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Perspectives

Transforming innovation policy in the context of global security

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ABSTRACT

Historically STI policy is connected to national security and the military. Yet, contemporary innovation policy is rarely discussed in a security context. This perspective argues that new, transformation-oriented innovation policies should more explicitly consider (a) the side-effects of policies on global security and (b) how the global security context influences the achievement of transitions. This need is further extrapolated by the current period of rapid major shifts in the global security landscape. The perspective suggests that policymakers should be proactive in setting criteria and evaluating the security implications of innovation and transitions. Innovation policy should anticipate the side-effects of innovation and transitions. It should also be flexible. This means reflection on the different positive uses and cascading effects of innovations for transitions, and responses to geopolitical developments. Improved dialog between innovation policymakers and other policy domains, and between scholars from different disciplines is vital.

1. Introduction

Science, technology, and innovation (STI) policies play an important role in societal development. We have seen great historical and contemporary advances resulting from science and innovation. These include, for example, the spread of private motorized transport, automated industrial production, artificial intelligence, and large-scale renewable energy production. Some of these advances have had significant negative consequences on the natural environment, such as air and water pollution, loss of biodiversity and climate change. Thus, STI policies are increasingly needed to address the negative side-effects of the economic growth it has advanced. Since the early 2000s, increasing attention has been paid to the environmental effects of STI policies and how STI policies could contribute to solving environmental problems. For example, a perspective of integrating environmental considerations into the objectives and decision criteria for technology policy was proposed (Kivimaa and Mickwitz, 2006).

The 'directionality' failure of innovation policy was only pointed out a decade ago. Weber and Rohracher (2012) argued that innovation policy should not only aim for effectiveness and efficiency in promoting innovation activities. They suggested it needs to provide direction for transformative change by addressing major societal challenges. Recent years have seen the emergence of proposals to address this 'directionality failure'. Frameworks, such as Mission Oriented Innovation Policies (MOIP) and Transformative Innovation Policies (TIP) emphasize directionality by focusing on the United Nations Sustainable Development Goals. These frameworks are based on scholarly work drawing on sustainability transitions (e.g. Schot and Steinmueller, 2018) and public governance (e.g. Mazzucato, 2018) research. They have also received increasing interest in policy communities, such as the OECD and the European Commission (e.g. Casula, 2022; EC et al., 2020; Larrue, 2021).

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TIP and MOIP have been proposed as new, similar ideas contributing to the third frame (cf. Schot and Steinmueller, 2018), where innovation policy should more explicitly contribute to solving global environmental and societal problems, such as climate change and poverty. Transformation-oriented innovation policy is described as a shift of innovation policy agenda from economic to social concerns, and a changing understanding of what counts as innovation processes (e.g. Diercks et al., 2019; Fagerberg, 2018). It introduces new or strengthens emerging characteristics of innovation policy. TIP, for example, places particular attention to: (1) Directionality via the articulation of visions for innovation policies. (2) The involvement of an expanding and more diverse group of actors into the processes where visions are formulated. (3) Experimental approaches in co-creating such visions. (4) And new kinds of approaches to evaluating STI policies. (E.g. Ghosh et al., 2021; Molas-Gallart et al., 2021; Schot and Steinmueller, 2018).

Such policy approaches also open new questions and challenges. What counts as transformation? How to create transformative enough visions or missions for environmentally and socially sustainable transitions? How to avoid the dilution of directionality in bottom-up processes? And how to avoid too technocratic processes?

I discuss transforming innovation policies here in the context of global and national security. I argue that as innovation policy begins increasingly to take societal challenges to heart, policy processes should more explicitly consider the different side-effects of innovation policies. Such effects can range from environmental and social justice impacts to security. Actors implementing transformative ideas should also be increasingly aware of how the global context and interdependencies influence the likelihood of and means available to achieve transformative change.

I focus on the security perspective, as it is relevant for one substantial reason: We are living a period of rapid and major shifts in the global security landscape. These shifts influence, for example, resource extraction and availability, the likelihood of peace and conflict, societal stability, data and information flow, and how environmental and health problems are managed. Thus, the achievement of sustainability transitions, which require new resources, knowledge, actor-networks, and governance models, and which the transformation-oriented innovation policies aim toward, are dependent on this global context. The Russian Federation's recent attack on Ukraine demonstrates how several societal sectors (such as energy, finance, and food provision) connect to global trade and geopolitics. Hence, security is also relevant to innovation policy.

