Introduction

Massimo G. Colombo, Luca Grilli, Lucia Piscitello and Cristina Rossi-Lamastra

Scientific achievements that make technological progress and the spread of innovations into economies possible are considered key factors in achieving sustainable economic growth and increasing overall welfare. The significance of science, technology and innovation (STI) as key elements of economic growth is well established in the economics literature. Although the micro-level transmission mechanisms that translate scientific knowledge into economic growth are far from being fully investigated and understood, the idea that the growth of an economic system ultimately depends on its capacity to produce new knowledge in a broad sense is a fil rouge that characterizes all the recent history of economic thought. To list just a few milestones along this path, one may start with Schumpeter and his celebrated Theory of Economic Development of 1934, and arrive at the endogenous growth theory of the 1990s (see Aghion and Howitt 1997). Along the way, it is worth mentioning Solow’s studies (1956, 1957) on technological changes and innovation as key components driving total factor productivity; Schmookler’s work (1966) on the importance of demand-pull factors for determining innovation – emblematically titled Invention and Economic Growth – and Freeman et al.’s (1982) famous study on the interdependencies between unemployment and technological changes in shaping long economic waves and economic development.

Science and innovation have undoubtedly played a key role in the past. However, their role has become more and more crucial in the present and will continue to be so in the future (OECD 2010). Currently, from diverse angles and perspectives, public opinion points to the development of new technologies as ‘the solution’ to most of the challenges that the world faces in the upcoming decades. New energy-producing technologies are envisaged to curb carbon emissions and reduce global warming alarms. Advances in genetics and biotechnology are expected to play a major role in alleviating the worldwide problem of famine. New ICT and broadband technologies promise further improvements in living standards and economic performances. Obviously, this ‘wish list’ could be extended almost
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indefinitely. Everyone may wish to add some items or change the rankings of some others. What is certain is that what can be reasonably achieved in the near future, ‘while undoubtedly constrained by the past, also [ed. crucially] depends on the actions that we make today’ (Morlacchi and Martin 2009, p. 571). These actions are likely to be much more complex than what has been required in the recent past. On the one side, science increasingly constitutes a fundamental prerequisite for producing valuable long-term innovation. In other words, science and innovation have become more and more interlinked, as reflected by the steady increase in the number of references in patent applications to scientific literature over the last 30 years (OECD 2004). On the other side, innovation requires the joint efforts of a growing number of stakeholders, including universities and other public and private research institutions, firms and users, often dispersed around the world. The emergent complex nature of the current international science and innovation landscape broadens the scope of STI policies, and possibly calls for more systemic and comprehensive approaches than those that have been pursued in the recent past. Allegedly, the process of policy design and its implementation increasingly needs to avoid inconsistencies and inaccuracies. In this respect, timely, scientifically rigorous but also practice-oriented STI policy research can help to mitigate (though, obviously, not solve) the risk of policy failures.

RATIONALES FOR PUBLIC INTERVENTION IN STI

According to a purely neoclassical economics perspective and to an ‘ideal’ vision of the functioning of markets, the public policy mission should be to expand the pool of scientific knowledge that benefits communities and societies at large but has little private value. In this view, STI policies should abstain from interfering in those fields in which private initiatives may efficiently take place. Adapting and combining the classical Stoke’s (1994) quadrant on different types of scientific research with Brown’s (1998) diagram depicting policy intervention on the basis of expected private and social benefits, public policy should intervene mainly (if not exclusively) in the A area – see Figure I.1.

In this area, pure basic research has a high level of expected social benefit, but a low value in terms of expected private benefit. Conversely, the public actor should refrain from intervening where private expected benefits are supposed to be sufficiently high to attract profitable private initiatives (B area).

