Chapter 3
Motivations guiding public research funding in science, technology and innovation (STI) policy: a synthesis

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To be cited as:

Aleman-Diaz (2023). Chapter 3 Motivations guiding public research funding in science, technology and innovation (STI) policy: a synthesis. In Lepori B., Jongbloed B., & Hicks D. (2023). Handbook of Public Research Funding. Edward Elgar Publishing Ltd., Cheltenham. Forthcoming in 2023.

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Abstract

A persistent tension between the autonomy of creativity and the politics of purpose surrounds discussions about science, technology and innovation over time. This conflict underlies public research investment. However, the environment surrounding public research funding (PRF) has changed in the last decades making the underlying rationales more complex, heterogeneous and hybrid. The chapter explores motivations guiding PRF that over time try to explain and justify more complex realities and demands. It synthesizes relevant literature around three main motivations –*creativity, purpose, and transformation*– and considers them as co-exiting in national research environments. This typology departs from the classical triad of curiosity, market and mission motivations, but re-casts them in light of emergent motivations that seek to transform PRF. The chapter extends Elzinga's contribution, which took a time-based, succession approach, by exploring the types of funding motivations described in the literature and providing a discussion about recent motivations that propose transformative change.

Keywords: motivations; PRF; STI; policy

Introduction

The organization of science, technology and innovation (STI) has been 'historically…trapped in a tension between the autonomy of creativity and the politics of purpose' (Borrás, 2012). This persistent controversy has been a key recursive device called upon by scientists or by the state to drive investment in STI. As the share of government involvement in STI has increased over time (Borrás, 2012), public research funding (PRF) has become a means to achieve varied policy goals. These include, for example, promoting research excellence (Dasgupta and David 1994), efficiency in the use of public funds (Hicks 2012) or the relevance of research to address and meet societal, economic or other kinds of needs (Larrue, Guellec and Sgard, 2019; Larrue, 2021). In this context, actors involved in STI policy (Elzinga & Jamison, 1995) and the state (Borrás & Edler, 2020) have been central, especially after World War II. Over time, these actors have either chosen winners, engaged in specific missions to address societal needs, or corrected market or system failures that prevent the growth and disposition of knowledge, technology and innovation (Borrás & Edler, 2020; Edler & Fagerberg, 2017; Martin & Scott, 2000). However, the policy landscape is getting 'more diverse, more complex, and ever more far reaching in its impact on science' (Simon et al., 2019)(p.7). The environment surrounding public research has changed in the last decades making the underlying motivations of science policy more complex, heterogeneous and hybrid (Borrás, 2012; Elzinga, 2012). In this chapter, motivations refer to the narratives used by various actors to envision what should be achieved through PRF, but also suggesting how it could be achieved.

Changes in the PRF landscape include shifts associated with emerging rationales such as academic capitalism (Slaughter & Rhoades, 2004), new public management (Ferlie et al., 2008; Geuna, 2001; Paradeise et al., 2009), transformative innovation (Schot & Steinmueller, 2018), responsible innovation (Stilgoe et al., 2013), responsible research and innovation (von Schomberg, 2013), or holistic innovation policy (Borrás & Edquist, 2019), to name a few. It has been argued that 'academic capitalism' might threaten the social norms of science and scientific cooperation with adverse long-term effects on the institutions of science (Squazzoni et al., 2013). See, for example, the chapter on academic capitalism (Bégin-Caouette et al, Chapter 4 in this *Handbook*) for a discussion on the types of academic capitalism and a comparison of how policies and their outcomes are tempered by countries' specific context. The diffusion of ideas, like new public management, suggest a retreat of the state and the introduction in the public sector of competitive and corporate practices that have an impact also on research and higher education policies (Ferlie et al., 2008; Paradeise et al., 2009). The changes have also entailed adjustments in the 'social contract for science' from steady support for basic science to economic, social and policy targets influencing its allocation (Guston and Keniston, 1994, 2009; Elzinga and Jamison, 1995) and greater support for applied and user-oriented research at the expense of basic research (Stephan 2012). Capano (Chapter 8 in this *Handbook*) finds the evolution in the social contract for science ‘to a new type of contract based on evaluation and performance (that) can be read as a process through which new ideas (about what publicly funded research should do or should give back to funders) and new instruments (the approaches to use to pursue the new ideas) have been adopted’. It is, therefore, timely to understand the motivations described in the literature that influence modes of governing socio-technical systems and PRF around the world.

