Joining Complexity Science and Social Simulation for Innovation Policy

Joining Complexity Science and Social Simulation for Innovation Policy:

Agent-based Modelling using the SKIN Platform

Edited by

Petra Ahrweiler, Nigel Gilbert and Andreas Pyka

Cambridge Scholars Publishing

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INTRODUCTION

PETRA AHRWEILER, NIGEL GILBERT
AND ANDREAS PYKA

In innovation policy, investments in measures such as fostering higher education institutions or science-industry networks are expected to produce high commercial returns although they very often fail to materialise promptly. These situations show the limits of conventional steering, control and policy functions associated with innovation support.

Socio-economic systems are complex systems, and have been studied in sociology and complexity science (cf. Castellani and Hafferty 2009). Complexity features such as uncertainty, non-linearity, emergence, path-dependency, contingency, multi-level and de-centralised organisation etc. particularly apply when it comes to the development of new knowledge, its diffusion, and its commercial application in innovation. Analytical approaches trying to offer guidance and support have to acknowledge that any forecasts and predictions of policy success or failure are difficult if not impossible.

For policy planning in innovation it is a fundamental problem that there is no linear relationship between a policy measure and its desired effect. This means high implementation risks for any new policies. Real-world implementations can be quite expensive if they turn out to be failures. Not only do they have the usual production and roll-out costs similar to their successful counter-parts; if they prove to be harmful, they might even lead to some unintended, not easy-to-remedy, and very costly side-effects. Finally, the time and effort wasted on the failure might have been better used for a potentially more appropriate policy change.

Social simulation can shed light into the darkness of the future: it can help to cope with the challenges of complexity by modelling the dynamics of the social systems under investigation, and by identifying potential access points for successful intervention. With simulation models, we can ask what-if questions for ex-ante evaluation of real-world policy implementations – an option that is normally not easily available in the policy-making world. Stakeholders such as innovation policy makers can use scenario modelling as a worksite for their 'reality constructions': simulation experiments can be used to give an indication of the likely effect of a wide variety of policy measures. Empirical 'un-observables' in this policy domain, such as knowledge flows in innovation or the learning of agents, can be observed, measured and assessed.

The agent-based **S**imulating **K**nowledge Dynamics in **I**nnovation **N**etworks (SKIN) model has been designed to simulate knowledge generation and diffusion in inter-organisational research and innovation networks. Since its first prototype in 2001 (http://jasss.soc.surrey.ac.uk/4/3/8.html), it has been developed into a platform with many modules and applications and has been adopted for a number of policy modelling studies. The largest policy testing application of the SKIN model to date focuses on impact assessment and ex-ante evaluation of European funding policies in the Information and Communication Technologies (ICT) research domain. The corresponding version of the model, referred to as INFSO-SKIN, was developed for the Directorate General Information Society and Media of the European Commission (DG INFSO) in 2011. It was intended to help to understand and manage the relationship between research funding and the goals of EU innovation policy. Changing parameters within the model is analogous to applying different policy options in the real world. The model could thus be used to examine the likely real-world effects of different policy options before they are implemented. Altering elements of the model that equate with policy interventions—such as the amount of funding, the size of consortia, or encouraging specific sections of the research community—made it possible to use INFSO-SKIN as a tool for modelling and evaluating the results of the policy interactions typically occurring between policy interventions, funding strategies and agents. The SKIN model applications use empirical data and claim to be realistic simulations insofar as the aim is to derive conclusions by so-called inductive theorising. This means that the quality of the SKIN simulations derives from an interaction between the theory underlying the simulation and the empirical data used for calibration and validation.

Joining complexity science and social simulation enables the modelling of innovation policy initiatives to take into account more parameters than previously possible and to perform simulations to forecast potential impacts of proposed innovation policy measures. In contrast to conventional methods of social research, this approach is capable of dealing with the fact that research and innovation do not follow a linear path and are highly complex.

To foster this approach requires outlining the benefits to stakeholders and showcasing example projects and their findings. However, at the same time, it is necessary to explain the limitations of the methodology, which can only offer a "weak prediction" in terms of likely scenarios and trends, as opposed to exact forecasts. For innovation policy projects using the combination of complexity science and social simulation, the interaction with stakeholders is key: this type of policy modelling is an area *par excellence* for participatory co-design. Finally, validation issues are crucially important: systematic checks of simulated policies against empirically implemented policies should be realised for all projects, which would require that stakeholders allow modellers to see how policies are actually formulated, implemented, and executed with or without relation to their model.

