**Developing and enacting Transformative Innovation Policy: A Comparative Study**

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**Abstract**

The contemporary world is confronted with a number of grand social and environmental challenges such as social inequality and climate change. Traditional innovation policies, focused on the provision of R&D funding, building innovation systems and promoting entrepreneurialism, are proving increasingly incapable of addressing these challenges in a satisfactory manner. Hence in recent years there has been a turn towards a different framing of innovation policy, placing emphasis on alternative futures and the co-production of science, technology and society, the non-neutral nature of technology, transformative potential of civil society, and attentiveness to the needs and wants of users and non-users alike. In this paper we tease out the basic features of this emergent framing which we call transformative innovation policy. Based on the experience of five countries – Columbia, Finland, Norway, South Africa, Sweden – we outline various attempts to pursue transformative innovation policies, exploring associated challenges, barriers and pitfalls.

**Introduction.**

Numerous and critical interlocking environmental, technological, economic, political and cultural challenges confront our world. They include resource depletion, population growth, industrialization, urbanization and inequality. These are collective challenges expressed in 17 Sustainable Development Goals (SDGs; United Nations, 2015). They concern both the developed and developing world, and they exceed the ability of any single country, body of governance or scientific discipline to manage them. Whilst innovation is widely invoked as essential to addressing these challenges, the innovation engine often appears to be faltering with the fruits of creative destruction increasingly morphing into destructive creation (Soete, 2013). Innovation may become as much part of the problem as the solution. The ambivalent and open-ended nature of innovation needs be incorporated into the thinking about science, technology and innovation policy. We suggest that policy needs reformulating to achieve the incorporation of a concern with the choice of various innovation options asking questions about which directions of innovative pathways will indeed help face the interlocking challenges. This type of thinking and framing has begun to be articulated under many different labels, for example, Responsible Research and Innovation (Stilgoe et al., 2013), inclusive innovation (Agola and Hunter, 2016), social innovation (Mulgan 2007; Joly, 2016), frugal innovation (Radju and Prabhu, xx). While differing in many aspects the basic themes of these

approaches seem to be recurrent: attention to alternative futures and the co-production of science, technology and society, emphasis on the non-neutral nature of technology, stress on the transformative potential of civil society and attentiveness to the needs and wants of users and non-users alike.

Integral to the new approach to science, technology and innovation policy should be a concern with the transformation of socio-technical systems rather than a focus on technological innovation in specific industries, and sectors. This concern is inspired by the sustainability transitions literature (Grin et al., 2010). The main argument for the need for transforming these systems is that optimizing existing institutions and practices in energy, healthcare, mobility, agriculture, food, mobility, communication and water management will not lead over the medium and long term to an adequate response to defined societal challenges such as the ones captured by the SDGs. Problems are embedded in the fundamental framing of socio-technical systems and reforms which ameliorate externalities and negative impact may extend the life-span of existing socio-technical configurations but will not resolve underlying problems. For example, changes to taxation may lead to welcome redistribution but will not provide incentives for different patterns of investment in innovation and economic growth which could have a more direct and lasting impact. Investment in health systems may lead to short term improvements in people's ability to access health care but long term pressures on health budgets and demographic change mean that more radical changes in health, social care and approaches to wellbeing will be needed (Broerse and Grin, 2017).

Over the past year working within the context of a new global Consortium of Science, Technology and Innovation funders and agencies we have begun to document the emergence of new ways of framing policy in specific country contexts and to explore ways in which analyse and promote research based approaches to further development of a new policy approach. The Consortium has named this new framing Transformative Innovation Policy (inspired by Schot and Steinmueller, 2016 but see also Steward, 2012 and Weber and Rohracher, 2012). It is underpinned by theoretical perspectives from a literatures on innovation, transitions/transformation and also relates to broader sets of literature, including political economy perspectives and evolutionary economics, which question and address the relationship between science, innovation and social and economic priorities and benefits. However, it is clear that transformative innovation policy needs further development into a compelling narrative about its prospects, a set of demonstrators how it can be done, and a network of people and institutions capable of implementing it. .

The Transformative Innovation Policy Consortium (TIPC) was formed in 2016 at the SPRU 50$^{th}$ anniversary conference, and designed to allow members to co-create understanding about new ways to use science and innovation to directly address social, economic and environmental challenges. In its pilot phase a mapping exercise combined with case studies is done to build up a picture and understanding of science and innovation policy in each location and existing efforts to move policy in a different direction. In the future TIPC will conduct experiments in science and innovation policy and funding aimed at developing insight into effective ways how of contributing to transformative change responding to the UN Sustainable

Development Goals.

In this paper we provide background to TIPC, an overview of the work of Consortium so far and next steps. The paper concludes with a number of focused questions about the nature of transitions and transformative change. The following questions underpin this paper:

1. How can we differentiate between ways of framing research and innovation policy?
2. What are the elements of transformative innovation in each of the five countries; and, how does each country combine different innovation policy approaches (or policy mixes) to promote transformative innovation?
3. What are some of the emerging issues involved in promoting transitions and enacting transformative innovation policy? What are some of the challenges, barriers and potential pitfalls?

Below based on Schot and Steinmueller's first paper (2016) we briefly characterise two dominant policy frameworks and introduce a third alternative. And appendix provides an overview table which fleshes out the three Frames. Next we provide a summary of initial work to map different types of innovation policy by five founding member of the Transformative Innovation Policy Consortium, covering the following countries: Norway, Colombia, South Africa, Sweden and Finland. We then consider some of the questions and issues that the consortium will work with as efforts to develop frame 3 initiatives progress. We conclude with a description of next steps and planned activities for TIPC members.

**Three frames for STI policy**

Before presenting different ways of framing research and innovation it is important to caveat the analysis. We recognise that the frames below are not water-tight categories and neither are they static. Frames 1 and 2 overlap and informed each other and will continue to do that with respect to each other and Frame 3. And even in its nascent stages, Frame 3 represents a variety of types of policy framings and interventions aimed at directly addressing social, environmental and economic issues with research and innovation. These characterisations of different frames should be seen as evolving and an attempt to better understand the orientation and nature of policies and interventions broadly rather than as detailed and finalised categories.