The chapter explores the motivations guiding PRF stemming from the tension between autonomy and purpose and aims to synthesize relevant literature describing them. It departs from the notion that these motivations emerge from ‘cyclical, socially constructed process(es) of interaction between science and technology, on the one hand, and cultural critique or response, on the other’ (Elzinga & Jamison, 1995)(p.575). Changes in the motivations driving PRF have been more gradual and less linear than frequently advocated (Larrue, Guellec and Sgard, 2019). The motivations in this chapter depart from the triad of curiosity, mission and market motivations, but aim to re-think the mix in light of old and new debates to transform PRF. The more classical triad takes for granted the structure of the science-society relationships, but, as I show through the chapter, these structures become insufficient to address new challenges. Therefore, the chapter suggests a slightly different mix of motivations –*creativity, purpose,* and *transformation*– and considers them as co-exiting in national PRF environments. This novel taxonomy enables the inclusion of emergent and disparate motivations, alongside more traditional motivations found in the literature.

The *creativity motivation* draws on curiosity based on the principle of ‘free research’ guided by experimentation and collegial debates. The *purpose motivation* centres around missions that involve planning and direction of research by the state or scientific knowledge used as a resource for the market. Some argue that ‘the post-war visions of ‘curiosity-driven’ research and mission-driven ‘big’ science turned into calculated investments in neoliberal ‘innovation science’’ (Juhl, 2016). Critics also contend that ‘we need a more realistic view of the relationship between basic science and technological innovation to frame science and technology policies for a new century’ (Stokes, 1997)(p.2); that ‘our present understandings and practices of STI policy are not sufficient to address Grand Challenges and set priorities accordingly’ (Kuhlmann and Rip, 2014); or that national innovation policies still remain fragmented and are ‘not truly systemic’ (Borrás and Laatsit, 2019). The *transformation motivation* describes these alternative views of the relationship between science, technology and society found in PRF, as well as more systemic approaches claiming to be more responsive to new societal requirements and expectations. This work extends Elzinga's contribution (Elzinga, 2012), which took a time-based, succession approach to exploring the meta narratives that guide public funding, by exploring the types of funding motivations described in the literature. For more explicit explorations of the connection between policy frames and instruments, see Ulnicane and Capano

(Chapters 5 and 8 in this *Handbook*, respectively). While Reale et al, Coburn et al, as well as Cruz-Castro et al (Chapters 10, 13, and 16 in this *Handbook*) explore the effects of policy frames in the formulation of specific instruments (i.e. R&D programs, research targeting, and, funding schemes, respectively) to address particular goals.

The motivations described here stem from centuries old discussions about the organization of STI where 'debates about knowledge, ideas, and growth have been central to economic and political thinking in all cultures' (Khan, 2020)(p.347). In these exchanges, Michael Polanyi represents a legendary figure of the curiosity motivation for his support of the autonomy of science, arguing that 'any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science' (Polanyi, 1962). John Desmond Bernal, on the other hand, argued for 'the essential socio-economic function of science, invariably requiring the grand mobilization of knowledge in order to achieve explicitly formulated goals in planned economies' (Borrás, 2012). For Polanyi science exists for science sake, whereas for Bernal 'usefulness...was the central objective of the scientific enterprise and the desired end of state support of science' (Pielke Jr., 2014). This usefulness becomes visible in the context of purpose motivations, which expect different actors (e.g. the market or the state) to either benefit or organize for STI. However, some argue that Bernal's early 'revolutionary thinking in the 1930's was … taken over by the captains of industry and ministers of government in the postwar period…(resulting in) the weaker (known) Bernalism of planning, programming, people, money and equipment for efficient growth' (Elzinga & Jamison, 1995)(p.573) used as the main legitimation for science policy. Figures like Polanyi (1962), Merton (Merton, 1973), and Bernal, 'still cast long shadows onto contemporary perceptions of the nature of science and government' (Bimber & Guston, 1995)(p.2). However, more recent motivations stem from observations that challenge 'the assumptions of the cold war era and the guiding conceptions of the state…(as well as) the political value and nature of basic research itself' (Elzinga & Jamison, 1995)(p.573). These motivations seek to transform the direction and impact of PRF, as well as its organization.