Unsurprisingly, the ‘real’ world substantially differs from this picture, and the room for policy intervention (of any type: institutional, organizational,
regulatory, level playing field) appears to be much wider. The literature on STI policy has singled out many motives that make a more pervasive public intervention compelling (Laranja et al. 2008; Aghion et al. 2009). The following two reasons figure prominently. First, the neoclassical market failure rationale is relevant here. Private research and development activities may generate spillovers that raise appropriability concerns, which, in turn, lower the expected private rate of return for research activities. In terms of Figure I.1, appropriability problems may reduce the private hurdle rate and consequently also move projects of applied research (Edison-type) and use-inspired research (Pasteur-type) into the A area. Even when the innovators pass the private hurdle rate, the presence of capital market imperfections that increase the wedge between the cost of external capital and internal funds might cause the failure of some potentially profitable innovations, unless the innovators are already wealthy. Second, researchers and innovators are influenced by the society in which they are embedded. The system of values (i.e., formal and informal norms, cultural traits, social and monetary incentives and rewards) that historically emerge in a society may be sub-optimal from a social point of view for carrying on research and innovation at an individual or global level (Baumol (1990) offers important historical examples in this respect). Public policy may play a crucial role in (re-)shaping the ‘rules of the game’ and determining on a long-term perspective an institutional background encouraging science and innovative activities (see also the wider literature surveyed by Edquist (2004) on the concept of National Innovation Systems).

Figure I.1  Rationales for STI policies in an ideal ‘neoclassical’ world
WHAT THIS BOOK IS ABOUT

If there is general consensus on the rationales for an interventionist policy, there is much less agreement on the policy instruments suited to accomplish the task of supporting the scientific and innovative effort. The spectrum of possibilities and the levels of intervention are extremely wide. They embrace different aspects of political economy at different territorial levels and involve the interplay of numerous complementary effects. This makes the subject extremely complex. From a historical perspective, the typical STI policy research approach has been oriented to reduce this complexity by focusing on specific and delimited issues. ‘Rather than being theory-driven or paradigm-driven’, Morlacchi and Martin (2009, p. 572) claim that:

[STI policy research] is primarily a problem-oriented field that focuses on practical issues to do with specific policies for science, technology and innovation, taking account of the central role of the firms in the evolution of technology and innovation. As such, much of it is empirically oriented and motivated; where there is theorising, this is mostly inductive, reflecting on what the empirical record appears to show.

This volume believes in the empirical core and inductive nature of STI policy research. After a close critical examination of the state of the art of some important STI policy research fields, it focuses on specific areas of intervention, both analysing and evaluating the effectiveness of implemented policy measures in these areas. The aim is to provide useful devices for the design of improved policy measures.

The basic idea that inspires this book is that much still remains to be done to strengthen the relationship between STI policy research and policy makers. Among other necessities (including the closing of communication gaps), this task surely requires that researchers give up a purely Manichean (i.e., yes or no) perspective in exploring the effectiveness of specific implemented policy measures in favour of the adoption of a more comprehensive lens of investigation. This new approach includes the acknowledgement that important contextual factors at all the possible levels of analysis are at work. These factors may or may be not controlled by the policy maker, but they may still influence the outcome of a policy intervention. In this respect, a policy research framework able to bring all of these moderating factors into focus is likely to be better able to provide useful advice on the characteristics (i.e. the so-called ‘design’) that a given policy should possess in order to be effective. At the same time, STI policy research needs to make additional efforts in delivering clear, neat, unequivocal and mostly important ‘usable’ policy recommendations. These efforts require the recognition that policy decision-making is a complex
political process that involves different actors with different perceptions, backgrounds and objectives. The less ambiguous the message, the lower the risk that it will be abandoned or misinterpreted along the way.

Trying to adhere to this perspective, this book collects some important pieces of work on specific areas of great interest for current STI policy research. The first section, entitled ‘Making a science of science and innovation policy’, brings together scholars’ insights on wide-ranging theoretical, operational and methodological issues that collectively aim to deliver a detailed analytical picture of both the state of the art and the directions of evolution for each focal area. In particular, the first essay reflects on epistemology and offers both an historical perspective and a prospective overview on the contribution of economics to the study of science policy. The subsequent papers deal with two fundamental methodological issues in STI policy research: the construction of reliable indicators for science and innovation activities and the use of econometric techniques for policy evaluation purposes.

