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INNOVATION FOR SUSTAINABLE DEVELOPMENT THROUGH THE LENS OF THOMAS KUHN'S PARADIGM SHIFT

Alina SZYPULEWSKA-PORCZYŃSKA[1*], Edyta ZDUŃSKA-LESEUX[2]

[1] SGH Warsaw School of Economics; aszypu@sgh.waw.pl, ORCID: 0000-0003-0177-545X
[2] SGH Warsaw School of Economics; eleseux@sgh.waw.pl, ORCID: 0000-0001-9338-5939
* Correspondence author

Purpose: The study investigates a paradigm shift in innovation policy driven by the increasing integration of sustainability principles. Using Thomas Kuhn's theory of scientific revolutions, it examines whether the transition constitutes a paradigm shift.
Design/methodology/approach: The study includes a historical-comparative analysis of EU innovation policy, tracing the transition from traditional neoclassical models to evolutionary and sustainability-oriented approaches and examining how the framing of innovation evolved in response to sustainability-related challenges.
Findings: There has been a shift from growth-oriented to sustainability-oriented frameworks, which displays features of a Kuhnian paradigm change, including anomalies (e.g., climate crisis, inequality), competing research traditions, and redefinition of problem-solving standards. However, the transformation is uneven and coexists with older paradigms.
Research limitations and implications: The study adopts a conceptual approach, which limits the assessment of the extent to which innovation frameworks integrating sustainability goals are implemented in policy and practice. Further research should explore how these frameworks operate in various institutional and national contexts and how they interact with or challenge traditional economic models that continue to support mainstream innovation policy.
Practical implications: A paradigm shift in innovation policy requires adjustments in policy design, evaluation metrics, and funding mechanisms to support innovations that address environmental and social challenges. While the study does not propose specific commercial applications, its findings imply that aligning innovation policy with sustainability goals may influence how enterprises assess value creation, risks, and societal impact.
Social implications: The study contributes to understanding how innovation can support societal transformation beyond economic growth. It emphasises the potential for innovation policy to address systemic environmental and social challenges, such as climate change and inequality. The research may inform public debate and policymaking.
Originality/value: The paper reinterprets Kuhn's framework, highlighting the emergence of sustainability as a transformative force. It is particularly relevant to scholars in innovation policy, economic theory, and sustainability transitions, as well as policymakers interested in understanding the structural changes influencing innovation governance.
Keywords: sustainability, innovation policy, paradigm shift, economic models, Kuhn.
Category of the paper: Conceptual paper.

1. Introduction

High social and environmental costs are prompting humans to accelerate socio-economic systems restructuring (Hepburn et al., 2020; Piketty, 2020). This process is mainly related to the redefinition of the relationships between production dynamics, development, and well-being (Ferrannini et al., 2021). This study examines the departure of innovation policy from traditional economic models in response to sustainability challenges. Specifically, it aims to identify the emerging pattern of innovation policy that aligns with sustainable development and evaluate whether this shift marks a paradigm shift, as defined by Thomas Kuhn. The research seeks to answer the following questions: What characteristics define the paradigm shift in innovation policy towards sustainability? How does this shift reflect broader changes in economic paradigms? What evidence can be drawn from Kuhn's theory? We argue that the paradigm shift in innovation policy towards sustainability represents a fundamental transformation in economic theory from traditional growth-driven models to a more integrative approach focusing on environmental sustainability and social equity. This shift responds to global challenges like climate change and a new scientific approach where innovation is seen as a tool for societal and environmental progress. However, the change has been overshadowed by the parallel presence of older paradigms.

To maintain our reflections within a coherent conceptual framework, we use the concepts presented by Kuhn in the Structure of Scientific Revolutions, except for the Postscript, which he wrote seven years later. Although Kuhn refined his theses in response to debates, the original statements retained their explanatory value (Richards, Daston, 2016). We propose, however, some reformulations to consider this study's topic.

We analyse the innovation–sustainability relationship under the framework of Kuhn's paradigm and paradigm shift for his approach to the historical perspective, as it lends meaning to comparisons with past findings (Bird, 2005). Kuhn directs the attention of researchers towards the impact of external factors and human interests on a given phenomenon, alongside internal laws, logic, and human self-reflection. Moreover, his approach to science as a non-linear development sheds new light on the search for scientific truth, creating space for various solutions to research problems in social sciences existing in parallel (Fekete, 2021). Finally, by bringing "revolutionary" changes to science, i.e. paradigm shifts, he helps us better understand problems that cannot be adequately addressed under the old conventions. The "space" Kuhn created for scientific inquiry that extends beyond the theory's core also motivates us to seek a foundation for economic considerations within the Kuhnian tradition. For Madej (2011), for example, this space encompasses the ideological layer, which this researcher considers necessary to understand findings from his paradigm-based research on different phenomena.