The directionality between motivations described in academic narratives and policy change can be hard to ascribe. Academic work on science policy '…advance(s) knowledge claims which appear to either anticipate or justify' policy interventions…(while policy documents) refer to or draw upon these academic narratives to justify the science–society interaction they advocate' (Jacob, 2006)(p.432). This chapter does not attribute directionality, but argues that academic and policy narratives co-exist and co-produce themselves. Raising awareness of this quality can support reflection by academics and policy-makers about the normative and practical implications of their positions.

The chapter describes the motivations -*creativity, purpose, and transformation*- and briefly describe how these motivations get inserted and operationalized in the US and in the EU.

Public Research Funding Motivations

The autonomy of creativity

The *curiosity motivation* draws on the principle of 'free research' guided by curiosity, experimentation and collegial debates (Beddeleem, 2015). Core ideas associated with this motivation include blind delegation, laissez-innover, excellent ('breakthrough') research (Dasgupta Partha & David, 1994), and Mode 1 (Gibbons et al., 1994). Polanyi, for example, envisioned a science that seeks the 'truth for its own sake' and that 'can be accomplished only if it remains free from political, ideological and economical influences' (Hartl, 2012). He further states 'that the pursuit of science by independent self-co-ordinated initiatives assures the most efficient possible organization of scientific progress' (Polanyi, 1962). Polanyi viewed the erosion of the distinction between basic and applied science as 'dangerous arguments for the social responsibility of scientists, central planning of scientific research, and relinquishment of individual freedom'(Nye, 2011)(p.194).

Within the curiosity motivation, Mode 1 knowledge production (Gibbons et al., 1994; Nowotny et al., 2003), defined in opposition to Mode 2 (see Transformation motivation), emerges as part of a two-form explanatory model of knowledge production primarily focused on science and technology but that also has been used to characterize innovation (Kaplinsky, 2011). Mode 1, often associated with the curiosity motivation, is compatible with the linear model of innovation[i]. Gibbons el at (1994) and Nowotny et al (2003) emphasized the knowledge that stemmed largely from an academic context and within disciplinary boundaries to demarcate 'sound scientific practice' (Gibbons et al., 1994)(p.167). Mode 1 science conforms 'with traditional knowledge production sites (universities, federal laboratories, industry laboratories), and hierarchical decision making' (Logar, 2011). It prioritizes basic research, often publicly funded and via universities, as 'essential to guarantee the generation of the knowledge and rationales to underpin the flow of innovations required for survival in the global economy' (Gibbons, 2013). Curiosity motivations focus on questions of why, as opposed to questions of how often associated with applied research (Jaffe et al., 2007). Mode 1 is discipline-based and Mode 1 scientists are accountable to one another and their discipline. They seek 'breakthroughs in fundamental science…carried out in typical university laboratories' (Gibbons, 2013)(p.1287). Success in Mode 1 can be defined as "academic excellence, which is a comprehensive explanation of the world (and of society) on the basis of 'basic principles' or 'first principles', as is being judged by knowledge producer communities (academic communities structured according to a disciplinary framed peer review system)' (Campbell & Carayannis, 2013)(p.32). Curiosity motivations centre on scientists and their needs in the quest to expand knowledge frontiers. They centre around an investigator-initiated mechanism, which affords maximum freedom of intellectual inquiry and hinges on the potential of great intellectual payoff, but does not define it. Examples of the types of PRF organizations that support and enable individual researchers in their pursuits can be found in the European Research Council (Benner, 2018b) and the US National Science Foundation (NSF). This motivation was also prominent in the arguments for the establishment of the US NSF (Bush, 1945; P. Stephan, 2015). In the US, philanthropic support, especially targeting specific diseases, was also a source of funding for this type of research (Benner, 2018a). But this kind of science also comes at a considerable cost, as it requires time both on the proposing and reviewing end and may also discourage risk taking…' (P. E. Stephan, 2012)(p.114). Historically, curiosity motivations have been used 'in opposition to rationales of socialism and centralized steering of scientific agendas' (Elzinga, 2012). And sole investment in this type of science has been seen as insufficient to 'guarantee the technology required to compete in the world economy and meet a full spectrum of societal needs' (Stokes, 1997)(p.58). And while curiosity rationales, as we have defined them here, appear 'to count for less in the official policy discourse' they are seen as a form of resistance to in response to management changes in research (Elzinga, 2012).