Next, the volume focuses its attention on two specific but increasingly relevant STI policy areas of investigation. As mentioned above, science and innovation have become increasingly interlinked so that innovating without the aid of science is becoming more and more difficult. Obviously, this dependence does not imply that scientific knowledge easily translates into innovation. Public policies are needed on both sides of the knowledge supply chain. In the relatively upper part of that chain, one key issue is how to secure a constant and efficient flow of scientific advancements and technology transfer from public research organizations to production activities and markets. The second section of the book, entitled ‘Knowledge and technology transfer policies’, addresses this issue, presenting the analysis of studies concerning two specific countries (the United Kingdom and Italy) to draw important policy implications on the role that the public sector should play in this field.

Moving along the science and innovation supply chain, the third and last section, entitled ‘Industrial innovation policies’, is instead centred on the fundamental enabling function that public policy may exert in promoting innovation activities at the industry level. The field represents a traditional cornerstone of economic policy for most advanced economies. Here, the focus is on two specific questions that are increasingly relevant and, consequently, figure prominently in the agenda of many policy makers. The first contribution analyses and critically revises the whole spectrum of policy instruments implemented in the European context with the aim of sustaining the birth and the development of a florid European industry of venture capital. The second contribution explores the role of public policies in shaping the mutual interrelationships between companies’
internationalization and innovative performances in the ongoing and disruptive process of globalization.

All of the collected essays are briefly summarized in the remainder of this introduction.

MAKING A SCIENCE OF SCIENCE AND INNOVATION POLICY

In their inspiring chapter, Antonelli, Franzoni and Geuna review the main principles informing modern Science Policy. They re-read these principles in light of the development and achievements of the Science of Science field, thus proving that they possess a sound epistemological foundation. Specifically, the authors develop their reasoning along the following lines.

To begin, the authors think back over the surge and development of a research stream in social studies that investigates the varied issues related to science and scientific research. They argue that such a stream has significantly contributed to create a Science of Science Policy, which has had an ongoing influence on policy makers’ decisions in matters of scientific research, higher education and economic development.

Then, they maintain that social science studies on science and scientific research have by now entered a paradigmatic phase. A sound, articulate and consistent pattern of theories, models, methodological instruments and data have recently emerged from the work of scholars in several disciplines. This body of knowledge is reviewed, beginning with early works in economics, philosophy, sociology, and the history of science. The authors highlight its core as providing a set of valuable tools for policy makers who aim to support scientific advancements.

Finally, Antonelli et al. devote attention to the seminal works that initiated and shaped the field of Economics of Science, eventually focusing on the most recent and relevant contributions in this rapidly expanding field. The review of the most recent literature is organized around the following main areas of research: Science and Labour Market; Industrial Economics and Science; Science and Regional Economics; Property Rights on the Outcomes of Research; Science and Higher Education; Technological Change and Science; Mechanism Design of Research Organizations; and Science and Economic Growth. For a grounding in this review, the authors discuss the main open questions in Science Policy and suggest areas for its future development.

The second chapter by Lepori, Reale and Slipersaeter deals with the problem of measuring STI activities for policy purposes and, in particular, illustrates experiments conducted within the PRIME Network
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of Excellence to develop science and technology (S&T) indicators in key areas that were not adequately covered by existing indicators, including public funding and higher education institutions.

The relationship between S&T indicators and policy making has always been difficult and contested. On the one hand, policy makers complain about the lack of simple and usable indicators when political decisions need to be taken. On the other hand, specialists in the field warn against abuses of simple and appealing indicators like productivity comparisons, composite innovation indicators or university rankings. Therefore, the development of new indicators is particularly challenging and requires a deeper understanding of the policy needs and wishes.

Specifically, the chapter provides a detailed case study for the development of indicators concerning public project funding, illustrating the phases required to reach a satisfactory design for new S&T indicators. The case study highlights the interdependency between policy makers and indicator designers that is necessary to create useful indicators, with policy makers defining the targets of policy, while designers define indicators to measure actual development towards targets, taking into account conceptual and technical issues on the measurement of science. For indicator specialists, this interdependency requires them to go beyond a purely technical work, actively managing the communication with policy makers and administrators and taking seriously their concerns, goals and values. The case study also highlights the different phases of this process and their distinctive characteristics: understanding policy makers’ needs; getting support and resources for experimental projects; achieving visibility and feedback; and adjusting the indicators and development procedures at a later stage. The final step, that not all new indicators will make (because of their different relevance and characteristics), is the integration into the regular production of basic indicators by national statistics institutes.

