Transformative policies for sustainable innovation systems

Lundvall, Bengt-Åke

2022

Document Version:
Other version

Lund Papers in Economic History

No. 239, 2022

Transformative policies for sustainable innovation systems

Bengt-Åke Lundvall

DEPARTMENT OF ECONOMIC HISTORY, LUND UNIVERSITY

Transformative policies for sustainable innovation systems

Bengt-Åke Lundvall[*]

Abstract

In this paper, we criticize attempts to present narrow perspectives on innovation policy as reflecting the use of the concept innovation system as policy framing. While it is correct that innovation policy, at least until recently, has given priority to economic growth and low priority to global challenges such as climate change and income inequality this is in no way immanent in the innovation system concept. To illustrate, we introduce concepts and perspectives related to the innovation system approach which are particularly useful, when it comes to develop innovation policies aiming at system transformation. They include the uneven rhythm of respectively incremental innovation, radical innovation, and technological revolutions, shifts in technological paradigms, system transformation at the organisational level and the distinction between policies aiming at path dependent innovation promotion and policies aiming at system change. We also point to the usefulness of the learning economy perspective that has been developed in close connection with the innovation system literature. We conclude that there is a need to combine different theoretical framings as inspiration for transformative innovation policy. In addition, we argue, first, that all these framings need to have a double focus on climate change and global income inequality and, second, that they all need to go beyond national perspectives and consider policies aiming at system transformation at the global level.

Keywords: Innovation system; Transformative innovation policy; Learning economy; Global governance; Climate change; Income inequality
JEL-codes: N70; O30

[*] Professor Emeritus, Lund University and Aalborg University. Contact: bal@business.aau.dk.

1. Introduction

The concept 'transformative innovation policy' (TIP) was launched some years ago by scholars at or around Science Policy Research Unit (SPRU) at Sussex University (Schot and Steinmueller 2018) taking their main inspiration from scholars with their background in Science, Technology, Society-studies predominantly and with original affiliation at Dutch universities (Geels 2002; Geels and Schot 2007 and Grin, Rotmans and Schot 2010). The SPRU-scholars have also organized an international platform for research on transformational innovation policy (Chataway, Daniels, Kanger, Ramirez, Schot and Steinmueller 2017).

The Schot and Steinmueller paper is programmatic in promoting transformative innovation policy framing as alternative to innovation policy based either upon neo-classical economics or upon innovation system analysis. To begin with, the paper is ecumenical arguing that all three framings may be useful, when it comes to move society away from unsustainable paths, but at the end it is stated that the old knowledge base (economics of innovation) has to be substituted by a different one (sustainability transition studies, STS and governance) (p. 1564). Given that SPRU has a history of productive co-existence between innovation studies and STS-studies this is a remarkable statement.

Policy framing is a nebulous and slippery concept that refers simultaneously to theoretical foundation and actual policy practice. The authors construct the three framings through a selective reading of theoretical literature and with few references to actual policy experiences. They do not reflect upon the well-known fact that transferring theoretical concepts into the sphere of policy is in itself a transformative process. Such transfers are characterized by selectivity, with the policy versions adapted to a policy sphere dominated by power, vested interests, path dependency and pragmatism. To illustrate, the OECD-version of the national innovation system concept is quite different (more compatible with neoclassical economics) from the theoretical version as developed by scholars such as Freeman, Nelson and Lundvall (see Chaminade et al. 2018).

The article leaves the reader with the impression that there exist two reasonably well-established framings now challenged by a new framing ready to substitute for the old ones. The paper does not inform readers that the Dutch tradition in STS has been around for several decades and that scholars from this tradition have made earlier attempts to substitute the concept socio-technical systems for the innovation system concept (see for instance Geels 2004). The fact that the sustainability transition approach has been tried out, as a kind of policy experiment, in the Netherlands the first decade of the new millennium (Kemp and

Rotmans 2009) is not mentioned and there is no attempt to draw lessons from this – not unproblematic (see Fagerberg 2018) – specific transfer of STS ideas from theory to practice.

It is certainly tempting to go through the article in detail and point to inadequacies in its criticism of the old approaches and in the postulated advantages of the new one. To anyone well versed in the innovation system tradition it is obvious that some of the claims are going too far. This is the case, when the authors claim that the innovation system perspective imposes 'a unique path of catching-up on low- and middle-income countries based on experiences from the North' and as when they claim that there is 'no room for diversity, conflict and dissent' in the innovation system framing (p.1565).

The issues at hand are too important to let them drown in sectarian warfare, however. We share the authors' view that there is a need to rethink 'innovation policy' in the light of global challenges and that it is useful to think in terms of transformational change. We also find some of the ideas in the STS-tradition useful, not as substitutes for the other two perspectives but as complementing them. In our discussion, we go beyond all the three proposed framings and argue that they have in common that they underestimate the need for radical institutional change in terms of both the predominant mode of production and the mode of global governance.