The politics of purpose

The politics of purpose, in this chapter, entail motivations around PRF that are about missions led by the state, aim to achieve value from research, or that explore the nature of purpose when doing science. This is a departure from more classical understandings that view market and mission motivations as distinct. However, these motivations are understood here as bringing together activities that often have clear goals and intention in their conception. They are the effect of a 'transformation within science' away from the politics of autonomy (described elsewhere as a quest for pure science) onto 'science as a source of economic, and by extension, political power' (Jotterand, 2006)(p.659). They also assume that stimulating innovation can be positive because ultimately everyone will benefit from it in some way, for example with the new high quality jobs that could be generated.

The market motivation refers to the idea that research supports economic growth and creates jobs. It focuses on the goal of achieving economic returns and value from PRF, which goes beyond the traditional view that the market is served indirectly or best through curiosity-driven research. This motivation stems from the rising importance of competition and economic incentives as main mechanism for the allocation of research (Geuna, 2001; Lepori, 2011; Slaughter & Rhoades, 2004; Teixeira et al., 2004) and responds to policy rationales, such as New Public Management (Christensen & Lægreid, 2001; Ferlie et al., 1996) that encourage the adoption of management practices from the private sector in the public sector. Competition in PRF is expected to lead to increased responsiveness and efficiency (Krücken, 2021; Musselin, 2018). As part of this motivation the entrepreneurial role gets added to the conventional responsibilities of research and education of the university (Thune, 2010). The triple helix framework[ii] (Etzkowitz & Leydesdorff, 1995), which is rooted in an evolutionary perspective (Jacob, 2006), tries to explain the emergence of entrepreneurship at universities, along with the infrastructure that promotes it (Jacob, 2006). These changes facilitate the adoption of new roles, such as the commercialization of knowledge and firm formation as part of the university's core mission (Etzkowitz, 1998; Etzkowitz & Leydesdorff, 2001; Jacob, 2006), and focus on turning knowledge into wealth (Jacob, 2006). The triple helix notion has evolved into the quadruple helix, as well as the quintuple helix (Carayannis & Campbell, 2013). The notion of the quadruple helix, for example, was endorsed by the European Commission in its strategy for smart specialization (Dominique Foray et al., 2012). These conditions enable businesses to invest in research and development and collaborate with complementary partners in the production of applications.

Yet competition appears as the source of incremental research, lower epistemic innovation, and an erosion of the academic social fabric (Boudreau et al., 2016; Franssen et al., 2018; Franssen & Rijcke, 2019; Heinze et al., 2009) It has also been conceptualizes as 'multiple competitions' within university governance that generate positive and negative unintended consequences (Krücken, 2021)(p.173-178). The notion of national innovation systems (Lundvall, 1992), so core to the market motivation, has also been challenged by the 'open, interactive, and globalized nature of much research and innovation activity' (Weber & Truffer, 2017)(p.102). These systems rely on political systems centered around nation-states or nation state-based political systems (Kuhlmann, 2001), which raises the question of 'whether and to what extent territorially and sectorally delimited innovation systems are still adequate to capture reality' (Weber & Truffer, 2017)(p.102). Other critics of this motivation allude to 'consensus of the literature that reliance on market processes alone will result in underinvestment in research and development, from a social point of view' (Martin and Scott, 2000). The market motivation has also led to performance criteria within university research (Geuna, 2001; Hicks, 2012) that 'has led faculty, and the government agencies that support faculty, to be risk averse …"Sure bets" are preferred over research agendas with uncertain outcomes' (P. E. Stephan, 2012)(p.149). The early focus on innovation as tied to competitiveness at national, regional or sectoral levels has also opened up criticism 'about the contribution of innovation activities to tackling major societal, environmental, and developmental challenges' (Weber & Truffer, 2017)(p.102). But some argue that even with these new challenges the systems-oriented approach to innovation, which emphasized functional and generic aspects needed for growth can still provide an appropriate guideline for STI policy (Gassler et al., 2007).