Therefore, this case study shows that, against widespread claims, it is possible to bridge the distance between indicator development and policy making, that is, to design indicators that better meet policy needs and to find a path to integrate them in official statistics and in official reports on science policy. Finally, the chapter also notes positively that well-established indicator systems, like R&D statistics, can offer opportunities for the renewal of their content to answer to new policy needs.

In the third and last chapter of this section, concerning foundation principles of a science of science and innovation policy, Grilli and Murtinu review the principal econometric methods available to the researcher to measure and evaluate the effectiveness of science and innovation policies. For the sake of simplicity, but without any significant drawback in the scope of applicability, the authors focus on the empirical methodologies
most often applied in the analysis of the impact of public R&D subsidies on firm performances. More specifically, by paying special attention to the issues of subsidy endogeneity and selection bias (Heckman et al., 1998a, 1998b), the authors show the main econometric challenges a researcher must face in order to overcome these problems and correctly estimate the impact of a government policy scheme. Because a plurality of econometric methodologies may be put in place, Grilli and Murtinu then discuss the main advantages and weaknesses of each approach. This discussion brings them to recommend using more than a single technique in policy evaluation exercises and, whenever possible, to complement quantitative analyses with qualitative insights. In fact, standard econometric methodologies are somehow unsuited to cope with the analysis of ‘stars’ (i.e., outstanding performance of the subsidized entities) that may act as ‘outliers’ in the econometric analyses on policy evaluation. Their inclusion in the quantitative assessment may lead to misleading findings on the ‘average’ treatment effect of the policy; conversely, their exclusion may prevent the identification of possible best practices that policy makers are willing to replicate. In this respect, case studies (or other qualitative techniques) may furnish valuable support. Finally, the chapter concludes with some suggestions for future advances in the field. In particular, the authors stress the need for evaluation studies that look not only at the short-term, but also at the long-term effects of policies, and that duly take into account possible moderating factors and spillover effects that may substantially alter the effectiveness of policy measures. As for techniques, since multiple-treatment cases arise often, and most of the econometric tools are tailored to single-treatment phenomena, there is room to develop sounded econometric methodologies that are able to elucidate the effect of each single treatment in multiple-treatment settings.

**KNOWLEDGE AND TECHNOLOGY TRANSFER POLICIES**

In the second section of the book, the focus turns to the upper part of the science and innovation supply chain and on the public policy’s capacity to stimulate efficient transfer mechanisms from knowledge production sources to firms and markets. In particular, the first contribution by Hughes, Moore and Ulrichsen analyzes the impact of a major public policy initiative undertaken by the UK government from 1999 onwards to enhance ‘third stream’ interactions with external organizations in the private, public and voluntary sectors by English Higher Education
Institutions (HEIs). The work provides four important contributions to the policy evaluation literature.

First, from a theoretical perspective, it argues in favour of a ‘system innovation’ approach to policy design and evaluation (Lundvall 2007; Metcalfe 2007) that goes beyond the traditional market failure approach inspired by mainstream microeconomics. A crucial strength of this approach is the consideration of ‘institutional failures’ that arise from potentially different norms and value governing the behaviour of agents, a situation that is very likely to occur in the interaction between the HEIs on one hand, and firms in the commercial sector on the other. From this perspective, third stream funding, while operating at the interface between these two types of institutions, is primarily concerned with affecting patterns of networking and collaboration across these boundaries.

Second, in line with this approach, the work addresses the question of whether the introduction of third stream funding secured cultural and behavioural changes towards third stream activities in HEIs. In addressing this question, the authors apply recent advances in evaluation practice based on behavioural additionality (Luukkonen 2000; Hsu et al. 2009). In particular, they focus on changes in the way academics and universities perceive, and behave in relation to, the development and operation of third stream activities. Behavioural evaluation is particularly appropriate in this case as quantitative changes may be difficult to measure and may occur with considerable time lags. Behavioural changes are clearly an important intermediate step on the way to longer-term effects of the policy measures under investigation.