*Frame 1: R&D leads to innovation*

The conceptualisation of the relationship between R&D and innovation in this frame is quite straightforward. Research leads to innovation - the key challenge is to spend money on research in an enabling way. This frame emerges out the 2nd World War and in the aftermath of the scientific milestones that occurred in those years as a result of significant investment in R&D. The main justification for spending money in research under this frame of thinking revolves around market failure. It is not possible for private

sector funders to recoup investment in basic research and a 'tragedy of the commons' arises - no one entity from the private sector will invest in the public good of knowledge. The frame provides a rationale for why the state, therefore, needs to step in to fund basic science and research. In response, governments in Europe and in the US began to expand the research funding architecture and institutional support mechanisms such as peer review and other 'supply-push' mechanisms begin to take hold.

The decades that followed from this expanded investment in science and technology witnessed a rapid growth in new technologies and economic growth, along with the expansion of sectors and industries such as agriculture, aviation and transport and health. However, alongside this rapid growth came new challenges to environment and health and a raft of negative consequences of technological advances begin to emerge (not unlike was seen after the industrial revolution). In keeping with the predominance of science and scientific expertise, these environmental and health consequences from the 1960s onwards are dealt with through science based regulation and a parallel infrastructure begins to emerge to link experts with policymakers around regulating science and innovation (see for example Jasanoff, 1990).

The implications of this approach resulted in the dominance of the so-called 'linear model' of innovation. While we now appreciate that the rhetoric of such a linear model never captured the complexity of the innovation process, it nevertheless prevailed in policy circles for many years and is still influential in 'pure' or modified forms that see the State investing in the supply of basic and more applied R&D.

*Frame 2: Innovation Systems*

During the 1970s and 1980s, increased economic pressures and international competition began to expose the limitations of the first policy framework. Differences in country's ability to withstand economic shocks became more apparent and the lack of substantial progress in bridging the gap between the poorest and richest countries in the world caused concern.

One major issue that analysts such as Richard Nelson and Eric Von Hippel began to note is that research does not flow freely. Knowledge is 'sticky' and tacit and difficult to transfer. Countries also do not follow a similar path, varieties of development pathway continue to persist. Development is bound in complex ways with the institutions that produce it. Evolutionary economists such as Paul David, Brian Arthur, Giovanni Dosi and others began to write about the importance of path dependence in innovation – essentially arguing that countries should follow their own established pathway, and not try to break from established routines and practice in order to follow an idealistic model.

To capture these complexities, a wide variety of scholars from different disciplinary and intellectual backgrounds increasingly began to refer to a variety of innovation systems (Freeman, Lundvall, Nelson). The capacity, capabilities and nature of the relationships between organisations and institutions in any 'system', be it national, regional or sectoral, deeply impacts the rate and nature of research which occurs.

This framework shifts attention from the creation and diffusion of research to consideration of how institutions and organisations function, and interact (and create demand for research). In this conceptualisation, it is the learning and absorptive capacity between different actors in the system which emerges as increasingly important, as well as entrepreneurship (the availability and readiness of actors to bring research to the market).

*Frame 3: Transformative innovation policy*

In the last decade, science, technology and innovation have been widely invoked not simply as the foundation for future growth strategies but as an important component for resolving a range of social issues such as environmental and health challenges. The view of research and innovation as socially-relevant in a multiplicity of interdependent ways, as well as economically-beneficial has led to increasing recognition that the first two policy frames are not well suited to this ambition and goal because neither conceive of research and innovation in ways targeted to the scale of transformation that is needed.

The relationship between research and innovation in this frame is not focused on ensuring innovation happens (as fast and as much as possible) but about the direction of innovation. A differentiating feature of frame 3 is therefore the conception of directionality failure (Weber and Rohracher, 2012; for the notion of directionality see Stirling xxx). In frame 1 the challenge is to overcome market failure and in frame 2 it is to link up organisations and make the institutions and actors which enable effective relationships for research translation into innovations with (commercial) impact. The aim is overcoming institutional failure and shaping markets. Rather than market or institutional failure, Frame 3 grapples with directional failure, or 'needs failure' – a failure to discuss how to meet social and environmental needs with STI (acknowledging that these needs are not predefined or given but are to be explored in the process too). Meeting needs depends on bringing together a diverse understanding and engagement of a wider range of stakeholders across all stages of research and innovation pathways, in a non-linear ways and a stronger shift to a culture of co-production. Routed in theoretical work on socio-technical transitions and long term transformative change, initial thinking about Frame 3 indicates that experimental approaches which will challenge existing socio-technical patterns are vitally important. Even where new macro level institutions emerge and signal the need for new direction, such as international treaties or national laws, any profound change will revolve around bottom-up socio-technical transitions achieved through opening up for a range of options, experimentation, learning, networking, and participation. This thinking underpins the work of TIPC.

**How does each frame address social, economic and environmental challenges?**

Whilst frame 3 is explicitly aimed at directly addressing societal challenges, each of the frames is, in principle, able to address social needs and environmental issues. Frame 1 would suggest mission oriented

R&D focused on challenges associated with social needs and the environment, and regulation and the organization of a social benefit system to compensate those left behind. It is a supply driven model which focuses on breakthroughs. Although links with the markets and users are recognized as important success factors for innovation, the main emphasis is on stimulating investment in an effective way. While this frame can integrate needs by allocation of research funding in areas pertinent to addressing social and environmental needs (e.g. medical research on new vaccines; clean tech programs), typically it does not enable sustainability transitions/transformations and inclusion of new non-research actors into the frame which are central elements in frame 3. Frame 2 would suggest intervening in existing national systems of innovation to achieve better alignment and coordination (e.g. innovations in the coordination between medical research and health care delivery) or stimulating entrepreneurship in relevant areas. Initiatives using this framing can and often do include a wider array of actors, yet focus on process and product innovation, learning and incremental change. It does not focus on radical change, and it leaves civil society actors at the periphery. In sum for both frame 1 and 2 a deeper transformation which would align social & technological change and redirect mobility, energy, food, agricultural and healthcare systems away from unsustainable pathways is not a core aim. Instead the focus is on stimulating innovation in order to generate economic growth. Questions about the directionality embedded in these innovation are not put central.

Frame 3 puts the issue of directionality front and center. It would suggest anticipating and experimenting with new approaches to innovation for social and environmental needs that goes beyond a focus on creating knowledge or improving innovation system functioning, and focuses directly on creating conditions for socio-technical system change. Here the main rationale for policy is transition/transformation head on. Frame 3 policies are open-ended, focused on learning, and bottom-up emergence of transformation, while keeping the transformation rationale up as a main driving question (Schot and Steinmueller, 2016).