In the next section, we sum up briefly, what we see as the core contribution of the Socio Technical System approach. Section three indicates some of the lessons that can be learnt from the Innovation System approach. Section four discusses how the concept the learning economy can inform transformational policies. Section five argues for the need to simultaneously address ecological and social sustainability, while section six goes beyond national systems and points to the need for global system transformation.

We conclude that while the three framings are complementary and may serve as inspirations for transformational innovation policy, they all need to consider the need for radical change in current modes of production and global governance. We end the article by recommending scholars of transformation to give more attention to the work on shifts in techno-economic paradigms by Christopher Freeman and Carlota Perez.

2. What we can learn from the Socio Technical System approach

A starting point for the socio-technical system approach is the observation that societies and nation states may be analyzed as organized in different sub-systems organizing societal activities such as energy production and use, transport, food production and use etc. Any major transformation aiming at environmental sustainability will require radical change in

each of these systems in terms of technologies and modes of organization and governance. According to the STS approach, the transformation should be organized at the level of the socio-technical system and diverse agents should be engaged in a critical dialogue on what choices to make. Emphasis is on the process of policy making at the national level in a world characterized by high complexity and uncertainty.

The paper by Schot and Steinmueller is rich and complex in terms of concepts used to specify requirements to this process. It refers to directionality, coordination, demand-articulation and reflexivity as well as to tentative governance, strategic niche governance and deep learning. Some of these concepts have appeared under other headings in earlier writings on innovation policy and in evolutionary economics. Mission oriented innovation policy was introduced in the 1980s by Henry Ergas (1987) and it certainly involved directionality as well as demand articulation. Innovation scholars in the evolutionary scholar tradition, such as Stan Metcalfe (1995), have emphasized that a major task of innovation policy is to promote experimental behavior and pointed to the need to keep options open – ideas in line with tentative governance and strategic niche management. But the STS-version of transition management has gone further in terms of conceptual richness and complexity.

While rich in terms of concepts referring to new requirements on policy and policy process the authors offer less insights in, how and by whom dialogues should be organized. Is it the responsible minister who has a political mandate, a specialized unit within the public administration or the STS-scholars themselves? There are important trade-offs to be considered. Getting close involvement with central decision makers may be necessary, while such involvement reduces the room for open and critical discussion. In the Dutch case the STS-scholars were involved as consultants, while the Ministry of Economics was setting up the process. It would have been of interest to get a critical assessment of, why this experiment was aborted after a decade.

To some extent the boundary of socio-technical systems is congruent with how governments and international organizations are sub-divided in sector specific ministries or directorates. This congruence may be seen as a strength since it means that transitional scholars have identifiable governmental interlocutors in the form of ministries of climate change, transport, energy, health etc. But it can also be seen as a problem since existing ministries will base their activities on well-established routines and patterns of collaboration with interest groups with a tendency to defend status quo. One alternative could be to set up a nation-wide transformation council, corresponding to national innovation councils, with the aim to stimulate the transformation process from above, but this alternative is rejected in the

article (p. 1563) because, according to the authors, it involves red tape as well as bigger risk for capture by incumbents.

The authors' emphasis on transformation at the level of socio-technical systems is a useful rectification of innovation policies oriented exclusively toward the business sector and toward the production system. The public sector constitutes a big share of the national economy, especially in high income welfare states. But is an addition and it remains a major task to transform the business sector and the national production system. Here, as we shall see, 'the innovation system-framing' gives useful insights.

Another fundamental problem is that, while the presentation of the STS approach is detailed in terms of ideas for how to set up the policy process, it makes few references to historical context. There are few attempts to draw lessons from earlier historical transformations and few reflections on current major trends in technology. In all these respects, the innovation system perspective has something to offer.

3. What can be learnt from the innovation system approach?

3.1 World development reflects technological revolutions and learning

While it is difficult to foresee, how different stages in the transformation of the production system will work out, we can foresee that it must/should end with fundamentally changed management principles, work organisation forms, workers' skills, consumers' norms and behaviour, engineering and design parameters. In the transformed innovation system, there will be new and very different patterns of user-producer interaction. The role of the state will be different. Indicators measuring performance outcomes will be different.

It is obvious that system transition - the move from the current state of systems to the new more sustainable state - will require a combination of *radical* change in technologies, institutions and organisations on the one hand and a *speed up of incremental learning* processes on the other hand. While radical innovations are important, they will only have an impact when they get widely spread. This distinction between and combination of radical change and incremental innovation is fundamental in innovation system studies and in the related understanding of the learning economy.

The national innovation system literature, and especially the contributions by Christopher Freeman, go far beyond giving advice on innovation policy. The early conceptualization of national innovation systems by Christopher Freeman reflected his interest in understanding the role of technological revolutions in shaping the history of world dynamics. Why did England become the homestead of the industrial revolution in the era of

steam engines and textiles and how come that its role as world leader nation was overtaken by Germany and the US in the era of electricity and chemical industry? To answer these questions, he combined the concept technological revolution with the concept national system of innovation. Together with Carlota Perez he enriched the analysis by introducing the concept shifting techno-economic paradigms (Freeman and Perez 1986; Freeman and Perez 1988).