The general objective of this book is to explore how complexity science and social simulation can be used to improve and inform policy making in research and innovation. First, the challenges of research and innovation policy are outlined. This is followed by a conceptual overview of European policy agendas in this area and by a chapter on policy practice issues. The methodological discussions of the book begin with two studies applying traditional quantitative methods in innovation research. Both are exemplary of this body of literature in two ways: they are carefully crafted methodological applications with data providing interesting findings, but they are also very clear in stating their limitations concerning missing causality, small parameter sets and feedback learning of simultaneous processes. Like many such studies they end by asking for future research addressing these limitations and highlighting the areas where they have to remain speculative. This is exactly the space where complexity science and computational modelling techniques such as social simulation step in to meet the requirements of research and innovation policy.

The editors' bridging chapter then opens the main part of the book dedicated to the conceptual claims about what and how complexity science and social simulation can contribute to policy making in research and innovation. Policy modelling means to identify areas that need intervention, to specify the desired state of the target system, to find the regulating mechanisms, policy formation and implementation, and to control and evaluate the robustness of interventions. The difficulty is that policymaking in complex social systems is not a clear-cut cause and effect process, but is characterised by contingency and uncertainty. To take into account technological, social, economic, political, cultural, ecological and other relevant parameters, policy modelling has to be enhanced and supported by new ICT-oriented research initiatives. The need for policy intelligence dealing with complexity becomes more and more obvious. The two following chapters of the book provide modelling examples concerning the effects and impacts of decision making and policy changes on the structure, composition and outputs of research and innovation networks.

After having introduced some components of the approach this way, a fully-fledged example of a case study working with it is presented: a research initiative funded by the Irish Government on innovation policy simulation for economic recovery. The project consists of empirical research on Irish research and innovation networks, and simulations of technology transfer issues and the commercialisation of research in high-potential areas for innovation and economic growth.

The book finishes with two chapters featuring areas for future research on complexity and related modelling activities. The concluding essay reflects on the maturity and utility of the approach combining complexity science and social simulation for research and innovation policy.

The chapters of the book are now introduced in more detail:

Benjamin Schrempf outlines the challenges of research and innovation policy in his chapter, “European and National Innovation Agendas”, with a conceptual overview of European policy agendas in this area. Research and innovation are regarded as essential factors for economic prosperity. The policy agendas fostering them, often referred to as ‘Strategy for (Science,) Technology and Innovation’ S(S)TI, contain measures to stimulate the generation of new ideas and knowledge, the transfer of knowledge between actors, the commercialisation of knowledge in marketable products and the protection of knowledge. The chapter provides information on five European countries based on the economic and political situations, the outlook and the main challenges for each country; the country sample includes Ireland as an introduction to the case study section of the book.

A policy practitioner perspective in addressing the challenges of research and innovation policy is presented by **Frigyes Hausz, Virág Zsár, and Bela Kardon** in Chapter 2, “Smart specialisation and universities – challenges and opportunities in the 2014-2020 programming period”. From a governmental perspective, the authors discuss the Smart Specialisation Strategies (S3) of the European Commission, which require that higher education development policy and science policy are fine-tuned to the larger context of regional development. They use a case study of Hungary (lessons learnt in science policy during the 2014-2020 Programming Period) to formulate a set of recommendations concerning higher education R&D development, discussing issues such as technology transfer between universities and the entrepreneurial sphere, obstacles to successful technology transfer, and general misperceptions about funding higher education research.

The first of the two chapters of the methodological discussion about applying traditional quantitative methods in innovation research concerns “The Interplay between environmental and quality/lean practices in supply chains”. **George Onofrei, Eamonn Ambrose, Frank Wiengarten and Brian Fynes** examine potential synergetic effects between investments in environmental and quality/lean practices within the supply chain using ordinary least square regression (OLS) analysis. The study does not confirm a linear relationship between investing in environmental practices and improved firm performance, but shows that environmental practices are important and are crucial support mechanisms for more traditional and existing practices, such as lean and quality practices, which again have an effect on firm performance. To investigate these non-linearities would require a complex systems perspective. Furthermore, from the data it is difficult to evaluate genuine causality, which “leaves room for speculation as to whether some portion of the interaction effect is based on some sort of learning effects due to implementing various programs simultaneously” (see the chapter). The concluding section can be read as a clear call for complexity science perspectives and methods.