Frames 1 and 2 on the one hand and Frame 3 on the other hand are following a distinct conception of how STI policies contribute to achieving public welfare and a clean environment (see figure 1). This figure shows that a main difference between frame 1 & 2 on the one hand and frame 3 on the other hand is that the former get to public welfare/clean environment through the stimulus of economic growth and regulation, while the latter encourage addressing public welfare and a clean environment in the innovation process itself assuming economic growth will follow too (albeit one with a different content). Please note that missing from the figure is that frame 3 incorporates the notion of directionality, which might also lead to a redefinition of economic growth.

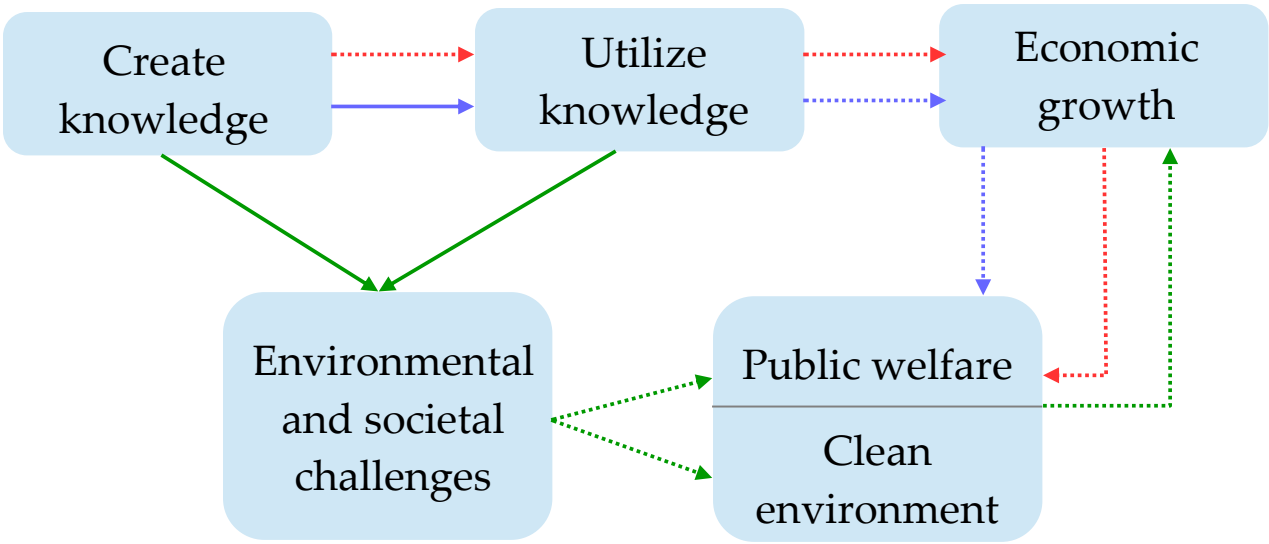


*Figure 1: STI policy frames and how they aspire to achieve public welfare and a clean environment. Different colours refer to different frames (red – frame 1, blue – frame 2, green – frame 3). A solid line indicates an aspect that has been explicitly addressed by the frame (e.g. the link between knowledge creation and utilization in frame 2), whereas a dashed line indicates an aspect that is expected to follow automatically once some prior activities have been conducted (e.g. the utilization of the results of basic scientific research by industries in frame 1 or regulation which corrects failure). A summary overview of the three frames is presented in table form in the appendix to this paper.*

**Using the three frames to map STI policy in consortium countries**

The Transformative Innovation Policy Consortium (TIPC) is in its pilot phase and part of the work associated with this phase has been to map research funding and innovation initiatives using the '3 Frames' as the basis for discussion and analysis. Here we offer a very brief stylized summary of some of the findings from this mapping exercise conducted in existing TIPC member countries – Colombia, Finland, Norway, South Africa and Sweden. We focus on how countries are moving towards incorporating Frame 3 perspectives. Mapping was achieved with background research carried out by SPRU and TIPC partners and in the context of country based workshops.

Sweden's Challenge Driven Initiative (CDI) exemplifies how some Frame 3 elements are being incorporated in current programmes. Initiated by Vinnova, CDI is designed around four challenges 'future healthcare', 'sustainable attractive cities', 'information society 3.0' and 'competitive production'. These go beyond simple Frame 1 funded research programmes aimed at social and environment needs because they include innovations in how end-users are engaged and networking. They span multiple thematic and sectoral areas with an environmental sustainability context. VINNOVA has also instigated the The Strategic Innovation

Programme (SIP) where agenda's have been defined in consultation with stakeholders across public, private and civil society sectors. The SIP approach is designed to foster more radical departures from existing social and technological trajectories through delegation to implementation actors. It involves considerable delegation of managerial authority from central VINNOVA staff to programme leads.

An important feature of the programme is that regular evaluation allows overall monitoring and evidence to feed into decisions about direction and progress of programmes and the initiative as a whole. VINNOVA has also plans to move more to an experimental approach to system innovation through the creation of national policy labs which would allow shielding from regulations which prevents further developments.

Finland has the BioNets programme administered by TEKES and other agencies. BioNets is 'bottom-up' in that the goals are defined by the stakeholders themselves. Finland also has a number of initiatives which come from sector based programmes, and are experimental by nature. Reconceiving transport as the provision of 'transport services' along with accompanying regulatory and procurement initiatives is an example of efforts to experiment with new sociotechnical systems and alter the direction of innovation. A programme for encouraging inclusive innovation in low and middle income countries and a new strategic research funding initiative to address 'wicked problems' (ones involving incomplete or contradictory knowledge and opinion, potentially major economic costs, and intricate inter-dependencies) by the Academy of Finland have also been instigated.

Norway has adopted a different route into this new terrain by drawing heavily on Responsible Research and Innovation (RRI) thinking to guide efforts. RRI underpins four programmes funded by the Research Council of Norway (RCN): Research Programme on Biotechnology for Innovation (BIOTEK2021), the Research Programme on Nanotechnology and Advanced Materials (NANO2021), the Initiative for ICT and digital innovation (IKTPLUSS) and the Programme on Responsible Innovation and Corporate Social Responsibility (SAMANSVAR). BIOTEK 2021 in particular evidences a commitment to meeting social challenges. Innovation Norway also runs an initiative called Dream Commitment, a brainstorming process involving a broad cross section of Norwegian society in thinking about future social challenges.