The mission motivation*,* on the other hand, revolves around national or societal interests and involves planning and direction of research by the state. It involves an active state, often directing, but also collaborating with stakeholders across society to further national strategic goals. Core literature includes old and new mission-orientation, grand challenges, as well as rationales about 'solvable challenges' and 'wicked problems'(e.g. Hicks, 2016; Larrue, 2021; Mazzucato, 2018a). Coburn et al (Chapter 13 in this *Hanbook*) show

how research targeting to address societal problems (in their case neglected diseases) can be affected by the way it interacts with existing research evaluation practice. A key characteristic of grand challenges is that they often involve diverse constellations of actors, especially civil society actors (Cagnin et al., 2012; Kuhlmann & Rip, 2018; Ulnicane, 2016; Weber & Rohracher, 2012). But research has found that civil society mostly gets involved as an additional party in constellations with more traditional innovation actors (Howoldt, 2021; Kallerud et al., 2013; Mazzucato, 2018b). These new missions, sometimes called grand challenges, are rationales that travel and get locally adapted, even if in practice the challenge is defined differently (Hicks, 2016).

Old and new mission rationales juxtapose the feats of 'public R&D programs…(like the) U.S. government-sponsored Manhattan Project or Project Apollo' with new societal missions that extend beyond technical matters and must be co-defined by a large number of stakeholders (D. Foray et al., 2012; Modic & Feldman, 2017). In their evolution earlier missions 'were designed, funded, and managed by federal agencies to achieve a specific technological solution for which the government was effectively the sole 'customer'; but new missions offer 'technological solutions to global climate change' to be deployed throughout the world by many different actors with very high investment from the public and private sectors (Mowery et al., 2010)(p.1012). In the space sector, original mission-oriented policies focused 'on clear challenges with identifiable concrete problems and directed by a strong centralized agency,' whereas new missions are broadly defined within a 'decentralized innovation systems with mixed top-down and bottom-up problem definition' (Robinson & Mazzucato, 2019)(p.936).

Another idea found in purpose motivations is *dual-purpose knowledge*, which reveals the limitation of describing PRF motivations in terms of curiosity or purpose alone. This assumes clearly defined boundaries between research that claims to pursue fundamental understandings and that which pursues application or to address societal challenges. However, research often does not lie clearly within either boundary and some have sought to explain the motivation behind such work. A prime example would be 'Pasteur's research on fermentation (which) simultaneously offered fundamental insights that led to the germ theory of disease and was of immediate practical significance for the French beer and wine industry' (Jaffe et al., 2007)(p.34). Daniel Stokes coined the term 'Pasteur's quadrant' to describe such 'dual purpose' knowledge (Stokes, 1997). In his seminal book, Stokes introduced two fundamental questions -whether research pursues fundamental understanding and whether it considers use. By framing the discussion in the context of these two purposes, Stokes brings to the reader's attention the notion of dual use or user-inspired research. Dual-purpose emerges from criticism of the linear model of innovation that faces off basic science against any consideration of use (Logar, 2011). Such a model makes science and use 'mutually exclusive' because it assumes basic research as the pursuit for fundamental understanding and an activity that is free from use considerations (Logar, 2011). Use oriented research has also been described as 'playing it safe' and 'not science in its truest sense because science is the process by which we define the unknown." (P. E. Stephan, 2012)(p.149). Stokes (1997) did not suggest 'turning the power of basic science to national needs' (p.151) as a way to displace basic research, but sought to bring together 'scientific integrity' to the use-inspired research that could be used to meet national needs in the United States.

The clash between the old mission paradigm or the market ideas and the new societal requirements and expectations gives a foundation to new iterations in which missions are again offered as a solution. The mission motivation is 'not just about throwing funds at problems but doing so in specific ways' (Mazzucato, 2018a). This involves a proactive state that wants to lead and 'business follows,' which differs from the old approach in that the state before took a role of 'a fixer of markets' (Mazzucato, 2018a). The scale of the problems sought to target by the new missions is novel (Ulnicane, 2016), but it still drawing on more traditional views about the social function of science and PRF. Critics also contend that 'our present understandings and practices of STI policy are not sufficient to address Grand Challenges and set priorities accordingly' (Kuhlmann & Rip, 2014).