The second example applying conventional methods to innovation research is Chapter 4 of **Peter McNamara, Cathal Ryan, Darran Jones, and Camilla Noonan** called “Appropriation Regimes and Firm Performance in Incumbent Services Firms”. The authors study the mechanisms that are most effective in protecting profit streams using a survey design, which obtained responses from 188 CEOs or senior management of Irish service firms with more than 50 employees. They reject a linear relationship, showing that focusing on legal or non-legal regimes does not result in above average firm performance. Instead, mixed appropriation regimes containing legal and non-legal mechanisms were found to be the most effective at protecting process innovations. However, the exact composition of this mixture is unknown - again due to missing causality, small parameter sets and feedback learning of simultaneous processes. The authors discuss options for future research addressing these limitations, suggesting complexity science perspectives and computational modelling techniques such as social simulation.

In chapter 5, "Innovation policy modelling with SKIN", the editors of this book, **Petra Ahrweiler, Andreas Pyka and Nigel Gilbert**, bridge to the conceptual claims about what and how complexity science and social simulation can contribute to policy making in research and innovation. Their chapter introduces the SKIN platform as an agent-based model to simulate the effects and impacts of policy making on the structure, composition and outputs of research and innovation networks. The claims are supported with descriptions of four policy-relevant contributions of the SKIN platform: (i) scenario modelling of higher education policies for business innovation networks, (ii) scenario modelling of Irish MNC[1]-directed innovation policy for Ireland's indigenous industry networks, (iii) simulating the effects of different innovation management strategies of firms in the biotechnology-based pharmaceutical industry, and (iv) scenario modelling of European funding schemes and the effect of the size and geographical diversity of project teams. Using real-world datasets and in response to questions put forward by stakeholders, SKIN can provide precise, detailed information on the effects of specific policy instruments, on how and how well research and innovation networks operate, and how to understand and manage the relationship between research funding and policy goals. Importantly, the model allows experimenters to change policy parameters in the simulations. This allows use of the system as a tool for modelling and evaluating the results of specific interactions between policies, funding strategies and agents. Using the simulation, policy makers can observe and manipulate patterns of network evolution by varying simulation parameters. Because changing parameters within the model is analogous to applying different policy options in the real

[1] MNC: Multi-National Corporation

world, the model can be used to examine the likely real-world effects of different policy options before they are implemented. The chapter ends with assessing the experience with the model and its applications so far in terms of difficulties, limitations, risks and contingencies; and with comments on managing the expectations of stakeholders, general apprehensions around the predictability of future developments, data availability issues and validation questions.

The first one of the two chapters which describe modelling the effects and impacts of decision making and policy changes on the structure, composition and outputs of research and innovation networks is the one by **Harold Paredes-Frigolett, Luiz Flávio Autran Monteiro Gomes and Javier Pereira Retamales**. Their contribution, "Extending Agent-Based Modeling via Multicriteria Decision Analysis", refers back to the conventional approaches in innovation research presented in Chapters 3 and 4, and suggests potential intersections and interfaces between agent-based models with behavioural dynamics and variable-based approaches.

Diving fully into the issues of complexity, agent-based modelling, and innovation concerning the effects and impacts of policy changes is the next chapter contributed by **Cristina Ponsiglione, Ivana Quinto, and Giuseppe Zollo**, "An agent-based simulation model of Self-Sustaining Regional Innovation Systems". They conceptualise regional innovation systems as complex learning systems, and suggest an agent-based model as a simulation tool for policy advice aimed at analysing the conditions under which regional systems develop self-sustaining innovation cycles. Some simulation experiments verify the model's internal coherence and explore the behaviour of the system (in terms of learning, innovation capability, and resilience of the system) under different parameter settings. The problems of model validation are discussed: an empirical study of the Aerospace Industry of the Campania Region in Italy is currently under way to collect data for calibrating model parameters and validating simulation results. Chapter 7 illustrates that SKIN is not the only model applicable in the area of complexity science, social simulation and innovation, but that this area is a growing research field with many possible avenues for computational modelling applications.

Nevertheless, the SKIN model is the central tool for the modelling tasks in the case study the next chapters are dedicated to the research programme "**I**nnovation **P**olicy **S**imulation for the Smart **E**conomy", the IPSE project. Funded by the Irish Government, the strategic objective of IPSE is to provide insights into the need of the Irish economy to breed an innovation ecosystem with optimally structured university-industry-government networks. IPSE uses computational modelling, informed by large new datasets coming from empirical research, to investigate the actors, designs, processes, and policies of Irish innovation networks. The project is set up to develop and test policy strategies and options for anticipating and analysing new developments to help the recovery of the economy. Simulations focus on technology transfer issues and on commercialisation of research options in areas areas with high potential for innovation and economic growth.