Third, in line with the view expressed by Grilli and Murtinu in their chapter, Hughes et al. use an intriguing blend of quantitative and qualitative methods, including case studies, surveys, interviews with key informants, textual analysis and secondary data analysis, to address in an original way the typical problems faced by the assessment of policy interventions in this area (extreme skewness of outcomes, absence of short-term effects, ‘needle-in-the-haystack’ problems). This approach is especially promising in situations in which identifying the counterfactual through standard econometric techniques is difficult or even impossible.

Fourth, the chapter highlights several important effects engendered by third stream funding. It documents that these support programmes triggered a dramatic change in attitude, culture and behaviour within UK HEIs in favour of knowledge exchange activities. It also led to a substantial increase of income generated by these activities – notably by contract research, which doubled in the 2001–2007 period. Therefore, third stream funding had both considerable behavioural and gross output additional-ity. Lastly, in spite of these positive effects, the authors claim that one
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has to be careful that the knowledge exchange products or services that HEIs are providing do not displace those offered by the private sector. Here, Hughes et al. show that the situation differed depending on the type of activity. When higher education institutions carried out original contract research and training services that were based on the latest scientific achievements, displacement was negligible. Conversely, the provision of consultancy activities is likely to have substituted similar activities offered by private firms. Therefore, while third stream funding is very helpful in general, policy makers should carefully monitor the use HEIs make of these funds, channelling them to high value added activities (contract research, science-based training), but hindering their use for activities, like consulting, that are likely to displace those provided by the private sector.

In the second chapter of this section, Leten, Landoni and Van Looy discuss the impact of university research on firms’ technological activities, thus shedding new light on technological spillovers from public research to private innovation. Focusing on the Italian case, the authors offer sound reasoning and valuable evidence on technology transfer mechanisms, which are expected to have profound implications on public policy. Decisions by governments to fund public research activities undertaken by universities exert considerable influence over both university research and the innovative performance of the local productive system in which universities are embedded.

Within the research stream on technology transfer, the authors investigate the role of the spatial proximity between firms and universities (Audretsch and Stephan 1996). They review the numerous conceptual and empirical contributions to the topic, which document that firms can obtain a technological premium by locating in regions that host universities. With a grounding in this literature, they present new findings from an original empirical study that relies on a unique panel dataset on university and firm research activities in Italian provinces. The study confirms the main findings of the extant literature. First, the authors show that the size of the technological premium that firms gain from spatial proximity depends positively on the scientific strengths of the universities. Second, they demonstrate that industrial technological activities do not benefit equally from academic proximity, with activities in science-based technologies benefiting most. This result complements the findings of previous studies that suggest that firm-specific characteristics moderate the impact of university spillovers (Colombo et al. 2010). Furthermore, the results of Leten et al. confirm those of previous studies that university knowledge spillovers follow a distance decay pattern, with firms in neighbouring regions capturing only part of the university spillovers (e.g. Belenzon...
and Schankerman 2010). This finding is in line with the view that direct contacts between actors of an innovation system are important to transfer tacit, complex knowledge.

The evidence produced by this study has important implications for regional development and science and innovation policy at the local level. First, it suggests that universities and firms play complementary roles within local innovation systems. Second, it highlights the importance of universities’ scientific capabilities for effective university–industry spillovers to unfold. Third, it indicates to local policy makers that fostering scientific research in universities should become a focal point for attention. However, it will only have a positive impact on industrial technological performance in the encompassing region if high quality scientific capabilities are present within the universities and there exist direct contacts between universities and local firms.