Common for these contributions and for more recent work by Carlota Perez is that they present economic history as characterized by periods of relative calm, or even stagnation, followed by periods of radical change with technological change at the core of this pulsation. Periods of radical technological change trigger the spread of new forms of organization, changes in management principles, new skills, new forms of government regulations. In such periods there will be change both in how the production system exploits natural resources and in domestic and global income inequality. This analysis of historical transformations of the global production system offers important insights for understanding future transitions, including transitions driven by the state.

The historical pulsation between path-following and path-breaking has been studied by innovation scholars at different levels spanning from the single organization and the work process to inter-organizational interaction and further on to regional, national and transnational innovation systems.

3.2 Technological paradigms and trajectories

The concepts technological trajectories and techno-economic paradigms as developed by innovation scholars such as Dosi, Nelson, Perez and Freeman are all based on the idea that periods of exploitation and stabilisation are followed by a phase of radical change and transformation. And they have been applied to issues related to ecological sustainability.

Technological trajectories indicate a direction of technological change that may remain dominant over several decades or even longer periods. They reflect routines guiding search and exploration among managers, designers and engineers and they emerge through selection and experimentation. But history does not end and as time goes by, the emergence of new technologies, institutional change, popular resistance or the limits of nature will make it problematic to move further ahead along the given trajectory.

Search routines giving direction to a technological trajectory will be stubborn and it will take time before they are abandoned, and search and exploration activities can move in new directions. In the meantime, there will be conflict, confusion and uncertainty. Engineers,

managers and workers will be exposed to new requirements in terms of skills and capabilities and established organizations resistant to change will disappear and leave place for new and more adaptive ones.

Some trajectories may be technology and sector specific with marginal impact on the overall innovation systems. Others such as the miniaturization trajectory in electronics have played a key role in the third and remains relevant even in the fourth industrial revolution. Dosi (1982), in the article introducing the concepts technological paradigms and trajectories, discusses briefly what kind of public intervention that might be most adequate in the transformation period, and he points to three types of policy interventions:

(1) emphasis on accumulation of knowledge in both 'scientific' and 'applied' forms and on bridging institutions.

2) institutional interventions allowing 'a hundred flowers to blossom and a hundred schools to compete'

(3) the selective and focussing effect induced by various forms of non-economic interests (such as, for example, military procurement, specific energy saving programmes, national drive toward self-sufficiency in a particular sector, etc.).

Freeman (1992) introduced the notion of the 'green techno-economic paradigm' as a new era of economic development. Freeman saw it as following the eras of steam power, electric power, mass production, information and communication technologies. He presents it as a precondition for sustained economic growth in the twenty-first century. But he emphasized that it would not occur spontaneously. Freeman refers to the need for fundamental institutional changes, including the effective regulation of pollution and major modifications to the economic system.

Segura-Bonilla (1999) takes this concept one step further and applies it to an analysis of Costa Rica's forestry sector. Drawing on the systems of innovation approach and ecological economics, he introduces the concept 'sustainable systems of innovation'. This concept introduces nature-human relationships in the 'systems of innovation' approach. The definition of innovation system is expanded through inclusion of natural elements:

> *A sustainable system of innovation is constituted by human and natural elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge*. (Segura-Bonilla 1999, p. 79).

Altenburg and Pegels (2012) take the literature on innovation systems and the early attempts by Freeman and Segura-Bonilla as starting point and apply those to global challenges. On this basis they introduce the concept of Sustainability-oriented Innovation Systems (SoIS). They

argue that global warming and other impending environmental mega-problems call for a new technological paradigm. They assign a critical role to the state:

> *The urgency of the development and deployment of technological solutions is such that governments will need to make widespread use of 'carrots and sticks' to ensure that next-generation technologies are developed and deployed, more demanding standards and regulations are applied and stricter enforcement is guaranteed.*

There have been several recent collective initiatives to follow up on the analysis of sustainable innovation systems such as Schlaile, M., Urmetzer, S., Blok, V., Andersen, A., Timmermans, J., Mueller, M., Fagerberg, J., Pyka, A. (2017).

It should be clear from what has been presented so far, that the idea of transformational innovation policy is not alien to innovation system research and that it has taken inspiration from the historical and analytical understanding of evolution as a pulsation of path breaking radical change and path dependent incremental learning.

3.3 System transformation at the organisational and inter-organisational level

Arrow (1973) offers an alternative to the transaction cost explanations of why hierarchies co-exist with market transactions. He shows, how organisations through building internal routines and common communication codes and channels become more effective in solving specific sets of routine problems than markets. With time, however, as the environment goes through radical change, they have problems to adapt because they have become stuck with their old routines. Organisations with a history of long-term success may actually be especially resistant to change.