The IPSE section begins with two chapters analysing Irish research and innovation policy. In “Exploring a neo-institutional approach to policy research - the politics of the emergence of a field of Science, Technology & Innovation in Ireland”, **Camilla Noonan, Séamas Kelly, and Simeon Vidolov** explore the role of the OECD in shaping and directing Irish science, technology and innovation (STI) policies. Drawing on a sociological perspective on institutionalism, they argue that there have been at least two broad dimensions to the OECD’s influence on Irish policy - governance by co-ordination and governance by opinion formation.

This sets the scene for chapter 9 by **Ciara Fitzgerald and Frederic Adam** on “Ireland’s Technology Transfer Policy”. Within the Irish context, the Strategy for Science Technology and Innovation (SSTI), 2006 – 2013, represents the government’s plan for Irelands’ universities to commercialise research in a competitive and dynamic knowledge-driven economy. The overarching vision of the SSTI is to ensure that ‘Ireland by 2013 will be internationally renowned for the excellence of its research and will be to the forefront in generating and using new knowledge for economic and social progress within an innovation driven culture’. As a result of this strategy, research commercialisation and technology transfer are emerging as new missions for Irish Higher Education Institutes and Technology Transfer Offices. By reviewing the existing policy debates, the authors prepare the way for a better understanding of current policy decisions.

Next follows a chapter providing an example of the empirical work done in IPSE to calibrate the simulations. **Nola Hewitt-Dundas, Colm Burns and Gary Chapman** analyse in chapter 10 “Additionality of Incubator Support on Networks of University Spin-Out Firms”, the network configuration of university spin-out firms, in two comparative contexts: a research intensive university *with* a university incubator on campus and a research intensive university *without* an incubator (either on-campus or off-campus), one located in Ireland, the other in Northern Ireland. This research addresses concerns about the high failure rates and no-to-low growth among university spin-outs. Universities have responded to this by investing in incubators. Yet how effective are incubators in supporting these firms? This is examined by the chapter in terms of the structural networks that spin-out firms form, the role of the incubator in this and the effect of this on the spin-out process. The aim of the investigation is two-fold: (i) to determine whether there is a structural difference in the network additionality of an incubator facility on spin-out firms and (ii) to explore the effect of an incubator on the early stages of firm development, particularly in terms of opportunity identification and entrepreneurial commitment.

Michel Schilperoord provides insights into the various modelling tasks within the IPSE project with his chapter “Start-ups when and where? Using the SKIN platform for modelling the birth of new companies”. The project focus - on technology transfer, commercialisation of research, and entrepreneurial activities - defined new requirements for developing some features of the SKIN platform, especially the process of how new firms come into being. Chapter 11 introduces a method of using SKIN for reasoning about the 'when' and 'where' of new start-up companies. The immediate objective is to model entrepreneurship by describing how entrepreneurs discover and evaluate new start-up opportunities, and how they create start-ups at fertile locations after testing the viability of the start-up opportunity in partnership with stakeholders in a competitive market that features thresholds for survival and growth. The method builds on new SKIN procedures for simulating start-up processes in two stages. In the first stage, entrepreneurs make a continuous valuation of their innovation hypothesis (IH) based on distance between their IH and the IH of their closest competitor in the market. This valuation mechanism implies that entrepreneurs with new and unique business ideas will value their IHs the highest, and will be the most likely to decide to 'go for it'. In the second stage, the entrepreneur creates a prototype of a new start-up company and the viability of the start-up opportunity is tested on the market. Only start-up prototypes that are able to survive this 'proto' stage will enter the market as real start-ups that can participate fully in the market. The SKIN market module provides the necessary mechanisms for obtaining market feedback on start-up prototypes. Initial results indicate that the method allows early identification of 'high potential' start-ups, since the entrepreneurs with the highest valued IHs (first stage) also tend to create the fittest prototype start-ups (second stage).

The final two chapters of the book return to some theoretical reflections, outlining areas for future research in complexity research and related modelling activities. In chapter 12, **Elena Pugacheva** contemplates “Collective Behaviour as a New Social Agent” and discusses how complexity theory might help in future to explain current phenomena of collective behaviour in the Ukraine and the Arab world using concepts such as synergy, emergence, self-organisation, and co-evolution. The last chapter, by **Özge Dilaver**, discusses epistemological and methodological issues in “Agenvironments? Towards simulating socially constructed complexity”. The chapter discusses what agent-based modelling might offer researchers for building better representations of socially constructed complexity. While agents and environment are often considered as separate design components, there are also discussions on interactions between agents through the environment, the role of the environment in enabling the pro-activity or purposefulness of agents, and the difference between how individual agents and the external observers perceive the environment. The chapter focuses on the social construction of environments, arguing that moving beyond strict distinctions between agents and the environment (agenvironments) may facilitate representing social construction in agent-based models.