With security, I refer to the absence of threats or low risks regarding societal values, or sufficient protection against such threats (Baldwin, 1997). The term 'security' is often connected to the protection of certain values, such as territorial integrity, human survival, or environmental sustainability. However, it does not only mean the protection of nation states, but also of individuals, societal structures, technical systems, and humanity as a whole (Baldwin, 1997). Security can have both positive and negative connotations. Gjørv (2012, p. 836) argues that "negative security can be understood as 'security from' (a threat) and positive security as 'security to' or enabling." Hence, transformation-oriented innovation policies, and the ensuing transitions, may reduce or increase the likelihood of threats (negative security). They may also create conditions, such as improved social justice, that progress human well-being (positive security). I also use the term 'stability' in connection to security. Stability has been defined as the situation where violence is absent (Indele et al., 2018). It has also been described as the capacity to maintain state security and the ability to withstand and avoid political shocks, benefitting from governance elements, such as inclusion and participation (Cortright et al., 2017). Stability is, thus, an integral part of maintaining security.

In the following, I start by describing the historical connection of security to STI policy in Section 2. Section 3 describes the changing global security setting, and how it may be relevant for transforming innovation policy. Section 4 deliberates some ways in which innovation policies could better consider questions of global and national security, and Section 5 concludes.

2. Historical connection of security to science, technology, and innovation policy

The origins of STI policy, in the early days called as science and technology policy, lie in the aftermath of the second World War. Schot and Steinmueller (2018) argue that the first framing of innovation policy—innovation for growth, mass production and consumption—began, when "[*c*]oncerns about the future of the industrially developed economies manifested themselves following World War II". There was a connection to energy transition of that period. WWII played a significant influence on the shift to oil as a major energy source (Johnstone and McLeish, 2022). In the aftermath of the war, there was interest in an expanded role for the state in advancing scientific research that was expected to help maintain peace and create industrial profits (Schot and Steinmueller, 2018). The post-war STI policy in the United States defined the contribution to national security as one of its tasks (Lundvall and Borrás, 2005). There was, thus, an early connection between global stability and the emergence of innovation and technology policy. In fact, during 1948–1989, the geopolitical tension known as the "Cold War" linked to defense-related R&D and is claimed to have fed into the emergence of national innovation systems (Mowery, 2012), categorised as the second framing of innovation policy (Schot and Steinmueller, 2018).

From then on, it was mostly the economic growth agenda that steered STI policy in many countries – with the exception of military R&D (c.f. Mowery, 2012). The degree to which national security has contributed as an objective has varied (Lundvall and Borrás, 2005). In the 1970s, following two global oil crises, energy security was associated with STI policy. The oil crises undoubtably led to selected R&D programmes to develop energy efficiency. Yet, for example, the OECD report on innovation systems in 1997 hardly mentioned energy. The oil crises led to slow growth, structural problems, and unemployment in the global economy; this is when the frame of national innovation systems began emerging (Fagerberg, 2018). The innovation system -oriented approach co-existed with a more 'laissez-faire' approach, where framework conditions for innovation are provided but selecting specific sectors or technologies is avoided (Lundvall and Borrás, 2005). Both have, however, predominantly focused on economic advancement as the key goal of innovation policy.

Subsequently, economic growth pursued via innovation has led to multiple environmental problems. These include, for example, unsustainable levels of energy resource use (most notably hydrocarbons), climate change, pollution of natural environments, and over-exploitation of natural resources. The expansion of such problems has gradually changed the focus of innovation policies. They have increasingly resulted in calls for innovation policies that are more systems-oriented and aim towards transformative environmentally beneficial and societally 'just' change.

3. Global security as an important context for innovation policy

This perspective is interested in how transitions, advanced in part by innovation policies, affect and are affected by different considerations of security. Further, I argue that these considerations should be better acknowledged ex-ante in innovation policy. Security considerations occur at different scales: the global, geopolitical scale and the national or regional scale as a potential setting for societal conflicts or disruptions in socio-technical systems.