This evolutionary idea was an important inspiration for the analysis of user-producer interaction and thus for theorizing national innovation systems. Lundvall (1985, 1988) saw the formation of user-producer relationships as speeding up product innovation. They have in common with organizations that they benefit from shared norms as well as from channels and common codes of communication. At the same time, they offer participants access to interaction with more diverse partners with diverse knowledge than a pure hierarchy. Finally, they offer more flexibility than hierarchies.

Nonetheless, with time, the network relationships become frozen and resistant to change. Channels of communication and shared norms represent sunk costs and the more successful the network interaction, the more difficult it becomes to reshuffle relationships. Classical examples of difficult Inies to adapt, can be found in industries with long tradition using mechanical technology. When confronted with the Information and Communication

Technology-revolution they found themselves locked in into old user-producer patterns – with office machinery and the watch industry as examples. Another example, directly related to green transformation, is how long-term links to carbon-based energy producers made it difficult for producers of alternative energy to join the grid.[1]

At both the level of the single organization and in relation to inter-organisational level the pulsation between incremental change along a technological trajectory followed by radical change and technological revolutions and its interaction with institutional evolution is at the core. These ideas inspired innovation policy ideas more than 20 years ago in Lundvall and Borrás (1999), a widely cited EU-report on innovation policy that presents a synthesis of insights from a series of studies produced within the innovation community.

3.4 An early attempt to define transformative innovation policy

The report makes a distinction between *two types of innovation policy*. One is to facilitate innovation along a given trajectory. The other one is to use innovation policy to foster a new (green) trajectory. Under the heading 'innovation policy in a wider perspective' Lundvall and Borrás (1999) pointed to path dependency and to the role of government intervention when it comes to foster a new technological trajectory.

The policy prescriptions (see box below) were incomplete and the idea of building new green technology system was intuitive and not fully developed. Today, it is clear that there is a need for a more comprehensive and radical approach that attacks global income inequality and involves global governance (see section 5).

[1] In the beginning of the 1990's, the author was invited by IEA for discussions on how to exploit insights from innovation studies to overcome problems with frozen user-producer relationships.

Excerpts from Lundvall Borrás (1999) on the need to build new technological systems directed toward environmental innovation

The environmental threats call for immense transdisciplinary and multi-technological efforts. A strategy for sustainable growth will include measuring what is going on at global level, developing clean technologies in manufacturing and transport, changing the incentive structures in agriculture and forestry to use more environment-friendly techniques and changing our everyday way of life.

It is useful to think in terms of 'technological systems' as a special version of innovation systems (See Carlson, 1995 and several of the working papers from the Edquist project, such as for instance Smith, 1997, Johnson and Gregersen, 1997, and Malerba, 1997).

In the case of environmental innovation, the following elements may be crucial for success in building a new technological system focused on environmental challenges:

1. *Establishing flexible but demanding standards in an interaction between users and producers this implies creating markets for green products and procurement policies involving private as well as public users.*
2. *Establishing institutes responsible for systematically measuring and evaluating the crucial environment parameters.*
3. *Stimulating experimental new initiatives in building training and research centers in crucial fields: such initiatives may be transdisciplinary, combining elements from a small number of disciplines.*
4. *Strengthening the links between environmental policy, innovation policy and general economic policy.*

4. A learning economy perspective on the transformation of national production and innovation systems

Lundvall and Johnson (1994) developed the learning economy hypothesis as a complement to the innovation system concept. The basic idea behind the concept is that globalisation and new technologies expose national economies to high transformation pressure. It results in an increase in the rate of obsolescence of knowledge and in a form of competition where the capacity to learn (and forget) is crucial for the performance of individuals, organisations, regional and national economies.

We propose that the learning economy perspective is useful when it comes to develop policy aiming at system transformations responding to global challenges related to

climate change and inequality.[2] This transformation process will require learning among workers, consumers, policy makers, engineers, managers and scientists. The process will combine massive application of already established technologies and organisational principles with intensive search for new scientific and new organisational insights. Learning may result not only in new skills and competences but also in new sets of values and norms (Lundvall, 2016, pp. 377-394).

Fundamental changes in the broadly defined national production and innovation system need to be outcomes of learning processes. This is true for the emergence of new:

1. Principles of management
2. Engineering and design parameters
3. Education and training systems
4. The organisation of work and workers' skills
5. Consumer norms
6. User-producer relationships
7. Research and development systems
8. Socio-technical systems
9. Openness of national innovation systems
10. Transnational governance and knowledge sharing.

The transformation will thus require processes of change at different levels of aggregation spanning from the individual to the world system. It will result in the formation of new modes of consumption, new modes of production and new modes of distribution. More specifically new transport and energy systems, less dependent on the use of carbon, will be established. Consumers, workers, managers, engineers will have to learn to operate based on new value sets and competences. New infrastructures and new institutions will be established at the local, national, regional and global level.

The transformation will require massive mobilization of existing knowledge as well as massive investments in new knowledge. It will require a speed up of both learning and forgetting. This is true for science-based as well as experience-based knowledge. The transition will depend on the design and strength of organizations and institutions shaping science as well as on those offering learning by doing. At both levels, knowledge production should be channelled in new directions.