The concluding essay by **Ben Vermeulen**, called “The merits of ABMs for policy evaluation”, reflects on the maturity and utility of the approach of combining complexity science and social simulation for research and innovation policy. Apart from the appeal of ABMs as the metaphors for actual real-world systems and inductive learning about possible mechanisms driving real-world phenomena when operationally designing them, there is a plethora of merits for policy evaluation that go beyond garnering a fundamental understanding. The essay starts with a juxtaposition of ABMs and other policy support tools and provides answers to some of the questions asked by stakeholders who are more familiar with those other tools (e.g. why use rule- rather than variable-based models, why use behavioural rather than econometric modelling and why are conventional equation-based models insufficient?). The remainder of the essay provides a detailed overview of three classes of benefit provided by agent-based modelling. First, ABMs can be calibrated to the empirical data of particular cases and can rescale themselves endogenously based on simulated events. Monte Carlo methods can be used to cope with unknown distributions and missing or sparse data. The downside is that modellers have to provide operationalisations and parameter settings for components that have no or an as yet unclear real-world counterpart, sometimes leading to lengthy simulation and modelling iterations. Second, all processes, events, decisions and flows in the artificial world can be fully controlled, recorded and experimentally studied, even those that are ordinarily unobservable or uncontrollable. This permits the study in detail of the connection of micro-level flows and decisions, non-linear interactions of agents at the meso-level with macro-level indicators and phenomena, and the feedback from macro- into micro-level behaviour. Third, many government policies (and agent strategies) are *ad hoc*, based, at best, on small pilots and without clear scientific support. There may be inconclusive or even invalidating evidence that particular policies should have been applied (e.g. it is by now recognised that the popular ‘best practice’ approach often neglects particularities). ABMs allow *ex ante* evaluation of policy interventions in a controlled environment, the tracing of structural interactions, and inductive-deductive discovery of non-linear effects. The author illustrates these benefits with examples taken from (SKIN-related) ABM work.

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PART I:

CHALLENGES OF RESEARCH AND INNOVATION POLICY

CHAPTER ONE

EUROPEAN AND NATIONAL INNOVATION AGENDAS

BENJAMIN SCHREMPF

Introduction

Technology policy is seen by all advanced economies as a means to accelerate and regulate the advancement of various technologies through innovation. Behind each technology policy there is a strategy, often referred to as ‘Strategy for (Science,) Technology, and Innovation’ (S(S)TI). This term also includes science and innovation as opposed to the more traditional term technology policy or strategy. Over the years a broader perspective was taken to achieve policies that influence knowledge generation, dissemination, and commercialisation in all areas including organisational change and marketable products.

S(S)TI usually includes measures to stimulate the generation of new ideas and knowledge at universities and in companies, the transfer of knowledge between actors, the commercialisation of knowledge in marketable products, and the protection of knowledge, for example through patents. The measures can be categorised in various ways, for instance into direct measures such as the funding of research through grants, and indirect measures such as tax credits for R&D expenditures.

Since technology and innovation are regarded as essential factors for economic prosperity, these strategies have received increased attention over the last few years in the wake of the financial and economic crisis. Many nations consider STI strategies as the basis for sustainable and long-term growth and necessary to overcome these crises. Furthermore, these strategies are also useful to help avoiding harmful developments in technology.

A sound S(S)TI first requires an in-depth analysis of the system which is to be influenced by the respective policy measures. It is crucial to understand the system, its actors, and their relations, as well as the boundaries of the system prior to introducing technology policy of any kind.

Therefore, all strategies are put into the perspective of the current economic situation, followed by a brief description of the main actors involved. The strategies for each country are then described in more detail, including the main goals and measures. Each of these strategy analyses closes with an outlook for each country and its major challenges. The following contains an overview of the S(S)TIs of the EU and five EU member states. The overview begins with the European Union and its overarching strategy, and then describes the strategies of in total five countries: Germany, the United Kingdom, Spain, Italy; Ireland's S(S)TI is introduced as the fifth country case, helping to put the following chapters about the IPSE (Innovation Policy Simulation for the Smart Economy) into context.

European Union

Economic and political situation

Even though the EU as a whole was hit severely by the financial and economic crisis unfolding in 2008 and 2009, differences within the Union are quite considerable. The Mediterranean countries, the UK, and Ireland suffered the most, which is reflected in their STI strategies. Most northern and central European countries were able to leave the economic turmoil behind relatively quickly. Unemployment ranges from 5% in Germany and Austria to about 25% in both Spain and Greece (Fig. 1.1), which is also reflected in GDP growth (Fig. 1.2).