3.1. Global, geopolitical scale

We live in an era of rapid and major shifts in the global geopolitical and security landscape. Besides the Covid-19 pandemic, the world is influenced by the securitisation of the economy and decoupling of US and China relations (Fjäder et al., 2021), increasing demand and competition for energy (Fadly, 2019; Kivimaa and Sivonen, 2021), growth in hybrid influence by major states such as China or Russia (Wigell, 2021), and tightening security interests and hydrocarbon exploitation in the Arctic following polar ice retreat (Morgunova, 2020, 2021). Besides these somewhat longer-term changes, Russia's attack on Ukraine reveals more sudden geopolitical shifts. While these changes are gaining increasing attention, for example, in the context of energy[1] or cyber space, they have been relatively little addressed in the context of innovation policy.[2,3] As an exception, Edler et al. (2021) note that growing geopolitical uncertainties and threat of global trade conflicts place attention to the principle of technology sovereignty.[4]

In the energy sector, a major shift is occurring via the phase out plans for fossil fuels for several countries. When the transformation from oil and coal to renewable energy and increasingly electricity-based and digitalised energy systems happens in a wider scale, it has major implications on global geopolitics. The power balance, now based on hydrocarbon producers, will change, giving more emphasis to the availability and supply of critical minerals and metals (Goldthau and Westphal, 2019; Scholten et al., 2020). The supply chains for the latter are largely controlled by China. In Europe, increasing attention is paid to critical materials, the natural deposits of these materials being relatively limited. For example, a half of European cobalt production is based in a small Northern European country, Finland. However, 98% of rare earth elements used in Europe are provided by China (EC, 2020). China has also set conditions on how technologies, using some of the critical materials it sells, must be produced on Chinese soil (Criekemans, 2018). Chinese ownership is also evident in the supply chains of technologies. For example: a Finnish company Valmet Automotive starts to produce electric vehicle batteries to increase domestic supply, while the company is part owned by a Chinese battery maker.[5]

Access to critical materials and technological components bring new security of supply considerations (Lee et al., 2020; Overland, 2019), also noted by the International Energy Agency (IEA, 2021). The availability of critical materials is paramount for many transitions currently relying on digital technologies. These include the energy transition based on renewable energy and smart grids, the transport transition relying on electric vehicles and green hydrogen, and transitions to more virtual services. This also places new needs for transformation-oriented innovation policy, to support circular economy solutions and alternative materials as an effort to reduce the impact of potential supply disruptions.

In addition, transformation-oriented policies need to address the social consequences of transitions, such as poor conditions in mining regions of the Global South (to improve positive security in those areas). For example, the transition to electric vehicles increases the use of lithium and cobalt mined in illegal or poorly regulated mines. Cases from the Republic of Congo show the use of child labor, poor treatment of women and significant local environmental impacts of mining (Sovacool, 2019). Conflicts created in such conditions can also have globally cascading security consequences.

Another security challenge forms around the uncertainty regarding how major hydrocarbon producing countries will react to energy and transport transitions—and other countries' transformative policies to advance these transitions—creating risks of regional or global instability (Scholten et al., 2020). For example, Algeria is dependent on fossil fuel trade with Europe, and a shift to renewables can create social conflicts and out-migration (Desmidt, 2021). Some have argued that Russia will be a greater threat, when it can no longer resort to the political leverage from hydrocarbon supplies, if other countries do not help it to decarbonise (Tynkkynen, 2019). Yet, the unfolding of events since February 2022 in Ukraine show that, Russia threats European security even when significant energy trade is taking place between Europe and Russia. The geopolitical reactions of hydrocarbon producing countries may have diverse

[1] For example, in the context of energy, new literature on the geopolitics of renewable energy and energy transformation is addressing the globally changing context (e.g Blondeel et al., 2021.; Scholten et al., 2020).

[2] There is emerging recognition and interest on security addressed in foresight reports published by the European Commission's DG on Research and Innovation (Focken et al., 2021; Ricci et al., 2017).

[3] Also, sustainability transitions research has largely ignored this topic (see Kivimaa & Sivonen, 2021).