The 1994 National Development Plan laid out the significant challenges that South African policymakers needed to address. Relatedly, the 1996 Science and Technology White Paper, the 1999 National Research and Technology Foresight, and the 2002 National Research and Development Strategy have all laid out means for trying to link research and innovation to socio-economic and development goals. To this end the Department of Science and Technology (DST) overseas a multi-pronged approach. A number of research-led programmes which link to economic and social challenges fall under the National Research Foundation (NRF) and the DST, which operates a tax deduction initiation to encourage investment in R&D to generate employment. These initiatives are governed by Frame 1 implementation modes. An array of recent

initiatives, governed by Frame 1 but to a larger extent, Frame 2 elements, aim at more direct involvement and coordination of stakeholders, with a view to achieving specific social and environmental outcomes. These initiatives include the Renewable Energy Independent Power Producers' Procurement Programme (RE IPPPP), and DST-led Technology for Rural Education and Development (Tech4RED) – a programme with six key components: ICT, Nutrition, Health, Water and Sanitation, Energy, and Science Centre. Other examples include support for the National Health Insurance (NHI), and programmes targeted at low income segments of the population, for example, a DST grassroots innovation initiative. The Department of Higher Education and Training (DHET) is also reconstructing finance packages to facilitate inclusion.

Recent initiatives in Colombia that target research and innovation on social and economic goals are also linked to specific development initiatives in addition to a continuation of policies and programmes to support economic development goals and to better articulate science, innovation and development. The 2011-2014 National Development Plan lays out broad ranging approaches to linking across research and innovation to sustainable growth and competitiveness across different sectors and areas. These initiatives might have Frame 3 rationales but are dominated by Frame 1 and 2 features in their operation. Colombia supports multiple schemes supporting potentially socially relevant research. However, the social innovation programmes falling under the National Strategy for Social Appropriation have moved policy towards linking knowledge creation and social goals in more direct and targeted ways. 'Ideas para el Cambio' launched in 2012 and 'A Cienca Cierta' launched in 2013 both initiated by Colciencias and funded by the Inter American Development Bank (IDB) take different approaches to making knowledge accessible and useful to local communities. The first engages in public or private sector researchers in technological problem solving. The second engages community groups in identifying possible solutions to social and environmental problems and makes their suggestions accessible to others by storing them in a database. Ruta N, an initiative in Medellin to create fablabs, creative labs and business accelerators highlight the potential importance of municipalities in instigating Frame 3 type approaches. The General Royalty System (GRS) that channels significant funds for STI investment to the regions provides the potential for both decentralization of governance and a change in focus of funding of STI to support regional initiatives that can have a big impact on inclusion. A particular challenge for Colombia will be to ensure STI policy has a positive impact in the post-conflict regions where working education, health, housing and agricultural policies will be critical

**Discussion based on results of mapping STI policies and discussions within Consortium**

*All three frames are visible*

All five countries provide evidence of a move towards a Frame 3 rationale. The need to address societal and environmental needs through STI policies is recognized and an emerging set of initiatives have already

been put in place to implement the new rationale. All consortium member countries are experiencing a different range of economic, social and environmental challenges and these challenges shape both the articulation and implementation of Frame 3 approaches. Cultural and political histories are important and also account for some of the differences in particularities. For example, the importance of consensus and bottom-up approaches in Sweden, the legacy of apartheid in South Africa and of conflict in Colombia have all played a role in shaping the content and institutional features of emergent Frame 3 approaches. Whilst it is true that Frame 3 policies are still marginal, they are presented as critical and in some cases as part of urgent and priority policy agendas. There is a weight of expectation which whilst reflecting a clear the need for new directions in policy may present problems if policies do not deliver rapidly. Each country has its own specific approach and its own narrative around the emergence of research and innovation policies targeted at social, economic and environmental challenges. In Norway a move towards a more knowledge based economy is accompanied by a move to using Responsible Research and Innovation (RRI) thinking to make research and innovation more responsive to societal demands. Sweden is developing green business as it restructures its industrial base and using state supported research and innovation to support that transition. Colombia's emerging Frame 3 policies are interwoven with its peace process and attempts to overcome regional divisions. South Africa's Frame 3 type policies are closely aligned to broader transformation of an economy based on the legacies of apartheid and integrated into efforts to overcome exclusion and unemployment. Finland's development of Frame 3 policies are integrated into initiatives aimed at overcoming economic crisis, and making up for the loss of Nokia.

In all five countries, the differences between the Frames are implicit rather than articulated. This has consequences for the way in which policy is developed, for the way it is implemented and for the way it is monitored. It also seems likely that lack of a more clearly defined Frame 3 agenda may limit consideration of a more formal reflection of how different framings of policy and instruments associated with them might or might not support or hinder each other and what gaps might exist. Rather, there is an implicit assumption that policies and instruments associated with them can be easily combined. There is also limited consideration of new instruments and mechanisms that might need to accompany changes in how organizations fund research and build networks. Frame 3 aims are largely pursued using Frame 1 & 2 instruments.

Yet some Consortium members are currently grappling with how to integrate frame 3 elements more explicitly and develop policy interventions and build clearer conceptual apparatus to guide policy development, implementation and evaluation. One expression of this is that during the mapping process two consortium agencies began to think about a more extensive mapping exercise that would map all instruments and programs onto the multilevel perspective (MLP) representation of transformative change in order to identify gaps in instruments. Here, niche experiments would be thought about in relation to

changes needed to facilitate broader meso-level change and in relation to support or obstacles presented by broader policy tools and environments. This kind of exercise would potentially have many benefits including encouraging reflection on 'policy mixes' which could facilitate successful transition (Rogge and Reichardt, 2015) and political economy factors which facilitate or impede transition and transformation (Byrne and Mbeva 2017).

The balance across the three policy research frames emphasising Frames 1 and 2 are very likely to be the subject of ongoing debate. Part of the complex management issues related to developing Frame 3 will be in defining where and how it intersects with policy and interventions rooted in other frames. This poses important questions about how best to achieve potential synergies across frames and across key actors and organisations associated with each frame. For example, will housing Frame 3 instruments and approaches alongside Frames 1 and 2 type funding mechanisms increase their prominence and impact or increase their vulnerability to capture or further marginalisation? This may well depend on the extent to which Frames 1 and 2 initiatives begin to define themselves in relation to new approaches and the kinds of links that are or are not built between the three frames. For instance, if traditional Frame 1 research outputs are systematically made accessible to socially and environmentally oriented initiatives will there be effective feedback from these initiatives that increase the pace of innovation and foster alternative directions. Similarly, if traditional network and linkage initiatives begin to incorporate social goals will those wishing to include other Frame 3 features be effective in arguing for different configurations of actors, practices, and governance processes?