Interestingly, while Kuhn (1991) was sceptical about applying his theses to the “human sciences”, his work inspired some studies in social sciences (Barnes, 1982), and economics was among these disciplines (Kindi, 1995). Kuhn points to economics next to psychology as disciplines mature enough to apply the paradigm concept (Fekete, 2021). Fekete (2021), referring to Kuhn's presentation of the differences between natural and humanistic sciences, indicates two main limitations of the applicability of Kuhn's theory to social sciences. First, in the framework of social sciences, researchers do not discover the laws of nature. Second, the subject of social research is unstable. For this reason, the mechanistic or teleological approach substantially reduces the modelled social processes.

This paper is structured as follows: First, we critically read the Kuhnian concepts to transpose his framework into the discussion of innovation and sustainability. Next, we explore the background of dominant innovation economics and its evolution. Finally, by analysing two seminal studies in innovation economics and policy, we track the trends in innovation research and the adjustments that address sustainable development challenges.

2. Adapting Kuhnian concepts: Paradigm and paradigm shift

Of Kuhn's two approaches to “paradigm”, we are more interested in the broader one. The paradigm understood as a discipline matrix includes the exemplar - the element that guides scientists through theory and rules, and the components critical to paradigm shifts. The latter include values, beliefs, and symbols shared by research communities. On the other hand, exemplars are scientific practices, solutions to "puzzles" accepted by research communities. Shared puzzle solutions are the basis of "normal science", within which scientists model their solutions and perpetuate them in textbooks. This theory becomes a paradigm, which is considered superior to competing theories.

Madej (2011) calls the Kuhn's paradigm “monistic”. He sees the presence of such tight, monistic paradigms in the existing schools of economics. He gives them a "medium rank" in the hierarchy of paradigms he creates. A "large rank he assigns " to a paradigm covering the entire discipline, and "small paradigms" would be about particular scientific problems or research methods in economics. Fiedor and Gorynia (2020) offer another interpretation, highlighting the multifaceted understanding of efficiency in economics, encompassing the relationship between inputs and outputs across various forms of human activity. They take the paradigm as a set of the most important theoretical problems related to the research problem and discuss the parallel functioning of many paradigms as a specific market for approaches or, following H. Koontz (1961), the "theory jungle".

Shiller (2020) provides a distinctly critical perspective on the mechanism of economic ideas, arguing that ideas in economics, much like epidemics, spread through contagion, destabilising economies as people 'infected' by an idea begin to alter their behaviour. Dembinski (2019) similarly critiques the dominant economic paradigm, noting its reliance on false assumptions of rational behaviour. He laments (Dembinski, 2009) the disconnect between economists' sophisticated abstract models and the reality of economic practice. Let us note that the assumption about the rationality of action became a showcase of economics half a century ago. This can be seen in the phenomenon described by Blaug (2019) in the mid-1970s: the so-called intellectual imperialism of economists. It involves applying economics to non-economic phenomena.

Rapprochement with Kuhn's approach can be seen in Hausner's understanding of cognition in social sciences. In Hausner's Economics and Social Imaginary (2020), simple accumulation does not create social knowledge. Hausner brings into play Institutions and the Environment by Ostrom (2012), where she formulates, according to her words, the most important observation about the non-existence of universal optimal solutions. Based on her recommendations, Hausner presents two components that define the decision-making situation of the subject: the perception of reality ("Imaginary") and the possibilities.

As Kuhn explains, the paradigm shift is triggered by the emergence of an awareness of the existence of an anomaly and its gradual recognition by scientists on an empirical and theoretical basis. Kuhn sees symptoms of a crisis in the proliferation of versions of a theory and research conducted in competing schools. The resistance to change is so profound that Kuhn sees good candidates for scientific revolutionaries as young scientists not previously associated with the field. The claim plays a vital role in the Kuhnian paradigm shift, stating that the differences between consecutive paradigms are irreconcilable because they cover different problem scopes, methods, and solution standards. Even more, the two traditions of normal science are incommensurable. The paradigm shift means, as Kuhn argues, changes in the criteria based on which the selection of problems and their solution is justified. We could speak of a quantitative anomaly if questions and research problems cannot be answered under the current convention. The appearance of a qualitative anomaly should be associated with a situation where the traditional approach worsens the current state of affairs and threatens economic stability.

The tension between old and new paradigms, when viewed through reinterpretation of Kuhnian concepts, is echoed in a recent systematic review by Weckowska et al. (2025), which observes that actors within innovation systems frequently hold divergent, and at times conflicting, views regarding sustainability challenges, solutions, and the pace or direction of transition.

3. The innovation bias and traditional approaches supporting innovation in the economy

Innovation occupies a central place in economics as one of the primary drivers of economic growth and competitiveness. If we use the division of discourses on innovation presented by Godin (2008), economics recognises innovation as progress. This has its consequences. Researchers have focused mainly on insight into managerial processes, how to acquire innovation capacity, etc. For the less developed, diffusion of innovation has become a measure of the impact of development programmes. Fougère and Harding (2012) find a recreation of the sense of superiority of Western societies in Rogers' Diffusion of Innovations, whom they recognise as a pioneer of the sociological approach to innovation.