Transformation

The transformation motivation implicitly questions the distinctions (e.g. between actors or sectors) found in the previous motivations and fosters 'hybrid' settings for PRF. It often emerges in connection to new purposes, such as the Sustainable Development Goals (SGD), that require a fundamental transformation of science-society relationships. The changing context of how scientific knowledge gets produced has enabled new interpretations of the relationship between society, science, and technology, and between the actors that produce, use and contest them. This motivation acknowledges that purpose or curiosity alone are not always transformative. It signals dissatisfaction with 'business as usual', and seeks to challenge it. The transformation motivation stems from 'frustration of insufficient or slow transformation' that seems to prevent major societal challenges from being eradicated (Borrás & Edler, 2020).

Part of the transformation motivation aims to better account for changes in knowledge production and the new relationships that have developed over time. Mode 2 emerged as part of the puzzle. Mode 2 'calls into question the adequacy of familiar knowledge producing institutions,' (Gibbons et al., 1994), including government research institutions. Mode 2 does not mean applied science 'because as yet there is no science to be applied in that context' (Gibbons, 2013)(p.1286). Actors in this mode may come from 'government laboratories, some from industry, and others from social action groups and concerned citizens, perhaps with no particular scientific training at all' (Gibbons, 2013)(p.1286), which is in accord with its transdisciplinary[iii] trait. The broadening and hybridization of knowledge production characterizes Mode 2 (Pfotenhauer & Juhl, 2017)(p.90), yet it signals increasing tensions around user involvement and the importance of local context in practice (Hakansta & Jacob, 2016). Collaboration tends to take varied forms, includes 'socially accountable decision making' (Logar, 2011) and exists 'only so long as the problem in hand requires them all' (Gibbons, 2013)(p.1286). Mode 2 has been characterized as a tempting concept but not as a change-agent or even good descriptor of social change, questioning whether it is just 'a metaphor, or just a catch phrase?' (Shinn, 2002). The forces described at universities 'are seen as quasi-natural and inevitable' (Pfotenhauer & Juhl, 2017)(p.90). In the case of Mode 2, it highlighted social utility and the organization of knowledge production. The Mode 2 framework[iv] suggests an interest in application with an acknowledgement of change in the organization of innovation and research, as well as an expansion in terms of its actors, users and beneficiaries. The changes associated with the transformative motivation seen in universities have also resulted in particular forms of performance-based research funding systems that aim for excellence, but in their execution 'may compromise other important values such as equity or diversity…(and) will not serve the goal of enhancing the economic relevance of research' (Hicks, 2012)(p.260).

Within this motivation there are also calls for re-visiting existing structures and systems of PRF. Ideas[v], such as responsible innovation or development, as well as an emphasis on inclusion, diversity, equity and access in STI, emerge as measures to optimise and broaden participation in PRF. Responsible innovation (Stilgoe et al., 2013), responsible research and innovation (von Schomberg, 2013)(also known as RRI), or broader impacts (National Science Foundation, 2014) address the interconnection between PRF, research practices, and the future that is enabled by them. The notions of RRI and broader impacts emerged in a policy context (Davis & Laas, 2013; Flink & Kaldewey, 2018), whereas responsible innovation has more academic roots that connect it to the study of ethical, legal and social aspects or implications of emerging technologies (Hilgartner, 2018; Swierstra & Rip, 2007)(also known as ELSA/ELSI). These distinctions connect the terms to practice and theory in ways that infuse the transformative motivation with different concerns. For example, that these ideas are supposedly too close to 'what politicians want and what gets funded' (Davis & Laas, 2013)(p.966), which runs against assumptions found within the creativity motivation about the expected benefits from the unpredictability of research. A criticism of PRF efforts in this area has been the mismatched expectations between involved actors, e.g. social scientists as 'mediators between nanotechnology and society' instead of being integrated into practices as scientists in their own right (Rip, 2009)(p.666). Also the 'practical barriers and cultural differences' within laboratories represent obstacles to achieving and enacting these ideas within science (van Hove & Wickson, 2017)(p.213). Ample work has explored and questioned the makeup of research landscapes by challenging the indicators used to assess them and calling for more diverse, equitable and inclusive participation. Cruz-Castro et al (Chapter 16 in this *Handbook*) explore differences in research funding for gender and underrepresented minorities; see also for example (Bird & Rhoton, 2021; Council, 2010; Francis et al., 2017; Goulden et al., 2011; Hodgins & O'Connor, 2021; Mcquillan, 2021; Meng & Shapira, 2010; O’Connor, 2020; Otero-Hermida & García-Melón, 2018; Page et al., 2009; Ratele et al., 2019; Shattuck & Cheney, 2020; Smith-Doerr, 2021; Smith-Doerr et al., 2017, 2019; Stirling, 2007). This work infuses the transformation motivation with a sense of self-reflection and change that calls for system overhaul. However, these calls for inclusion, diversity, equity and access often exist outside existing instruments for PRF or within specific research calls, which prevent them from becoming the norm.