INDUSTRIAL INNOVATION POLICIES

The third and last section of the book moves further along the science and innovation supply chain by dealing with two increasingly relevant policy themes at the industry level. In particular, the chapter by Bertoni and Croce analyzes the different typologies of policies put in place by different countries in the European context aimed at sustaining the birth and development of a solid venture capital (VC) industry. In fact, VC (i.e., early stage financing provided by professional financial intermediaries) is considered an important ingredient for accomplishing the long-standing goal of turning Europe into a well-functioning, knowledge-based, smart economy (European Commission 1998, 2010). However, public policies that foster the development of VC have proved to be, at best, only partially effective, and the VC market is still far smaller in Europe than in the US. In their chapter, Bertoni and Croce investigate which policies have been enacted by European Member Countries to develop the VC industry after the revision of the Lisbon agenda in 2005 (European Commission 2005). Using MICREF, a database developed by the European Commission to improve the surveillance of microeconomic reforms in EU Member States and that systematically records product market reforms adopted by these countries, the authors identify all the reforms that relate to policy areas directly affecting the development of VC. This process identifies 747 reforms in 14 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom) since 2005. The authors divide these policies into two categories: subsidies and structural reforms. Each
category is then further divided into sub-categories; subsidies are divided between demand-related and supply-related (i.e., respectively targeted to investee companies and VC investors); structural reforms are divided into four areas: entrepreneurship; financial markets; human capital; and the tax system. The cross-country comparison reveals a huge heterogeneity among European countries along all dimensions: the relative importance of subsidies vs. structural reforms, the type of subsidies that are chosen, and the areas upon which structural reforms are concentrated. Interestingly, the differences are only partially explained by the differences in the underlying characteristics of Member Countries. By comparing the intensity of policy reforms with the areas of relative structural weakness of sample countries, the authors identify two opposite strategies. Some countries, such as Austria, the United Kingdom and, to a lesser extent, Belgium and Spain, have aimed, with their reforms, to address those structural aspects with respect to which they were relatively deficient. Scandinavian countries, Italy and, to a lesser extent, Ireland have instead focused their reforms mostly in areas in which they were already relatively strong.

If the absence of a unique European way of sustaining the VC industry might be somewhat objectionable from a political perspective, from another perspective it will give STI researchers a unique opportunity to evaluate the effectiveness of different policy strategies by providing a sort of experimental framework in which somewhat similar countries follow completely different political strategies. This policy evaluation exercise, the authors conclude, can possibly contribute to the understanding of which public policies can eventually help Europe in developing a common, well-functioning, active VC market to support knowledge and innovation.

The final chapter by Amorim Varum and Piscitello targets the intricate nature of the bi-directional relationship between firms’ innovative activities and internationalization processes, and investigates the role of public policy in the matter. There is wide consensus among academia, policy makers and practitioners that innovation and internationalization are becoming increasingly important for the survival, growth and long-term viability of business organizations. Although it is difficult to disentangle the directions of causality, innovation is clearly important to compete internationally, but firms may also innovate as a result of learning by internationalization. In fact, innovation increasingly depends on the international sourcing of resources and capabilities as well as on permanent contact with new markets and new technology trends worldwide. Through internationalization, firms may not only exploit ownership advantages generated at home in other countries, but also gain access to technology internationally and tap into worldwide centres of knowledge that in turn improve the firms’ technological base. Internationalization also makes
it possible to reduce innovation costs by having access to materials and R&D inputs from the cheapest available sources, and even to locate R&D and other departments in the most productive regions. Firms with a higher innovative capacity can develop better products and processes, faster and at a lower cost, which, in turn, boost these firms’ competitiveness. Additionally, operating in a large number of countries helps to exploit the competitive advantages created, spread the costs and reduce the risks associated with innovation. However, internationalization might also increase the risk of knowledge leakages and the costs of coordination and control of the international operations.

Hence, a major challenge for policy is to enable domestic actors to access world markets and leading knowledge in a way that benefits firms’ competitiveness and strengthens the home country’s innovation system. This chapter addresses these issues with a focus on the importance of internationalization for innovation – a direction of causality relatively neglected in the literature. It then examines the main instruments used by governments to promote internationalization and provides some empirical evidence on the effectiveness of these instruments. In particular, the latter highlights the need for appropriate and reliable evaluation techniques, an issue still not fully investigated with reference to measures and policies addressed by companies’ internationalization.

NOTE

1. For a review of economic studies of links between universities, innovation and regional development, see Åstebro and Bazzazian (2011).

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