*Actors and new management and organizational practices*

In each country, the constellation of actors involved in initiatives with Frame 3 characteristics and ambitions is different. In all countries, traditional funders of research and innovation have played a key role. Thus there is evidence that funders are seeking to move more to a role of change agent for transformative change. This is far from straightforward of course. Initial analysis suggests that this maybe linked to the point made previously that explicit articulation of Frame 3 rationale, and theories of change for how to address societal and environmental challenges through STI policies are missing.

The active involvement of multiple government ministries, and a host of local actors, include grassroots innovators, informal economy actors, and civil society and city actors is key to Frame 3 initiatives. Involving a multiplicity of actors does not necessarily mean constructive or non-rivalrous relationships between them, and transformation processes typically will induce and provoke conflict, e.g oppositions and a diversity of views and positions. This can be productive since it might lead to second-order (or deep) learning, yet obviously it can also lead to noise and non-action, or even counter-action. Whether or not conflict exists, frame 3 approaches add complexity of participation, and this again raises questions about

management and appropriate management and governance arrangements. One of the aims in the case studies that we will introduce later in the paper is to explore the way in which conflict and disagreement is handled.

A host of questions need to be asked in relation to the way that more engaged agendas develop. Will 'bottom-up' participative mechanisms actually reflect the need for more radical transformation to achieve environmental or particular social goals or will they reflect lowest common denominators and a series of compromises that may need to be made? Or might more radical agendas be captured by powerful interests? In Sweden, an OECD assessment indicates that whilst the CDI programme builds explicitly on action oriented approaches involving multiple stakeholders, including end-users and gives those users more responsibility in implementing and monitoring projects, the outcomes are quite conventional. The same OECD report notes that the SIP programme, whilst also seemingly built on the need for more radical change in innovation trajectories and new patterns of engagement between stakeholders, maybe reflecting the more traditional short term growth oriented objectives of powerful industrial partners (Coenen et al, 2017).

Another question often asked is whether the relationship between actors should be managed through administrative coordination such as in various inter-ministerial committees or even national science, technology and innovation council? Or might this approach run counter to the experimental ethos which Schot and Steinmueller (2016) suggest might play a crucial role in the development of Frame 3 approaches? In that case the best option is perhaps not to focus on administrative coordination but engage a range of actors in new initiatives to ensure coordination on the ground.

*Experimentation*

The Frame 3 perspective contests the idea that there is a best or optimal approach to achieving the socio-technical innovations necessary for meeting social and environmental needs. It therefore focuses on experimental approaches. Experimental approaches in this case do not imply that randomised clinical trials are the most appropriate means of progressing policy. The levels of contextual difference and variation are too great to make that approach the most relevant vehicle for learning or establishing good practice, and the focus on a broad change process cannot be captured through RCTs. Experiments have to be seen as instrument contribution to niche formation. The relationships between niche experiments, socio-technical transition and transformation is an important component of theoretical framework underpinning TIPC work (Schot and Steinmueller, 2016)). This includes a focus on shielding, nurturing and empowering of niches. At the same time a destabilisation of prevailing socio-technical systems is seen as a necessary condition for enduring change too. Another aspect of analysis that is highlighted by the need to view smaller scale niche experiments as triggers for the introduction of more radical change is the need to

develop thinking and understanding of the political economy of frame 3 initiatives. Recent work on political economy perspectives makes a strong argument for 'discursive institutionalist' approaches to political economy analysis (Kern, 2011; Byrne and Mbeva, 2017) which are particularly relevant to situations characterized by high degrees of uncertainty in which actors may not full understand their interests (Hudson and Leftwich 2014). From this perspective it is important to focus on ideas and discourses, as well as interests and institutions.

In all of the countries participating in TIPC, experimentation with new practice and discussions on new directions for innovation policy can be discerned (while destabilization policies are not present). In South Africa, the triple challenge of eradicating inequality, poverty and unemployment is the backdrop for new initiatives which devolve responsibilities to local communities, seek to support grassroots based entrepreneurialism, and bring stakeholders together for improvements in education. There is also an indication of broader involvement of actors in Colombia in a limited range of programmes with a particular emphasis on articulating problems from a community level and expressing these online to encourage ideas for solutions from a variety of sources. Policies and programmes that specifically link research to social goals are oriented to traditional actors but also supported by a new National Strategy supported by taxation on mineral royalties. A regional development bank has also played an important role in helping to bridge broader development efforts to science and research policy. In both countries, however, experiments with new configurations of actors and more decentralised initiatives are secondary to efforts aimed at maintaining or improving traditional science, technology and innovations institutions. A similar conclusion can be drawn for Norway, Sweden and Finland for their responsible research and innovation initiatives, and their challenge led and strategic programmes.

In all five countries, there are examples of important experimental initiatives of local municipalities, cities or regional authorities in promoting Frame 3 approaches. In terms of fostering experimental approaches, creating space in broader regulatory, organisational and institutional frameworks for these initiatives is a significant issue. An important question might be how we connect these initiatives, upscale them and make them transformative. This question can be answered on a national but also transnational scale. This connecting up work might be an important role for national funders and innovation agencies.

*Role of funders*

The Consortium's composition focusses attention on the role of national research funders on the balance between the Frames and the understandings and definitions of social and environmental needs. Because research funders have an ongoing responsibility for the knowledge infrastructure and because they are major players in the national innovation systems it would be surprising if they chose to cast aside

established practices of governance and evaluation mechanisms which supports that governance. However, conventional indicators associated with spending on research are powerful and shape as well as measure behavior. Governance and evaluation are key to the extent to which Frame 3 are able to take root in policy environments.

The experimentation with practice noted in previous section involves an ongoing set of changes in the structure of governance which involve both dispersal of administrative control to other actors and assumption of a more active role in the implementation of initiatives. The principal type of dispersal is in the definition of initiatives where it now seems broadly accepted in all the countries that local (in terms of geography or sector) definition of objectives and the means of meeting those objectives is desirable. This change, in turn, leads to other questions concerning governance.

Where traditional funding arrangements might focus on well-established actors, new initiatives are likely to involve a multiplicity of organisational types, most of which are less formal and perhaps less stable than the traditional actors. This has implications for the funding agencies' roles in monitoring activities and making interventions during the life of particular projects. It also suggests a less arms-length relationship between the funding agency and those who might seek to be included in new initiatives. To what extent do funding agencies need to develop new capabilities for promoting the availability and assisting in the application for support for social and environmental initiative that have Frame 3 elements (broader participation, openness to experimentation, and attention to issues of anticipation or foresight)?