[2] For a recent STS perspective on the role of learning, see Van Mierlo and Beers, P.J. 2020.

4.1 Discretionary learning and active inclusion as key elements in transformational innovation policies

Within innovation studies it has been widely recognized that it is useful to distinguish between science-based and experience-based knowledge. At the level of the enterprise different modes of innovation – learning by doing, using and interacting – DUI-Learning - vs. learning on the basis of science - STI-learning – have been related to different forms of knowledge – tacit vs. codified (Jensen et al 2007). It has been demonstrated that for most sectors innovation success requires a combination of the two modes.

Transforming a national innovation system will require a combination of the two modes. While the STI-mode may be especially important for promoting radical technical innovations in green technologies (Freeman 1996) the DUI-mode is critical for absorbing new technologies developed by domestic and foreign lead firms. While it is of crucial importance to intensify STI-efforts for exploration and searching in the deployment phase, the rate of change will accelerate and therefore there will be a need to speed up the different forms of learning constituting the DUI-mode. To focus analysis and policy only on how 'science policy' contributes to system transformation, results in a narrow and misleading policy framing.

One of the advantages with giving attention to the DUI-mode is that it helps understand that innovation is a process that involves workers and why the form of work organization matters for innovation. Research comparing the organisation of work in Europe (Lorenz and Lundvall 2006) has shown that there are significant differences across Europe. In the most advanced form of organisational learning – discretionary learning – employees combine discretion when it comes to choose work methods and to plan work with learning from working. Analysing 15 EU-countries, the analysis shows that the proportion of all workers engaged in this form of work is highest is countries with low degrees of income inequality. It shows that inequality in income is almost perfectly correlated by inequality (a rank correlation of 0.95) in access to discretionary learning.

While all forms of learning – including what has been referred to as lean production – will be important during a period of transformation, forms involving 'active inclusion', as defined above, will support the transformation. With workers (consumers and citizens) engaging actively in organisational, technological, and institutional change, there is a bigger chance that state-led mission-oriented innovation policies aiming at system transformation will be successful. In the next section we will argue that transformation strategies need to define global income inequality as a challenge in line with global warming. The research

referred to in this section indicates that a reduction in income inequality goes hand in hand with wider participation in discretionary learning. While, so far, this has been documented for workers in Europe, we would expect to find similar patterns when it comes to consumer, worker and citizen learning world-wide.

5. On reducing global income inequality and climate change mitigation

Most of the literature on transformative innovation policy refers to ecological challenges such as global warming. To develop political responses to this set of problems is a major and difficult task. Nonetheless there is a need to take a broader view of the objectives for the transformation.

To clarify we start from the UN sustainable development goals. The agenda consists of 17 sustainable development goals (SDGs) presented as a road map for the next 15 years. The plan integrates the three dimensions of sustainable development: the economic, the social and the environmental (UN, 2015). In what follows we focus on goal 10 on Reduced Inequality and goal 13 on Climate Action. This choice is in line with the most widely quoted definition of sustainability by the Brundtland Commission of the United Nations on March 20, 1987: It is clear from the report that sustainability has both an ecological and a social dimension.

> *There has been a growing realization in national governments and multilateral institutions that it is impossible to separate economic development issues from environmental issues; many forms of development erode the environmental resources upon which they must be based, and environmental degradation can undermine economic development. Poverty is a major cause and effect of global environmental problems. It is therefore futile to attempt to deal with environmental problems without a broader perspective that encompasses the factors underlying world poverty and international inequality.* (WCED 1987)

The two goals differ when it comes to public discourse and international coordinated action. Goal 13 has found world-wide (vocal) support through the Paris Agreement (UNFCC, 2015) on greenhouse gas emissions mitigation, adaptation, and finance. There is no corresponding international agreement on coordinated action to reduce income inequality.

This difference reflects that, while there is some 'diversity, conflict and dissent' in connection with the design and implementation of policies to mitigate global warming, this is even more so when it comes to mitigate income inequality. While the rich may express some concern for the increasing income inequality at the annual Davos-meetings, they invest heavily in lobbying to counteract any political movement trying to change the trend including

attempts to establish a fair and efficient global tax regime. The state in rich nations give symbolic development assistance while protecting their intellectual property to avoid knowledge sharing with enterprises in the poor countries.

In consonance with the UN Goal 10, the 2020 UN social report focuses on inequality *within and across countries* and indicates that there is a need for multilateral initiatives like the Paris Agreement in relation to income inequality (UN 2020, p. 15):

> *It is increasingly clear that reducing inequalities strengthens not only the social fabric but also the economic and environmental dimensions of sustainable development. However, this awareness has not yet been translated into the necessary normative changes. Instead, growing inequalities and overreliance on the capacity of markets to bring about social justice threaten the social contract in many countries.*

We will thus discuss the transformation process in the light of environmental sustainability and income distribution and, in both cases, we focus on *outcomes at the global level*.