Fig. 1.1: EU unemployment rates 2014. Source: Eurostat

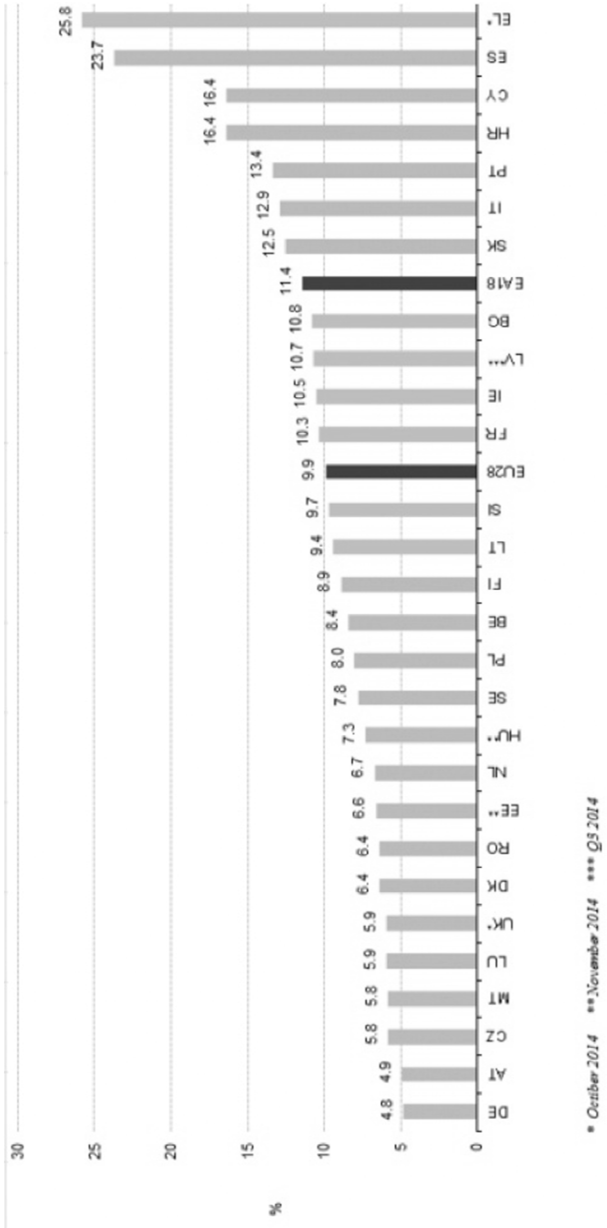
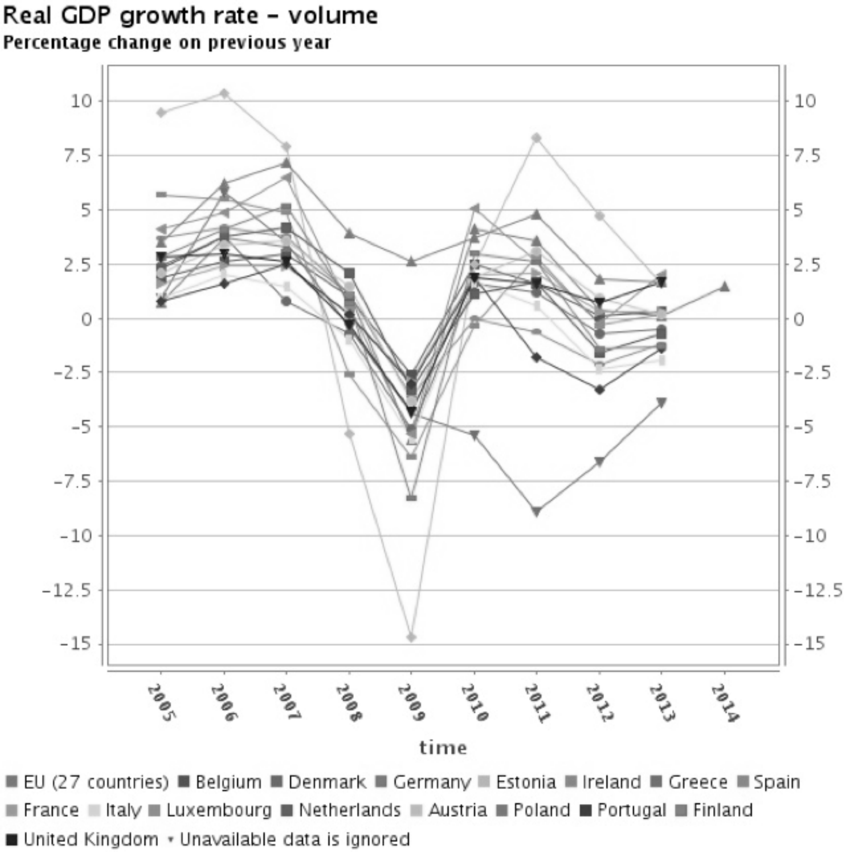