More ambitious visions of transformation acknowledge that policy should give direction and support the generation, use and diffusion of innovations (Borrás & Edler, 2020) as well as call for new arguments to legitimize policy interventions (Weber & Rohracher, 2012). They contest the direction and form of technical change (Irwin, 2006). They acknowledge the interconnections that exist in socio-technical systems and understand that innovation does not always equal social progress and that many technologies fuel persistent environmental and social problems (Schot & Steinmueller, 2018). Optimizing existing institutions and practices is not sufficient to meet challenges, such as those posed by the SDG (Daniels et al., 2020). The need to restructure scientific research to meet society’s needs (Conn et al., 2021) raises questions about the ability of existing coordinating structures to meet this goal (Flagg & Garg, 2021; Fuchs, 2021; McNutt & Crow, 2020; Schot & Steinmueller, 2018). The relationship between inequality and innovation becomes salient in the transformation motivation highlighting the trajectory of high-tech solutions that assume particular infrastructures in place and high purchasing power (Kaplinsky, 2011). These visions also acknowledge that innovation policies remain ‘skewed, unfocused and limited’ (Borrás & Edquist, 2019)(p.2). The PRF landscape needs a ‘…more explicit, conscious approach to understand governance conditions’ that elicit the transformative change it envisions (Borrás & Edler, 2020). The transformative motivation brings attention to alternative futures and to the co-production of STI with society (C. Daniels et al., 2020). These visions of systemic change see policy as playing a role in supporting positive societal development and claim that it should be transformative (D. Foray et al., 2012; Kuhlmann & Rip, 2018; Schot & Steinmueller, 2018; Weber & Rohracher, 2012). And transformation should be the aim and a complement to policies that target market or system failures in directionality, policy coordination, demand-articulation and reflexivity (Weber & Rohracher, 2012). It calls for a PRF landscape optimized for different incentives (Flagg & Garg, 2021).

The transformation motivation, as presented here, grapples with concerns about the changing relationships within PRF, the need for institutional and structural change in order to engender more equitable and socially responsible knowledge systems, and ends with calls for systemic changes that can better respond to the complex needs of our society. In their quest for transformation, all these ideas embrace complexity differently – by describing it, by calling for new values or holistic responses, or by acknowledging the politics of policy change. But in all the ideas within the transformation motivation we run the risk that ‘that complexity is simply ‘black boxed’ and rendered unproblematic.’ (Flanagan et al., 2011)(p.701).

Conclusions

Throughout this chapter, we see a gradual move from individual curiosity to systemic explanatory models that aim to connect organization, actors and goals sought through PRF. The politics of purpose, as described here, ‘assume that stimulating innovation is positive, (yet) there is no deep engagement with the fact that innovation always represents a certain directionality’ (Schot & Steinmueller, 2018)(p.1562). This lack of engagement with the potential negative long-term effects of technology development gave way to more expansive and ambitious motivations that seek to challenge the ideals and governance of PRF. The transformation motivation articulates an increasing attention to PRF as a means to meet societal expectations (Husted et al., 2000) and encompass ‘a modernistic commitment to innovation and global growth …(that) encounters more democratic and inclusive perspectives on the necessity for, and direction of, such change’ (Irwin, 2006)(p.317). While this synthesis focused on the motivations found in the literature, I include two text boxes that illuminate their dynamic presence in STI policy beyond academic narratives.

