks of users (and employees) and consumers that use the cheap and easy to handle tools to satisfy their own needs and wants in the context of the broader platforms. One only has to look at the ways in which the (mobile) Internet manages to inspire users and consumers to understand the power of this model. Also we will see a stronger tendency of entrepreneurship becoming a public-private kind of association (as is already visible in Corporate Social Responsibility missions).

As this is the shape of future innovations which are likely to drive "the next wave" we can see a large number of policy questions coming. Some of these questions are there already, but will be intensified. How will this kind of "socialized innovations" affect economic growth and how do we measure their impact? How to balance widely accepted standards for platforms with bottom-up entrepreneurial, creativity and individual experiences driven innovations (e.g. Pine and Gilmore, 1999, Jacobs, 2014)? Who owns innovations and who reaps the benefits in this fully networked environment? How can research and innovation become more transparent and accessible for the wider public? What are the implications for our research and innovation institutions? What are individuals allowed to do with the new tools and in how far may public controls be needed? Etc. On most of these questions thinking has only just started (e.g. Leadbeater, 2008, Green, 2007). But in the meantime practices are also growing. Crowd sourcing has spread around the world, not only for product development and getting production started, but increasingly also for R&D.

In order to really "innovate out of the crisis" and igniting a new growth wave based on tackling major societal challenges, we need to find answers to the questions raised above. Taking a rather optimistic view of the future, this note points in certain directions. And even if things turn out to follow less optimistic paths, the nature of technological changes forces innovation policy to change.

[5] We prefer to use "socialization of innovation".

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Appendix: Summary table of Post-War science, technology and innovation policy

The Table 1 attempts to capture the main characteristics of the phases of science, technology and innovation policies since the World War II until today. Since the late 1980s and in the 1990s, the awareness of the actual and potential threats of technological change to social and ecological problems has increased in industrialized countries. Social problems, especially unemployment, and ecological problems (e.g. the depletion of ozone layer) have become severe. Accordingly, in STP, increasing attention was devoted to social and ecological issues, for example, to social embedding of technologies, integration social and environmental issues into R&D, social innovations, and interactive learning.

A remarkable element the modern STP is the global perspective or “the techno-globalism” as OECD characterizes (1991). Another important issue is a recognized necessity to integrate an ecological dimension into STP-making, which is a challenge to the rules of the game under which national and multinational companies operate. Strategic priority setting, the identification of core technologies and the assessment of techno–economic strengths of industries play key roles in the short and long term STP-planning.

What is the impact of STP in the promotion of innovation activities? According to Henry Ergas the policies in Western economies are of a facilitating nature rather than based in strong explanation. The critical variables lie in how industry responds to the results and signals of efforts to upgrade national technological capabilities. This, in turn, depends to a large extent on the environment in which industry operates. According to Freeman and Soete (1999, 295) the national environment can have a considerable impact by stimulating and facilitating but also by hindering or even preventing the innovative activities of firms.

The evolution of the characteristics of past, current and foreseeable developments in public research, innovation and technology policies have been collected in the following table, which consists of six sub-tables detailing different areas. These characteristics are further elaborated i.a. from Caracostas and Muldur (1997, 20), Freeman and Soete (1999, 388), Schienstock (1994, 21) and (Rothwell and Dodgson 1992, 227).

In science and technology expenditures, the big expansion occurred from 1940s to 1950s, and after that followed a continued but slower expansion from 1960s to 1970s, and then from 1980s to 1990s a levelling off and sometimes reduction of science and technology expenditures. With respect to this development, Sub-Table 1 describes strategic economic issues with respect to STP, such as the developments in the economic environment, changing role of state, objectives and main determining factors of STP, types of policy, geographical scale of policy, ministerial leadership, coordination and integration in policy-making, and emphases in the economic rationale for STP. Sub-Table 2 illustrates trends and developments in STP implementation, e.g. forms of policy, trends and methods in public R&D funding, methods in R&D project and program assessment, principal selection criteria, policy instruments, nature of policy measures and instruments. Sub-Table 3 illustrates trends and developments in evaluation and assessment of R&D and STP, such as scope of evaluation, timing of evaluation, evaluation and assessment procedures. Sub-Table 4 describes techno-economic trends and developments in businesses and industries, for example, the emphasis of STP on industries, dominant industrial areas, organization and management trends in firms and production, and in R&D and innovation respectively. Sub-Table 5 illustrates trends and developments in R&D, technological change and innovation, e.g. such as characteristics and stages of R&D, model of research and R&D process, nature and determination of priorities, main funded technology areas, nature of innovations and of R&D work. Finally, Sub-table 6 describes primary inspiration sources of STP in general and main sources and contributions in the economic analysis of STP in particular.