Fig. 1.2: GDP annual growth rate, selected countries. Source: Eurostat



GEO/TIME	2002	2003	2004	2005	2006	2007	2008	2009	2010
European Union (27 countries)	1,88	1,87	1,83	1,82	1,85	1,85	1,92	2,02	2,01
Euro area (17 countries)	1,88	1,87	1,85	1,84	1,87	1,88	1,96	2,06	2,06
Belgium	1,94	1,87	1,86	1,83	1,86	1,89	1,97	2,03	2,01
Denmark	2,51	2,58	2,48	2,46	2,48	2,58	2,85	3,16	3,07
Germany (until 1990 former territory of the FRG)	2,5	2,54	2,5	2,51	2,54	2,53	2,69	2,82	2,8
Ireland	1,1	1,16	1,23	1,25	1,25	1,29	1,46	1,76	1,71
Spain	0,99	1,05	1,06	1,12	1,2	1,27	1,35	1,39	1,39
France	2,24	2,18	2,16	2,11	2,11	2,08	2,12	2,27	2,24
Italy	1,12	1,1	1,09	1,09	1,13	1,17	1,21	1,26	1,26
Netherlands	1,88	1,92	1,93	1,9	1,88	1,81	1,77	1,82	1,85
Austria	2,12	2,24	2,24	2,46	2,44	2,51	2,67	2,71	2,79
Poland	0,56	0,54	0,56	0,57	0,56	0,57	0,6	0,67	0,74
Portugal	0,73	0,71	0,74	0,78	0,99	1,17	1,5	1,64	1,59
Finland	3,36	3,44	3,45	3,48	3,48	3,47	3,7	3,94	3,9
Sweden	:	3,8	3,58	3,56	3,68	3,4	3,7	3,6	3,39
United Kingdom	1,8	1,75	1,69	1,72	1,74	1,77	1,78	1,85	1,8
Norway	1,66	1,71	1,57	1,51	1,48	1,59	1,58	1,78	1,69
Switzerland	:	:	2,82	:	:	:	2,87	:	:
United States	2,6	2,6	2,53	2,58	2,62	2,69	2,82	2,87	:
China (except Hong Kong)	1,07	1,13	1,23	1,32	1,39	1,4	1,47	1,7	:
Japan	3,12	3,14	3,13	3,31	3,41	3,46	3,47	3,36	:

Table 1.1: R&D spending as percentage of GDP, selected countries. Source: Eurostat

Institutions involved

The European Commission developed the Horizon 2020 strategy and the Innovation Union initiative.

Member States work together with the European Commission to develop a coherent S(S)TI for Europe.

Strategy overview

The Lisbon Strategy published in 2000 set out a vision for Innovation in the European Union. This included both an analysis of the current innovation needs in terms of societal changes (e.g. the dominance of the knowledge economy, demographic changes, etc.) and specific expenditure requirements to keep Europe a world leader in these fields of innovation. The projection at the time was that by 2010 R&D intensity (R&D expenditure as a percentage of GDP) in the EU should reach 3%. In 2010 that expenditure accounted for 2%, and the existing projections do not see any further increase (see Table 1.1). At the same time central government funds allocated to R&D showed a slight decrease from .77 [% of GDP] in 2009 to .76 in 2010. These discrepancies are due to the economic crisis, but they also set the stage for the current innovation dialogue in Europe and the Europe 2020 strategy (European Commission 2013b).

The '2020 Strategy for Europe' is the European Commission's strategy for growth. Within this strategy, the European Commission has set up the 'Innovation Union' Flagship Initiative (European Commission 2013c). As part of a joint vision and a common series of global challenges (climate change, energy scarcity, demographic change) and objectives, each country must specify its own objectives determined by their current situation and potential development. The strategy Europe 2020 has three priorities:

- **Smart growth**: generate value based on growth in knowledge and innovation. This will reinforce opportunities and social cohesion by making the most of education, research and digital economy potential;
- **Sustainable growth**: create a more competitive economy that is both connected with and friendly to the environment;
- **Inclusive growth**: strengthen the role of citizens in inclusive societies.