[4] Technology sovereignty has been defined as "as the ability of a state or a federation ofstates to provide the technologies it deems critical for its welfare, competitiveness, and ability to act, and to be able to develop these or source them from other economic areas without one-sided structural dependency" (Edler et al., 2021, p. 2).

[5] Finland Seeks Investors to Build Electric Vehicle Battery Industry - Bloomberg (accessed 14 June 2021).

impacts on the advancement of sustainability transitions. The recent events show, however, how geopolitical conflicts create a need to accelerate the zero-carbon energy transition, while in some hydrocarbon-rich countries the effect can be contrary. Potential trade-offs may be created between energy transitions and global or national security. This dilemma places a need for information exchange and coordination between innovation policy, climate policy, international relations, and defense.

3.2. National-regional, socio-technical and societal scale

Transitions in the mobility, energy and digital domains show a rising sector-dependency, often referred to as 'sector coupling' (Andersen and Markard, 2020). This is demonstrated especially on the national scale, while sectoral boundaries go also across national boundaries. Socio-technical systems around mobility or energy can also be organised on a more regional scale. Sector coupling means that any security risk or effect, for example, in the telecommunications system, has more direct implications on the operation of energy or mobility systems than before. Sector coupling is often suggested to improve the flexibility of the energy system. However, this means that a 'disruption' (cf Kivimaa et al., 2021.) in one system affects the others more directly than before. For example, energy systems relying on digitalised electricity networks are more dependent on ICT than energy systems based on fossil fuels and their stockpiling. The tightening of systemic interdependencies can easily lead to cascading system shutdowns. This is another dimension that should be considered in transformation-oriented innovation policies, the networks they create and funding allocation, requiring improved interaction with other policy domains.

Linking to internal security in the national scale, growing polarization of views, the rise of far right, far left and populist politics is evident. Far-right political parties tend to be more opposed to action on climate change (Żuk and Szulecki, 2020) and, hence, transformative policies more generally. Populist politics is argued to be incompatible with ambitious climate policy due to its effects that weaken political institutions and fact-based public debates (Vihma et al., 2021). This also connects to the deliberate weakening of trust for democratic institutions.

Extinction Rebellion, described as a non-violent disobedience movement and driven by "radical hope" (Stuart, 2020), represents opposing values to those of the far right. It has created nonaggressive conflicts with those that oppose substantial climate action. The increasing divide between extreme movements creates risks of growing internal conflicts within European countries. This is already visible, for example, in the widespread negative reactions of others to yellow vests protests in France or the peaceful but traffic-blocking demonstrations of Extinction Rebellion in Finland (that are both using their democratic rights to protest). This divide in values and creation of tensions can also be seen spatially "between the urban cores driving change and innovation and the peripheral hinterlands that are challenged to adapt to… uneven development outcomes" (Skjølsvold and Coenen, 2021, p. 4). Thus, accelerating transitions with transformation-oriented innovation policies may face more visible resistance and requires attention to the perceptions of different societal groups. Wanvik and Haarstad (2021) have argued for the need to reformulate transitions as driven by conflict and instability in order to look beyond the narrative focused on proliferation and upscaling innovations.

Initiatives to promote 'just transitions' are one way to increase societal stability and reduce security risks, while not sufficient on their own. Measures, such as the European Just Transitions Mechanism or the Just Transitions Commission in Scotland, have brought justice to the agenda on par with tackling environmental problems. Academic research is shifting from (primary) focus on employment concerns and costs to broader considerations of social justice (e.g., Bazilian et al., 2021). Thus, transformation-oriented innovation policies should try to anticipate the justice implications of scaling environmental innovations, which impact societal stability, and consider different options.

4. Opportunities for more explicitly addressing security in transformative innovation policy

The examples above show that innovations as solutions to global sustainability challenges have complex interactions. They have both positive and negative effects on global security and stability. Thus, innovation policy initiatives, such as TIP and MOIP, should consider the side-effects of scaling niche innovations and of the disruption of dominant socio-technical systems. Further, innovation policy should reflect and react to changes in global security and geopolitics, as these developments might hinder the achievement of transformative visions or missions.

Security can be connected both to the conceptualisation of transformation-oriented innovation policies, and the practicalities of innovation policy. Below, I exemplify how security is connected to TIP.