	- - 1950 - - 1970 - - 1975 - -	- - 1975 - - 1985 - - 95 - -	- - 1995 - - 2000 - -	- - 2000 onwards
Sub-Table 1. DEVELOPMENTS IN STRATEGIC ISSUES OF TECHNOLOGY POLICY				
Developments of economic environment	"Golden age" of economic growth Importance of national policy & regulation & protection, state owned companies Gradual growing influence of Japanese techno-economic development	Oil crises, recession, "Euro sclerosis". De-industrialization - to re-industrialization Gradual shift towards economic liberalization, economic integration (EU) Gradually increasing techno-economic importance of NICs, their recession 1997-	Growing global importance of ICT, technology based companies, Nasdaq Escalation of global financial markets, Collapse of IT stock exchange (bubble), Rise of emerging Asian economies, BRICs	Globalization (economies, ICT, media) Global climate change, Economic recession since 2008
Role of the state	Central actor in technological research and innovation process	Decreasing role of the state, removal of regulative structures	Facilitator and coordinators of the self-regulation of innovation	
Objectives of technology policy	Political, economic Space research (US-USSR competition)	Economic (stability), increasingly social, organizational, institutional & environmental	Economic, social, cultural, organizational, institutional, & environmental Towards ethical and social responsibility	
Main determining & guiding factors of technology policy	Defense, economic growth, productivity	Industrial competitiveness, energy efficiency, change of industrial structure, toward diversification, information society	Techno-economic competitiveness, employment & quality of life, social & environmental compatibility	
Policy type	Direct control	Towards context control	Context control, favorable environment & conditions providing policy, strengthen firms´ absorptive capacity to apply new knowledge	
Geographical scale	Mainly national	Growing internationalization Growing role of regions within nations	Techno-economic globalization of industrialized & industrializing economies; Growing role of cross-border regions (EU)	

Ministerial leadership & coordination & integration	Defense, education & research Science advisory councils Part of economic & science policy, *implicit* R&D policy. Little coordination	Education & research & industrial Science & technology advisory councils Gradually to independent policy field Increasing coordination	*Explicit* technology policy Inter-ministerial co-operation and co-ordination	
Economic justification of public R&D funding	R&D effects to welfare, market failure (inadequate basic research from society´s perspective), S & T infrastructure (energy, transportation, communication..) Areas of critical mass (space, aeronautical)	Market failure + government failure. Areas of critical mass and long time horizon. R&D schemes for SMEs. Environmental damages (negative externalities)	Market + government + system failures Innovation network externalities Environmental damages (climatic change)	
	- - 1950 - - 1970 - - 1975 - -	**- - 1975 - - 1985 - - 95 - -**	**- - 1995 - - 2000 - -**	**- - 2000 onwards**
<u>Sub-Table 2</u>. DEVELOPMENTS IN TECHNOLOGY POLICY IMPLEMENTATION				
Policy forms	Universities & other government research labs & bodies, public & private CROs	Incentive programs, promotion of cooperation	Task forces, interdisciplinary programs & projects	
Trends and method of public R&D funding	Big expansion of R&D expenditures Administrative	Levelling off of public R&D funding Techno-administrative	Diversified development in public R&D funding Techno-financial	
Methods of R&D project & program assessment	Scientific assessment by peers	Scientific assessment by peers & users, S&T foresights	Integrated assessment of financial aspects & socio-economic & environmental impact, and S&T foresights, technology road-mapping	
Principal selection criteria	Scientific excellence	Scientific excellence & contribution to competitiveness & welfare	Contribution to needs of society, industry & environment, increasing private venture capital	

Policy instruments	R&D subsidies, regulation, patent system	R&D subsidies, provision of infrastructure, R&D programs, taxation, public procurement, technology transfer schemes, incubating activities, pilot & prototypes, liaison offices, public and private venture capital	R&D subsidies, incubating activities, promotion of innovation networks, rewards, prizes	
Nature of measures & instruments	Basic R&D centered on spill-over	Pre-competitive R&D and indirect support for innovation	Targeted R&D (incl. socio-economic aspects) up to commercialization of innovations	
<u>Sub-Table 3</u>. DEVELOPMENTS IN EVALUATION & ASSESSMENT OF R&D AND TECHNOLOGY POLICY				
Scope of evaluation	Evaluation of scientific impact (perhaps) of research projects	Extension of evaluation to scientific & technical impact of projects, programs Increasing valuation of institutes and policy programs	On-going evaluation of socio-economic and environmental impacts of projects, programs, institutes, policy programs, towards ethical (perhaps)	
Timing of evaluation	Ex-post evaluation	Ex-post & gradual ex-ante and intermediate ("on-line") evaluation	Integrated ex-ante & foresight & ex-post technology assessment & R&D evaluation	
Procedure	Occasional	Gradually towards professional & systemic practices	Professional & systemic practices	
	- - 1950 - - 1970 - - 1975 - -	**- - 1975 - - 1985 - - 95 - -**	**- - 1995 - - 2000 - -**	**- - 2000 onwards**
<u>Sub-Table 4</u>. TECHNO-ECONOMIC DEVELOPMENTS OF COMPANIES & INDUSTRIES				
Emphasis of technology policy in industries	Large industrial firms, industrial agglomerations, state owned companies, national "flagships"	Large industrial firms & increasing interest in innovative SMEs Growing importance of cooperation & industrial clusters	Large industrial firms & service companies & SMEs, new technology based firms (NTBFs) Company networks & business value chains Industrial clusters	
Dominant industrial areas	Energy (systems), chemical,	Automation, information and	ICT, bio & gene, environmental,	