*Evaluation*

We are at an early stage with developing evaluation tools and perspectives for transformative change. Frames 1 and 2 are associated with a variety of supply, networking and demand policy interventions. The relative success of those interventions can be measured against theoretical and practice based expectation and learning. Frame 3 initiatives are making use of some of the same mechanisms in targeting social, economic and environmental challenges but as yet little thought has been given as to whether new instruments are needed or whether different combinations of policies may be combined in novel ways to achieve different aims and objectives and whether initiatives that do not achieve immediate goals should be judged to have failed. In summary, the following issues and evaluation criteria will be important to consider as part of developing Frame 3 policy thinking for evaluation:

1. Democratisation of deliberation and choice with regard to goals and possibly implementation (with the accompany question of how to democratise governance and evaluation). How can these criteria be built into evaluation frameworks?

2. Explicit consideration is needed of means to disrupt existing arrangements that are negatively affecting or blocking paths to meeting social and environmental needs (not only 'bad' prospective innovations but existing innovations that have negative implications). What is the best way to identify and evaluate the impact of negatives?
3. Explicit pursuit of experimental approaches based upon the logic that a) more of the same (policies, practices, etc.) produces more of the same (outcomes, perpetuation of policies and practices) and b) a prior or ex ante knowledge of best alternatives is unavailable without experience. But adaptation will be important. How can we promote adaptive approaches?
4. Existing evaluative frameworks and methods reinforce existing practices and bias planning and implementation toward prioritising traditional goals. Nonetheless, new evaluative frameworks and methods are needed for accountability. Can ex-ante methods and theory of change approaches be helpful here?
5. A broader scope of analysis is needed to anticipate alignment in changes with specific socio-technical systems in the direction of more profound change. What should be the indicators and signs of change that we identify and use?

These questions are at the core of the evaluation and accountability analysis that TIPC hopes to develop and will be important as consortium members progress experiments in Frame 3 policy. What makes an experiment worth doing? Can an experiment that fails to achieve its initial objectives be seen as an investment with a social return? If there is not a universal path to transformation, how can we evaluate the nature of transition? How can we assess when a particular initiative is to generate higher order or double loop learning (learning useful insights about the larger process in which the initiative is lodged that will positively influence the definition and implementation of future initiatives)? At present, the mapping work suggest that Frame 3 initiatives are being undertaken because of their self-evident value – i.e. because their objectives are consistent with address social or environmental challenges. In some cases, particularly in the cases of the Scandinavian countries, initiatives have been taken under the premise that better outcomes might be possible by more 'bottom up' definition of initiatives. In either case the eternal evaluative question – how can we know whether progress has been achieved? – is relevant.

Work in this pilot phase of TIPC will inform the development of broader evaluation approaches and the development of Frame 3 based theories of change. These evaluation strategies needed to be rooted in theoretical understanding of the relationships between niche experimentation, socio-technical transition and transformation, political economy perspectives as well as initial learning from the mapping exercise and the case studies which discussed in the next section. Currently, the lack of explicit articulation of Frame 3 rationales and logics is a barrier to being able to develop more precise thinking about what specific partnerships, networks, interventions, instruments and policy tools are meant to achieve (Marjanovic et al,

2013) to developing a more coherent approach to developing Frame 3 thinking. Learning and adaptation is central to Frame 3 thinking and so the ability to continually iterate between intended impacts and outcomes and implementation is vital.

Theories of change and development of Frame 3 narratives may be usefully supported by various type of 'futures' and ex-ante evaluation work. Consortium members have begun to think about this. For example, Finland and Norway are to some extent integrating foresight activities into current efforts to link research and innovation with targeted social and environmental goals. Foresight, and other futures techniques, may well be an important tool for provoking more creative and radical approaches to transformation. Scenarios based approaches, particularly those that are agent based and look at how behaviours may change and evolve could help both in designing and monitoring work and encouraging experimentation. Using futures work in developing theories of change may also be a way to counter the inherent conservatism (the tendency is to look for evidence that approaches have worked in the past not to consider the scenarios which may allow them to work in future) in ex-ante evaluation of proposals for Frame 3 type work.

## 3. Next steps: Developing case studies

Consortium members are currently working on a series of case studies which will enable further analysis of the factors that promote and impede attempts to focus research and innovation directly on social and environmental goals. They will also be used to strengthen theoretical underpinnings related to frame 3 transitions and transformative policy. This in turn will feed into development of realist theory of change based evaluations that will be used to evaluate and monitor progress in work on frame 3 'experiments' which will follow this pilot phase of TIPC.

Cases cover diverse areas but have been selected according to the following principles: 1) directionality: focus on alternative futures associated with technological design choices; 2) goal: focus on grand environmental and/or social challenges; 3) impact: focus on socio-technical systems and system-level issues; 4) degree of learning and reflexivity: focus on second-order learning, problematization of operating routines of different actors and the creation of spaces for experimentation; 5) conflict: focus on disruptive change, possibly resulting in major disagreements between actors; 6) inclusiveness: focus on initiatives with a broad base of participation, including the consideration of non-users as potentially affected parties.

Data will be collected through semi-structured interviews and the analysis of policy documents. A workshop with stakeholders will construct transformative innovation histories. Use of this methodology

will help to ensure that although the case studies are diverse, there will be value in comparing across these attempts to formulate and implement frame 3 approaches. The case studies are as follows:

**TEKES, Finland: Smart, low-carbon mobility solutions for passenger transport.**

The project's principal aim is to reduce carbon footprint by developing sustainable and smart mobility solutions. Over the past decade, Finland has had over 20 projects, both public and private, seeking to challenge and change the socio-technical system. These initiatives can be viewed as niches for wider system transformation. This case study will build an understanding of the strengths and weaknesses of these attempts at niche experiments.

**Research Council of Norway: Responsible Research and Innovation (RRI) within the Biotechnology for Innovation (BIOTEK2021) programme.**

This is a large-scale, long-term project with various actors from across the biotechnology sector. Its flagship, the 'Centre for Digital Life Norway' (DLN), was created to enhance collaboration between life sciences, informatics, mathematical sciences and engineering. This programme has progressed furthest in Norway in the adoption and development of RRI and has led to their 'Framework for Responsible Innovation'. By examining this case-study, the country team can examine how RRI develops as part of a Transformative Innovation Policy 'toolkit'.