5.1 On dilemmas and trade offs

Branco Milanovic (Milanovic, 2009), who is world leading expert on global income inequality, has demonstrated that in this era (in contrast to what was the case in the 19th century) income inequality at the global level predominantly reflects differences between nations rather than inequality within nations. *This implies that the only way that global income inequality can be significantly reduced is through a process of catching up where the low and middle income countries grow faster than the rich countries*. Most of the reduction in global inequality that has taken place since 1980 reflects the high rate of economic growth in China. Now the income level in China has reached the world average and therefore it is only through an acceleration of growth in lower income countries and regions such as India, Indonesia and Africa that global income inequality can be significantly reduced.

It is interesting to note that Milanowic refers to technological revolutions as major drivers of global inequality. The industrial revolution in the North (and the colonial suppression of the South) was crucial for opening income gaps between countries while the ICT-revolution created a window of opportunity for Asian countries – especially China. Increased access to knowledge and technological capabilities for low-income countries is a prerequisite for a significant reduction of global income inequality. More specifically a wide and quick dispersion of green technologies is a prerequisite for combining growing living standards in the lower income countries and regions with respect for planetary boundaries.

6. On the need for global system transformation

The UN sustainable development goals aim at world level impact and the same is true for the Paris agreement on climate change. Specifically, the Paris agreement requires that each national state take responsibility to reduce greenhouse gas emissions from activities located *within national borders*. It reflects a reality where political governance capacity is located mainly at the level of the nation state. Correspondingly most of the literature on transformative innovation policy, including the socio-technical system literature, aims at transforming national innovation systems.

Nonetheless it is necessary to consider the transformation toward *a new world system* with less poverty, inequality and global warming. As any system transformation it would be characterized by simultaneous change in system *elements* and in the *relationships* between elements.

This global perspective is necessary for several reasons. First, a world system perspective is required to avoid national strategies undermining global inclusion and sustainability. Second, it reveals how current global governance constitutes a barrier to transformations at regional and national level and the need for global governance innovation (Lundvall, 2012, p. 51). Third, it points to opportunities to exploit techno-economic synergy and institutional learning across regional and national innovation systems.

One form of global system change where science collaboration has been at the core has been the establishment of world-wide collaboration of scientists in the Intergovernmental Panel on Climate Change (IPCC), an intergovernmental body of the United Nations dedicated to providing the world with objective, scientific information relevant to understanding the scientific basis of the risk of human-induced climate change. This collaboration has played an important role in establishing a wider understanding of the urgency of the climate change challenge.

The Paris agreement may be seen as an example of world system change– as nation states commit to deliver specific outcomes, a new form of global governance is introduced. Further steps in this direction are prerequisites for reaching the sustainable development goals. They may take the form of more ambitious binding global agreements and they may involve global policy initiatives aiming at simultaneous reduction of greenhouse gas emissions and income inequality.

An obvious example would be the introduction of a global CO2 tax with revenues allocated to investments in transforming production, energy and transport systems toward low

carbon solutions in the world's low-income regions. Fagerberg et al. (2016) argue for such a scheme at the level of the European Union. As extra argument for giving special attention to the transformation of lower income regions of the South and East of Europe, he refers to the fact that they are characterised by more carbon-intensive production systems. Therefore, the impact in terms of reducing greenhouse gas for Europe would be correspondingly more substantial. If those principles were extended to the global level, they would contribute both to climate action and to a reduction of international income inequality.

One of the factors contributing to national and international income inequality has been the increasing role of tax competition and tax havens. National governments have reduced taxes in order to attract business activities and promote economic growth. This is a negative sum game since it undermines the capacity in all countries to use public funding for investments in knowledge, building green infrastructure and social investments. A successful outcome of current negotiations at OECD on common standards for how and where to tax multinational firms would represent another change in the relationships between national systems and thereby in the world system.

Piketty has proposed a more radical change in the world system in the form of a global wealth tax. It would attack directly the enormous and growing gap in wealth where a very small number of individuals and monopolistic companies increase their wealth while paying very low taxes while ordinary workers and small and medium-sized enterprises pay more in taxes. The revenue from such a global wealth tax could, similarly to a global CO2-tax, be channelled to investments in building a stronger knowledge infrastructure in low-income countries and regions.

Such changes in global governance would require a fundamental change in the current regime where governments focus on the competitiveness of firms located within their national borders and on the material needs of their own citizens. This form of international competition, combined with a dominant role of global financial capital, leaves little room for transformative policies at the national level. 'The market' tends to punish national governments that take the lead in reforms – especially when reforms constrain the role of the market mechanism (Lundvall, 2016, pp. 380-381).

As pointed out above a prerequisite for a significant reduction in global income inequality is building stronger innovation systems in lower income countries and regions and to increase their access to the global pool of science and technology. Led by the US, high-income countries have imposed stringent global regimes regulating intellectual property

making access difficult for poor countries. Significant reductions in global income inequality require changes in the current trade and IPR-regimes.