The Innovation Union will not only help tackle the identified global challenges, but it will also create growth. The initiative aims at a fundamental reform of the STI strategies of its member states. This will be achieved by the following measures:

1. Delivering the European Research Area (ERA)[1]:
    - facilitating cross-border research activities and remove regulatory obstacles;
    - coordinating European science projects in order to manage complexity of new technologies and profit from effects of scale.
2. Easier access to funding:
    - stimulating private investment on Research & Development (R&D) (the venture capital (VC) market of the EU is significantly smaller than the VC market of the US);
    - proposing new funding instruments by the Commission until 2014 in order to leverage private investment in R&D;
    - using funding to substitute private funding gap (due to financial crisis);
    - bridging the 'valley of death' between the phase-out of public funding and the not-yet forthcoming of private funding;
    - funding the expansion into other markets;
    - funding high-risk projects;
    - Competitiveness and Innovation Framework Programme (European Commission 2013a).
3. Establishment of a single European market for innovation:
    - making use of public procurement by EU institutions to stimulate innovation;
    - achieving more intelligent regulation ;
    - simplifying patent registration to cut cost for Intellectual Property Right holders (EU Patent).

The Innovation Union consists of a range of initiatives (for a full list, see: European Commission 2011), which should contribute to achieving the aims above:

- With the '**smart specialisation platforms**' (European Commission 2013d), the European Commission provides professional advice for EU member states and regions to help them design their STI strategies for smart specialisation. The smart specialisation approach aims at economic development

[1] The ERA was first introduced in the year 2000, and since then it has been the objective of a number of initiatives (e.g. Framework Programmes). With Innovation Union, the European Commission is planning to finalise the ERA.

through targeted support to Research and Innovation. It provides the basis for Structural Fund investments in Research and Innovation (R&I) (Cohesion Policy of the Horizon 2020 agenda).

- **European Partnerships** (European Commission 2012a): Initiated to deal with the 'Grand Challenges', these partnerships aim at bringing together all stakeholders involved to reach a critical mass. The partnerships, for instance, deal with the coordination of research efforts and help to develop norms.
- Promoting the **European Institute of Innovation and Technology** (EIT (European Commission 2012b)). The EIT provides a bridging function in Horizon 2020 from excellence-driven education, research and industry to innovation. It supports the development of innovation-driven solutions to societal challenges.

Challenges and outlook

Like most EU member states, the EU is also trying to cut its budget due to ongoing economic pressure. Since the new budget is still up for negotiation (European Parliament 2013), it remains to be seen how it will affect spending on R&D. Furthermore, as some goals in the Innovation Union agenda are ambitious (Blaauboer 2013), there is room for failure as partially happened to the Lisbon Agenda (European Commission 2010a; European Commission 2010b). National interest, as can be seen for instance in context with the realisation of the European Patent and the related discussion about language issues (Mullin 2012), is also a challenge.

Germany

Economic and political situation

Having experienced a sharp downturn in GDP in 2009, the German economy returned to reasonable growth in the following years, however at diminishing rates. The unemployment rate amounts to about 5% in 2014. Public investment in R&D sharply increased, whereas private investment remained stable in 2009 and increased in 2010, totaling about 2.9% of GDP in 2012 (Bundesministerium für Bildung und Forschung 2012a).

Institutions involved

Public support of science and R&D in Germany is a joint task of federal and regional institutions. The following focuses on the federal institutions involved:

- BMBF (Federal Ministry of Education and Research): primarily responsible for science and technology policy; implements several instruments such as grant-based project funding and institutional funding for public research organisations (e.g. Fraunhofer, Max Planck);
- BMWi (Federal Ministry of Economics and Technology): responsible for the implementation of industry-related research programs as well as collaboration between industry and Higher Educational Institutions (HEIs) – the commercialisation of R&D;
- German research foundation (DFG): runs research programs, grants funds mainly to academic research for research projects and infrastructure;
- KfW (German development bank): provides financial support for start-ups and small and medium enterprises (SMEs) - e.g. High-Tech start-up Fund.

Strategy overview

Research and Technology policy in Germany goes back to the 1960s. However, the High-Tech-Strategy (HTS 2010), published in 2006 (Bundesministerium für Bildung und Forschung 2012a), was the first national strategy for Germany developing a shared concept and vision including all relevant topics and encompassing all stakeholders involved in the innovation process. Those are HEIs, public research institutions, and industry, as well as the government and various ministries at the federal level. The strategy aimed at creating an innovation-friendly economic environment, and the activities proposed concentrated on the pooling of innovative power of science and industry, the improvement of conditions for SMEs and start-ups, the fostering of technology dissemination, the strengthening of international cooperation, and the investment in human capital.