Collaboration emerges as a common thread throughout the motivations described here, especially those about purpose and transformation. For them coordination, for example across actors, sectors and organizations becomes a necessary condition for success. Yet all the motivations in this chapter depart from a knowledge production system that ‘discourages scientists from helping contenders’ (Franzoni & Sauermann, 2014)(p.9), while prominently pushing for interdisciplinary research (Simon et al., 2019). In an interdisciplinary or transdisciplinary world, synthesizing the understanding from different disciplinary and practice contexts becomes crucial (Bammer, 2008)(p.877). Therefore, understanding the ideas, expectations and limitations embedded in the motivations informing PRF becomes critical to explain and grasp how they can shake the knowledge production systems in place. The fate of the most ambitious motivations for PRF depend not only on narratives, that for example put a primacy on collaboration, but on actors, actions, and institutions that value, integrate, and invest in them.

In short, the chapter focused on motivations for PRF because they shape choices that policy actors take (e.g. the design of funding schemes), have an effect on the relationships between actors/sectors, and become embedded into policy instruments. As Capano (Chapter 8 in this *Handbook*) explains, the relationship between motivations and instruments runs deep and represents an important source of policy dynamics. Therefore, it is crucial to take a step back and revisit the motivations that inform PRF, i.e. the ideas that shape what actors conceive as possible within them. The motivations in this chapter signal a recurrent concern between scientific inquiry and application, that at times appear as separate, but that seem to blur over time. One major criticism of these academic explanations has been that they have not yet given way to the concrete problems faced by policymakers (Borrás & Edquist, 2019) because they do not imply a 'one to one mapping between scholarly ideas and policy rationales' (Flanagan et al., 2011)(p.704). However, the chapter shows how the transformation motivation is based on an acknowledgement that society's needs require profound changes to the way we envision, structure and organize PRF.

Acknowledgements

My interest in writing this piece emerged from co-authored research in the *Isomorphic difference project: familiarity and distinctiveness in national innovation policies* project (Independent Research Fund Denmark (grant number 8019-00044B)) presented at the EUSPRI conference in June 2021. I am grateful to Professors Diana Hicks, Benedetto Lepori and Ben Jongbloed, who offered the chance of an in-depth exploration of some ideas from the original paper for this handbook. Their comments and suggestions strengthened this piece. Any errors are my own.

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[i] This model is often connected to Vannevar Bush (Bush, 1945) – see e.g.(Carayannis & Campbell, 2013), even though 'models of innovation' emerge in a later era (Godin, 2015). Additionally Bush did not propose a 'linear model' explicitly nor did he pioneer the conceptualization of innovation in a linear way (Pfotenhauer & Juhl, 2017)(p.90).

[ii] The triple helix framework is presented here as part of the market motivation due to its strong connection to entrepreneurship and the mix of actors and institutions it seeks to explain. One could also argue that in its construction and application, the triple helix also speaks to the transformation motivation but with the goal of turning research into wealth (Jacob, 2006).

[iii] 'Strictly speaking, it is neither multidisciplinary nor interdisciplinary because the knowledge elements that enter Mode 2 draw on sources beyond those of any set of disciplines (Gibbons, 2013)(p.1286).

[iv] This framework has seen developments towards Mode 3 knowledge production that acknowledges the existence of national innovation systems but emphasize their global embeddedness (Carayannis et al., 2015).

[v] There are other related ideas that due to space I did not include, but would be relevant, e.g. inclusive innovation (Agola & Hunter, 2016; Chataway et al., 2014), social innovation (Howaldt et al., 2021; Joly, 2017; Mulgan et al., 2007), grassroots innovation (Gupta, 2012; Smith et al., 2014; Smith & Seyfang, 2013), frugal innovation (Leadbeater, 2014; Radjou & Prabhu, 2014; Ratten, 2019), and innovation for inclusive development (C. U. Daniels et al., 2017; Organisation for Economic Co-operation and Development, 2012).