Finally, there is a need for global initiatives to promote existing and develop new global innovation networks especially in 'green technologies'. National innovation systems, even big ones, need to create absorptive capacity to import and use technologies developed abroad. Here as well strict use of IPRs at the national and global level makes it difficult to fully exploit synergies that could be derived from a combination of international technological specialisation and cooperation.

The assumption that any form of 'innovation policy' or 'STS-policy', on its own, can bring about a transformation that responds to the current global challenges may be somewhat pretentious and misleading. It is difficult to envisage a transformation of innovation (or socio-technical) systems that would lead the world to inclusive and ecological innovation paths without radical change in mode of prevailing modes of production and global governance.

7. Conclusions

In this paper we have discussed how lessons from the innovation system literature can inspire transformational innovation policy where transformation refers to global income inequality as well as global warming. We have referred to early contributions as well as to conceptual ideas that can inspire policy. We tend to disagree with Schott and Steinmueller (2018) when they argue that the STS framing for innovation policy should substitute for the old framings 'innovation for growth' and 'national innovation systems'.

In order to respond to global challenges all the three different framings need to be applied. There is a need to combine ambitious investments in knowledge and building new user-producer relationships with the transformation of socio-technical systems at the national level. In the transformation there is a need both for establishing niches and experimentation (what kind of method is best when it comes to store energy) and for swift government action to promote the diffusion and use of specific technologies that are ready to go (could be support to the instalment solar panels or electrification of transport). But all three framings need to give more attention to global interdependence and to the transformation of global governance. They also need to design innovation policy that address simultaneously climate change and global inequality.

One major point in the Schot and Steinmueller paper is that STI policies should not aim exclusively at economic growth and competitiveness. In an early OECD-paper on science policy from 1968 republished in Freeman (1992), Freeman lists five possible aims for Science

Policy and suggests that most governments prioritize them in the following order: 1. Arms race. 2. Economic growth. 3. National prestige. 4. Social well-being. 5. Science for its own sake. He declares that he would prefer the opposite order. At the end, however, he recognizes that in low-income countries it is necessary to mobilize science, technology and innovation for economic development. Not doing so, they end up with what Freeman refers to as 'voluntary underdevelopment'.

To develop policies and methods to tackle the challenge of ecological sustainability is a complex task and the STS approach of 'transition management' tries to respond to that complexity. The task becomes even more complex if we agree that it is important to combine green trajectories with reduction of global income inequality and with the eradication of poverty (Arocena and Sutz 2009). While a first step is to transform *national* innovation systems, the ultimate aim is to move toward a world-wide sustainable innovation system.

Science, technology and innovation policy needs to become both transformative and transnational. My personal view is that the most promising general framing for transformative policy is the long-term perspective on world development as developed by Christopher Freeman and Carlota Perez (Perez 2004 and Perez 2014).

First, they combine a certain optimism in terms of what science, technology and innovation can contribute to human well-being (if it were allowed to do so) with a criticism of the current institutional setting. Second, they base their analysis in a normative perspective where solidarity is combined with sustainability. Third, they study 'the present as history'. Hereby they go beyond general principles and situate policy in its current context.

References

Altenburg, T. and Pegels, A. (2012), 'Sustainability-oriented innovation systems – managing the green transformation', *Innovation and Development*, 2(1), 5-22.

Chaminade, C., Lundvall, B.-A., & Haneef, S. (2018), *Advanced introduction to national innovation systems*, Cheltenham, Edward Elgar

Chataway, J., Daniels, C., Kanger, L., Ramirez, M., Schot, J., Steinmueller, E. (2017), Developing and Enacting Transformative Innovation Policy: A Comparative Study, in: papers, S.w. (Ed.), http://www.johanschot.com/wordpress/wp-content/uploads/2017/06/Developing-and-enacting-Transformative-Innovation-Policy-A-Comparative-Study-FINAL-DRAFT.pdf.

Dosi, G. (1982) 'Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change', *Research Policy* 11, 147–162.

Fagerberg, J. (2018), 'Mobilizing innovation for sustainability transitions: a comment on transformative innovation policy', *Research Policy* 47, 1554-1567.

Fagerberg, J., Laestadius, S., & Martin, B. R. (2016), 'The triple challenge for Europe: The economy, climate change, and governance', *Challenge*, 59 (3), 178–204.

Freeman, C. (1992), The Economics of Hope: Essays on Technical Change and Economic Growth, Pinter, London.

Freeman, C. (1992), 'Science and Economy at the National Level', in Freeman, C. *The Economics of Hope*. Pinter Publishers, London, 31–49.

Freeman, C. (1996), 'The greening of technology and models of innovation', *Technological Forecasting and Social Change,* 53 (1):27–39.

Freeman, C. and Louca, F. (2002), *As Time Goes By: From the industrial revolutions to the information revolution*, Oxford University Press, Oxford.