**Department for Science & Technology, South Africa: Cofimvaba's Technology for Rural Education and Development (Tech4RED).**

In collaboration with the Department of Education (DoE), this transformative innovation initiative investigated a range of technologies and measures that could address rural education and development challenges in South African. The main components of Tech4RED are: ICT and Education, Nutrition, Water and Sanitation, eHealth, Energy, and Science Centre. Each component involves a range of stakeholders including government (national, province, district and local), academia, industry, and civil society. Although spearheaded by the DST, partners in the Cofimvaba Tech4RED initiative, for example in the ICT and Education component, include the DST, Department of Basic Education (DBE), schools with the District, the Eastern Cape Department of Education (ECDoE), and the Department of Rural Development and Land Reform (DRDLR). In the Nutrition components stakeholders include CSIR, Agricultural Research Council (ARC), Nestle, and schools; while in the Energy component, stakeholders include Eskom, Municipality, schools, and industry actors - Anglo-American Platinum, Clean Energy Investments, and Air Products.
The conceptualisation, design and implementation of Tech4RED is influenced by various policies which together helped to shape the context within which Tech4RED operates. Some of the core policies are: The National Development Plan; National ICT R&D and Innovation Roadmap; The

Department of Education White Paper on e-Education; The National School Nutrition Programme; The National e-Health strategy 2012-2016; and, Schooling 2025. . The Tech4RED programme is comprehensive, holistic, and child-centred while also incorporating families and wider communities. The case study explores aspects of the programme and draw out learning from this complex and ambitious initiative.

**Vinnova, Sweden: Challenge-driven Innovation initiatives (CDI).**

This case study illustrates one of the central principals of examination for TIP. How can we turn social and environmental challenges into opportunities for growth through the development of innovative solutions? By going straight to the heart of societal problems and seeking direct solutions to them, growth could be created by addressing challenges and directly improving public welfare. Not by (as the dominant innovation policy paradigm assumes) orientating to innovations that address primarily economic factors first, and that then, assume that growth from these will raise living standards. CDI focuses on four areas: 1) future healthcare; 2) sustainable attractive cities; 3) information society 3.0; 4) competitive industries. From a transitions perspective, these CDI initiatives mainly aim to facilitate niche development and the case study will allow initial analysis of progress to date.

**Colciencias, Department of Science, Technology & Innovation, Colombia: Inclusive Innovation in coffee sector**

The Colombian coffee industry has been an arena of learning and innovation for best part of 90 years. A remarkable feature of the Colombian coffee sector is that whilst it is an internationally competitive sector, the suppliers are overwhelmingly independent micro and small agricultural producers. Through a combination of technological innovation, institutional entrepreneurship and support of STI policy, the coffee sector has provided a viable and sustainable livelihood. Important social features such as sustainability, participation, quality of life, fair trade, R&D and technical assistance have featured. Further, a balance appears to have been maintained between human and natural resources. This case study will investigate the degree and manner in which frame 3 elements played a role in the process. Also whether social and technological niches evolved to support transformational processes, and how the regime, region and sector institutions may have aligned priorities to protect and nurture the evolution of inclusive niches? How too were capabilities and other inclusive features “scaled up”?

**Conclusion**

This paper has provided an overview of both thinking behind transformative innovation policy and the

Transformative Innovation Policy Consortium (TIPC) designed to foster new approaches to science and innovation policy. It is clear that the journey of TIPC has just begun.

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**Appendix 1: 3 frames summary**

The table below is a selective mixture of ideas relating to the three frames of research and innovation policy. The table aims to function as a simplifying device so that the distinctiveness of each frame can be easily grasped at a glance. This leads to certain implications:

Avoidance of excessive specification: yes, each frame is more nuanced than the table allows and has also developed over time (for example, innovation systems literature has started to pay attention to civil society, entrepreneurship approaches have started to talk about social entrepreneurship). The simplifications in the table are made purposefully, reflecting a trade-off between precision and clarity. It is always possible to add more nuance and complexity in the text describing the literature around each framework.

Choice of criteria: ideally the table should not contain too many criteria, otherwise it would become too difficult to follow. This indicates a (future) need to agree on the crucial ones. Admittedly, there is much work to be done in this regard.

Exclusivity: as a general rule, cells in each row should differ substantially from each other. Therefore, criteria common to all or most of the approaches should be avoided where possible. Moreover, since the frames are cumulative with each partly reacting to but also building on the previous ones it is sensible to construct the table in such a manner that each cell would focus only on the novel additional features of each frame.

Symmetry: the essential differences between the frames should be outlined symmetrically (e.g. "conflict vs. consensus" should be specified for each frame, not only some of them). If this creates difficulties with filling the table it indicates some gaps in current thinking that require additional reflection. However, it is not necessary to achieve symmetry for criteria containing descriptive characteristics (such as "typical policy activities" for which the number of activities in each cell may well differ).

Finally, the table proposes that frame 2 contains two variants. In reviewing policy frameworks in the existing five consortium countries we note that within the national systems of innovation framing there are a number of variants and in this table we have delineated more and less market-based approaches and have begun to characterize a market-based approach ("entrepreneurship"). The latter can be seen as an application of a more general neoliberal approach to the domain of innovation policy. Hence we have highlighted the distinctive emphases of each with (a) and (b) where appropriate.

**3 FRAMES: A COMPARISON**

**Input provided by:** Johan Schot (SPRU), Ed Steinmueller (SPRU), Laur Kanger (SPRU), Tuomo Alasoini (Tekes)

| | Frame 1: R&D | Frame 2: systems (a) and entrepreneurship (b) | Frame 3: transformative change |
|---|---|---|---|
| **Time of dominance** | 1960s-1980s | 1980s to today | Emerging |
| **Main geographical focus** | National | National and regional systems of innovation intersecting with sectoral and technological innovation systems (a)/ National with particular attention to "centres of excellence" or "clusters" of innovative activity (b) | Multi-scalar: focus on grand challenges that extend to multiple scales exceeding geographical, sectoral, technological and disciplinary boundaries |
| **Focal actors** | Government, scientists and industry actors with a tendency to prioritize large firms | Interlinked configurations of government, science and industry actors with particular attention to the role and missions of universities (a)/ enterprises, markets and the government with a particular focus on New Technology-Based Firms and start-up culture (b) | Government, science, industry, civil society, end-users and non-users (as potentially affected parties and contributors to the innovation processes) |
| **Justification for policy intervention** | Fixing market failures: industries fail to conduct basic scientific research that is not fully appropriable or conduct less of this research than socially desirable | Fixing institutional system failures, including failure to generate entrepreneurship: increase in R&D spending does not automatically lead to high performance in terms of innovative activities. NB. System refers to set of links between actors as in national system of innovation | Fixing transformational socio-technical system failures: R&D, innovation systems and commercialization do not lead to solving important social and environmental problems |
| **Main strategy** | Knowledge generation: provide | Knowledge utilization: boost absorptive capacity; increase | Solving social and environmental |