TIP already addresses some security concerns implicitly by focusing attention to environmental challenges. Such efforts can contribute to improved environmental security, societal stability, and human wellbeing. Local or regional improvements may reduce the magnitude of cascading risks with potentially global implications. Some consideration of stability, indirectly, is also included in the TIP's aim of 'inclusivity' (Akon-Yamga et al., 2021; Schot and Steinmueller, 2018) and acknowledgement of growing inequality (Diercks et al., 2019). Involving multiple stakeholders, also those in more marginal positions, may improve societal stability. However, how the processes of creating directionality and the evaluation of TIP consider security is less certain. Global security could, for example, be built in the processes that co-create visions. The side-effects on security could be evaluated at different scales.

Practically, the measures that can be taken in innovation policymaking, from setting objectives and designing strategies, to concrete instruments and funding decisions is trickier. So far, the extent to which innovation policy strategies, innovation programmes, and funding criteria consider the globally changing geopolitical landscape has been limited. This is perhaps partly, because it is a rather new idea to consider transformative goals or missions for innovation policy, which will increase the importance of geopolitical developments to the policies' success. This is also a difficult balancing act. One must consider the implications of innovation policy, while also maintain the elements of serendipity and independent science (see Lundvall and Borrás, 2005, p. 606, regarding the latter)

Table 1
Example questions for innovation policy to consider security.

Objective setting and strategy design	Are risks and opportunities arising from a changing global security setting considered in innovation policy planning? Are the importance of security risks and opportunities assessed for transformation-oriented innovation policies? Is there any coordination between innovation policy and security/defense policies? Are explicit aims to reduce future security risks included (e.g., security of supply, or conflict reduction)?
Policy instrument design and implementation	Do ex-ante or ex-post impact assessments of policy instruments include also effects on global or national security? Are means to improve positive security, via inclusion and justice, included in the instrument mix? Are assessments made of the resource and material implications of the funded technological developments, if such technologies were applied in a larger scale? Are there personnel with expertise in security or international relations to inform instrument design and implementation?

and not overwhelm innovation agencies with too many new responsibilities. These deliberations may benefit from connections to the discussion on responsible innovation. For example, the four dimensions of responsible innovation—anticipation, reflexivity, inclusion, and responsiveness (Stilgoe et al., 2013) —could be adaptable for security-related innovation governance.

Innovation policy organisations can address security, for example, by anticipating potential global developments, conducting ex-ante and ex-post assessments of the security implications of policies, and improving their knowledge on security and geopolitics Table 1. illustrates some example questions as a starting point:

Concluding remarks

This perspective argued for the need to better consider global security and geopolitics as part of transformation-oriented innovation policies. Considering the recent events, where Russia attacked Ukraine, this is more pressing than ever.

We are moving from old to new dependencies in a rapidly changing global context. This requires thinking, for example, the resource requirements of advanced transformations and their implications on global security. Geopolitical conflicts can also rapidly curtail the availability of critical resources or accelerate transitions, as shown by European states' and major companies' quick reactions to break dependency on energy trade with Russia

Policymakers should be proactive in setting more specific criteria and evaluating the global security implications and dependencies of new innovation policies and innovation funding. A reactive approach alone —which responds to new problems by creating new solutions—is not enough. Research on socio-technical transitions shows that innovation can create new path dependencies, the lock-ins of which are difficult to re-open later. Yet, innovation can also have many unforeseen positive consequences. For example, many military innovations, such as lasers, have had socially important uses later. Thus, transformative-oriented innovation policy approaches need to couple an anticipatory approach with analysis of the potential side-effects of transitions. They should also be flexible. This means reflection on the different positive uses and cascading effects of transformative innovations, and responses to geopolitical developments.

Different mechanisms that recognize side-effects and global developments need to be developed. This also means that improved dialogue between innovation policymakers and other policy domains, and between scholars from different disciplines is vital. Innovation policy and transitions scholars should seek collaborations with researchers of international relations and those with sociological, philosophical, and historical perspectives. Innovation agencies, in turn, need to increasingly look for crossovers not only with the energy, mobility and agri-food domains in transition, but also with those in charge of internal affairs, foreign policy and defense.

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