Freeman, C., Perez, C. (1986), 'The Diffusion of Technical Innovations and Changes of Techno-Economic Paradigm', *Conference on Innovation Diffusion, Venice*.

Freeman, C., Perez, C. (1988), 'Structural crises of adjustment, business cycles and behaviour', in Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (Eds.), Technical Change and Economic Theory. Pinter, London, pp. 38–66.

Geels, F. (2002), 'Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case-Study', *Research Policy* 31, 1257-1274.

Geels, F. W. (2004), From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from s,ociology and institutional theory', *Research Policy*, 33, 897-920.

Geels, F. and Schot, J. (2007), 'Typology of sociotechnical transition pathways', *Research Policy*, 36(3): 399–417.

Grin, J., Rotmans, J., Schot, J., (2010), *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change,* Routledge.

Kemp, R. and Rotmans, J. (2009), 'Transitioning policy: Co-production of a new strategic framework for energy innovation policy in the Netherlands', *Policy Sciences*, 42 (4), 303–322.

Lorenz, E. and Lundvall, B.-A., (2006), *How Europe's Economies Learn: coordinating competing models*, Oxford, Oxford University Press.

Lundvall, B.-A. and Borrás, S. (1999), *The globalising learning economy: Implications for innovation policy*, Office for Official Publications of the European Communities, Luxembourg.

Lundvall, B.-A. and Johnson, B., (1994) 'The learning economy', *Journal of Industry Studies*,1 (2), 23–42.

Perez, C. (2004) 'Technological Revolutions, Paradigm Shifts and Socio-Institutional Change', in E. Reinert (ed.), *Globalization, Economic Development and Inequality: An alternative perspective*. Edward Elgar, Cheltenham.

Perez, C. (2015), 'Capitalism, Technology and a Green Global Golden Age: The Role of History in Helping to Shape the Future'. *The Political Quarterly* 86, 191-217.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin I., F.S., Lambin, E., Lenton, T., Scheffer, M., Folke, C., Schellnhuber, H.J. (2009),. 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity', *Ecology and Society*, 14.

Rotmans, J., Kemp, R., Van Asselt, M. (2001), 'More evolution than revolution: transition management in public policy' *Foresight* 3(1), 15–31.

Schlaile, M., Urmetzer, S., Blok, V., Andersen, A., Timmermans, J., Mueller, M., Fagerberg, J., Pyka, A. (2017), 'Innovation Systems for Transformations Towards Sustainability? Taking the Normative Dimension Seriously'. 9, 2253.

Schot, J., Steinmueller, E. (2018), 'Three Frames for Innovation Policy: R&D, Systems of Innovation and Transformative Change', *Research Policy* 47, 1554-1567.

Bonilla, O. (2000), *Sustainable Systems of Innovation: The Forest Sector in Central America*, Doctoral Thesis at Department of Business Studies. Aalborg University, Aalborg.

United Nations (2015), Resolution A/RES/70/1. *Transforming our world: the 2030 agenda for sustainable development*. In: Seventieth United Nations General Assembly, New York, 25 September 2015. New York: United Nations.

United Nations (2020), *World Social Report 2020: Inequality in a rapidly changing world*, New York, United Nations.

UNFCCC (2015), *Adoption of the Paris Agreement*, Report No. FCCC/CP/2015/L.9/Rev.1.

World Commission on Environment and Development (1987), *Our Common Future*, London, Oxford University Press.(The Brundtland Report).

Van Mierlo, B. and Beers, P.J., (2020), 'Understanding and governing learning in sustainability transitions: a review', *Environmental Innovation and Societal Transitions*, pp. 1-15.

Waddock, S., Meszoely, G.M., Waddell, S., Dentoni, D. (2015), 'The Complexity of Wicked Problems in Large Scale Change', *Journal of Organizational Change Management*, 28, 993-1012.

WCED (World Commission on Environment and Development) (1987), *Our Common Future*, Oxford University Press, Oxford.

Lund Papers in Economic History
ISRN LUSADG-SAEH-P--22/239SE+20

Orders of printed single back issues (no. 1-65)
Department of Economic History, Lund University
Postal address: P.O. Box 7083, S-220 07 Lund, Sweden
Telephone: +46 46 2227475
Telefax: +46 46 131585

Full-text electronic issues (no. 58, 60, 61, 66--)
www.ekh.lu.se

Lund Papers in Economic History are published by the Department of Economic History, Lund University, Sweden. This series replaces the former series under the title *Meddelande från ekonomisk-historiska institutionen, Lunds universitet*. The change of name reflects the orientation of the series towards an international readership. The series is multilingual, but the majority of the working papers appear in English.

Lund Papers in Economic History are published as occasion arises, not at fixed intervals. Printed issues are distributed to libraries. From 1999 and onwards, full-text electronic issues are also available on *www.ekh.lu.se.* Those who would be interested in receiving information by email on new issues of **Lund Papers in Economic History** are requested to send an email message to *Lund.Papers@ekh.lu.se.*

LUND
UNIVERSITY