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|---|---|---|---|
| | support for basic and applied science | system performance by creating of links between actors and facilitating mutual learning (a)/ promote entrepreneurship and facilitate the creation of markets for innovative goods and services (b) | challenges: more space for experimentation with niche solutions enabling socio-technical systems change and tilting the institutional and regulatory regime field towards transformative change of socio-technical systems |
| **Nature of critical knowledge** | Appropriate and transferable: easy to adopt, apply and utilize without protective measures | Sticky and situated: utilization requires proximity, absorptive capacity and interactive learning | Emergent and co-produced: generated through dialogue between multiple actors as part of a collective search process |
| **Focal areas** | High technology: stress on the creation of radical novelty | Radical and incremental product and process innovations: stress on significant price/performance improvements through successive incremental innovations | Socio-technical systems: stress on fundamental transformation of system architecture, changing both its components and its directionality of development |
| **Typical policy activities** | 4. R&D stimulation (subsidies, tax credits, procurement, mission-oriented programmes)<br>5. Building the Intellectual Property Rights regime<br>6. Education policy with | • Constructing links between actors (building platforms, networks, databases) and organizing technology transfer<br>• Stimulation of learning-by-doing, learning-by-using, learning-by-interacting<br>• Use of demand stimuli (e.g. procurement) to enhance | • Stimulation of experimentation with niche technologies, scale-up and acceleration of socio-technical transitions (e.g. Strategic Niche Management, innovation intermediaries, Transition |

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|---|---|---|---|
| | emphasis on Science, Technology, Engineering and Math (STEM) subjects<br>7. Science communication to explain the importance of STEM to wider public<br>8. Foresight to select focus areas, regulation and technology assessment to manage negative impacts | and accelerate market development<br>• Building regional and national systems of innovation by assessing capabilities gaps and technological opportunities, implementing policies to address them<br>• Enhancing skill development based on proactive analysis of skill gaps and shortfalls<br>• Programs to stimulate entrepreneurship and incubators (including indoctrination in the social value of entrepreneurship)<br>• Improving business conditions for Small and Medium-Sized Enterprises and start-ups<br>• Addressing the nature of equity markets (mezzanine level finance, IPO, inclusion in exchanges), especially angel and venture capital markets | Management)<br>• New institutional solutions for changing the directionality of existing R&D and innovation activities (e.g. technology forcing, Responsible Research and Innovation, policy mixes for stimulating niches and destabilizing existing systems)<br>• Promoting social, inclusive, frugal and pro-poor innovation<br>• Bridging science/engineering, social sciences and humanities in the education system |
| **Underlying model of innovation** | Linear model: invention (discovery) leads to innovation (commercialization) leads to diffusion (adoption) | Interactive and system-bound: chain-linked model stressing feedback loops between invention, innovation and use; evolutionary model, stressing ongoing interactions between actors, networks and institutions resulting in path-dependency (a)/demand-pull model – needs of organizations and individual consumers largely drive innovative activities (b) | Socio-technical and experimental: quasi-evolutionary model including non-random (purposeful) variation, selection and retention while accepting emergence as main dynamic; stress on feedback loops between invention, innovation and use, and ongoing interactions between actors, networks, institutions and technologies across |

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|---|---|---|---|
| | | | scales. Focus on circulation and appropriation instead of diffusion |
| **Basic assumptions about innovation** | • Division of labour: clear division of labour – government provides, science discovers, industry applies and consumer adapts; increase in R&D will automatically translate into more innovation<br>• Conflict vs. consensus: most often embedded in a military-industrial complex that takes defence needs as forerunners and large industries as the "natural" intermediary to translate scientific advances into commercial application; open conflict with new firms and industries that are not part of the club<br>• Technological and social progress: the link between the two is largely uncontested | • Division of labour: multiple closely interacting actors with different but partially overlapping roles contributing to the overall performance of the system (a)/ clear division of labour – the task of the government is to facilitate the operation of existing markets and to create markets where they do not yet exist; left to themselves markets provide novel products and services at optimum quantity and price (b)<br>• Conflict vs. consensus: evolutionary in rhetoric but functionalist in practice, emphasis on cooperation and orchestration between various actors, leading to the fulfilment of system functions (a)/ tends to be conflict-oriented, mainly stressing international competitiveness of states and competition between enterprises (b)<br>• Technological and social progress: the link between the two is largely uncontested | • Division of labour: blurred boundaries, multiple actors crossing various domains and enacting overlapping roles, resulting in the co-production of science, technology and society<br>• Conflict vs. consensus: mix of competition, cooperation and intermediation is required to achieve disruptive socio-technical systems change<br>• Technological and social and environmental progress do not automatically go together: technology choice is not neutral, but contains societal choices and directionality with implications for equality and the environment. |

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|---|---|---|---|
| **Basic assumptions about outcomes** | • Dealing with consequences: new technologies are associated with high degree of uncertainty and unpredictability making it virtually impossible to address major environmental and social impacts proactively<br>• Causality: stress on innovation as a motor of economic growth leads to public welfare as a bonus | • Dealing with consequences: largely reactive, major environmental and social impacts are usually addressed after they have occurred, sometimes with a particular emphasis on the provision of adequate market stimuli (b)<br>• Causality: stress on innovation as a motor of economic growth and increased competitiveness leads to public welfare as a bonus | • Dealing with consequences: proactive, stress on anticipating alternative futures associated with certain technological choices<br>• Causality: stress on innovation as means for directly addressing environmental and social challenges leads to economic growth and increased competitiveness as a bonus |
| **Main hazards** | • Government failure: insufficient funding for basic R&D<br>• Market failure: negative externalities that require regulation | • System failure: innovation system fails to perform as a synergistic whole and to enhance innovative activities (a)<br>• Government failure: too many state restrictions on business activities (b)<br>• Market failure: regulatory need to deal with negative externalities in a way that would not stifle entrepreneurship (b) | • Transformative failure: failure to induce fundamental transformation to socio-technical systems forming the backbone of modern societies<br>• Societal and environmental needs failure: failure to solve extra-economic and collective problems on multiple scales |
| **Parallel counter-narratives** | • Appropriate Technology movement, focus on small-scale solutions | • Politics and democratization of Science and Technology<br>• Inclusive and interactive technology assessment | • Technological fix: strong state intervention with massive investment in Big Technologies which promise to solve large |

environmental and social problems

- Social innovation: move away from technical solutions which are perceived as part of the problem