	metal, manufacturing, building	communication technologies (ICT)	alternative energy, welfare technology, nano technology	
Firm & production organization & management	Hierarchial, top-down, command & control “Fordist” production systems	Lean organization, JOT, FMS, reversed & concurrent engineering, Toyotism	Lean interactive and participatory work organization, motivation	
R&D and innovation management & organization	Separate R&D units, weak linkage between R&D and other firms activities	Out-sourcing of R&D, acquisition of external R&D services, integration of R&D with company activities & concurrent engineering, road mapping, user-producer linkages	Interactive and integrated R&D, techno-economic competitiveness, strengthen absorptive capacity to apply new knowledge	
	- - 1950 - - 1970 - - 1975	**- - 1975 - - 1985 - - 95 - -**	**- - 1995 - - 2000 - - 2005 ……**	**- - 2000 onwards**
Sub-Table 5. DEVELOPMENTS OF R&D, TECHNOLOGICAL CHANGE, INNOVATION				
Characteristics & stages of R&D	Basic & fundamental Science push Little bearing on markets	Growing interest in applied R&D and technology dissemination & transfer Closer to the market, demand pull	Integration of basic - applied R&D & dissemination of R&D results Demand & market oriented	
Model of research and R&D process	Linear from R&D investment to rates of return of R&D	From linear towards complex, growing emphasis on creation & dissemination	Complex, interactive and systemic innovation process	
Nature & determination of priorities	Politico-scientific, top-down	Techno-industrial, shift from top-down to bottom-up	Socio-political, integrated top down & bottom-up	
Main funded technology areas	Large scale nuclear, military, aeronautical, physics, chemistry	Energy, civil aircraft, automation, electronics, computers, ICT economic & social aspects & studies	ICT, materials, bio & gene technologies Hybrid & generic science & technologies, combined to address specific economic, social and environmental problems; health technology, nano technology; technological fusion	Sustainable energy technologies: fusion (ITER), renewables, wind, solar, bio-energy, renaissance of nuclear power
Nature of innovations	Radical technological innovations	Incremental technological innovations & gradual increase of	Technological and social innovations	

		social & organizational innovations	Diffusion of innovations	
Nature of R&D work	Individual, researchers and labs separate to each other	Towards professional R&D work, cooperation of researchers and labs	Professional & integrated R&D and production systems	

	- - 1950 - - 1970 - - 1975 - -	- - 1975 - - 1985 - - 95 - -	- - 1995 - - 2000 - -	- - 2000 onwards
Sub-Table 6. INSPIRATION SOURCES OF TECHNOLOGY POLICY AND ECONOMIC ANALYSIS OF TECHNOLOGY POLICY				
Intellectual inspiration	D.J. Bernal (1939), Vannevar Bush (1945), OECD 1963, OECD 1971, The Brooks Report	Japanese VLSI & 5th generation computer programs The Brundtland Report on Sustainable Development, OECD (1979, 1991, 1994, 1990), National Innovation System, social shaping of technology,	Innovation system, “Mode 2” of knowledge production, Kioto Protocol and Post-Kioto perspectives, system transition, globalization,	Emerging economies, open innovation, 9/11 terrorism, Bush
Selected contributions to the economic analysis of technology policy	Nelson (1959), Arrow (1961)	Dasgupta and Stiglitz (1981), Rothwel and Zegveld (1981), Freeman (1982), Nelson and Winter (1982), Averch (1985), Freeman (1987), Stoneman (1987), Dosi et al. (1988), Lundvall (1992), Lundvall (1992), Metcalfe (1993)	Metcalfe (1995), Freeman and Soete (1999), Gibbons et al (1994), OECD STI Review No. 22 (1997), Research Policy Vol. 29, April 2000,	Von Hippel (1999), Chesbrough (2003), Mazzucato (2014)

Table 1. Evolution of the characteristics of public research, innovation and technology policies (further elaborated i.a. from Rothwell and Dodgson (1992), Schienstock (1994), Caracostas and Muldur (1997), Freeman and Soete (1999)

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(to be completed)