The existence of innovation bias, but with a different cause, is stated by Nowotny (2006). According to her, we live in pursuit of innovation because it enables us to construct a shared vision of the future. Innovation is good material with the interplay of culture, society, and technology. In the prominence researchers and politicians attached to innovation at the beginning of the twenty-first century, Nowotny sees a way of dealing with an uncertain future.

The innovation-oriented mindset in science can also be rooted in politics. This phenomenon is described by Godin (2008), who illustrates this with economists offering expert services to governments and gathering around think tanks. According to the researcher, financing innovation research is an essential channel through which the impact of politics on science takes place. Godin points to the symbolic shift in names that accompanied this tightening relationship: from "science policy" through "science and technology policy" to "innovation policy" (Godin, 2008, p. 41). Owen (2018) draws attention to the sphere of political artefacts, citing the example of the European Union's commitment to developing the responsible research and innovation framework announced in 2011.

Reflections on development supported by innovation were initiated by neoclassical economists. They endogenised innovation and technological progress in economic models, and the entrepreneur-innovator became an essential element of their approach. The latter, operating in the conditions of free market access and complete information, entirely used the factors of production and favourable conditions to maximise profit (Nelson, 1959; Arrow, 1962).

In the neoclassical model, information equates with universal and readily available knowledge, and enterprises can use it equally. The specificity of knowledge limits the optimisation of innovators' decisions and profits. Therefore, conducting research and innovative activities under this model is burdened with high risk and costs, but the results are available free of charge to other entities, including competitors. This way, knowledge becomes a public good (Foray, 2004). As a result, innovators' propensity to conduct research and innovative activity is much lower than it would result from the public interest (Chaminade, Edquist,

2006a). In such conditions, the knowledge market turns out to be imperfect, and the resulting inefficiencies of market mechanisms require correction by the state as part of the innovation policy.

The neoclassical approach to supporting innovation and development is based on linear innovation process models: the supply model, the science-driven innovation model, the demand model, and the market-driven innovation model. Due to their simple linear logic, the neoclassical paradigm of supporting innovation shows the highest levels of internal continuity and cohesion. This allows for the definition of clear and straightforward assumptions regarding state intervention, the selection of tools, and effects.

However, the simplicity of linear models began to be perceived as a drawback. They did not allow reflection on the specificity of research and innovation activities and the relations and dependencies between science, technology, the market, and business. The response to the criticism of the neoclassical approach to the innovation support policy was the emergence of a new paradigm in the 1990s derived from the evolutionary economic theory. The authors referred to Darvin's theory of natural selection and evolution and Schumpeter's (1960, 2009) innovation and entrepreneurship theory (Nelson, Winter, 1982). By placing innovations and enterprises at the centre of the economic development theory, Schumpeter was the first to introduce the concept of innovation into economic sciences.

Knowledge in the evolutionary approach is not a public good to which there is complete and unlimited access. It can be general or specific and particular to a particular user: individual, enterprise, or industry (Smith, 2000; Drelichowski, 2004). Access to knowledge is expensive, and its creation no longer takes place in isolation by a single researcher or entrepreneur-innovator. It results from joint activities within the enterprise or cooperation of various actors in the innovation process (Edquist, 1997; Cohendet, Meyer-Krahmer, 2005).

The innovative process, which begins with the crystallisation of an idea for innovation and ends with its commercialisation, is understood under this perspective as numerous interactions and feedback loops between opportunities, market needs and entities. Such relations and dependencies are illustrated in interactive models such as the chain-linked innovation model of Kline and Rosenberg (1986) or the coupling model of Rothwell and Zegveld (Dodgson, Rothwell, 1994). Hence, innovation is a path-dependent process in which knowledge and technology are produced through the interaction between various actors and other factors. R&D is no longer the most crucial stage in the innovation process. It is implemented when a given entity cannot solve a problem or implement a new solution using the available knowledge and techniques. Optimisation and market failure lose relevance in the evolutionary approach (Bryant, 1998).

According to Metcalfe (2000), problems appear if access to the necessary knowledge is limited due to the lack of an appropriate organisation allowing access to this knowledge or missing or blocked communication channels between the relevant organisations. As the most critical systemic problems, Lundvall and Borras (1997), Smith (2000), and Chaminade and

Edquist (2006b) indicate: 1) restructuring problems most often related to technological issues; 2) infrastructure problems related to transport, communication and research infrastructure; 3) blocking problems resulting from blocking the entity in existing technologies; 4) institutional problems related to the difficulties associated to formal and informal regulations/institutions; 5) learning ability problems, 6) intra-network problems resulting from too weak or too strong connections in the system, innovation; 7) and issues related to the complementarity of the elements of the innovation system. Therefore, the need to solve problems within the innovation system is a cardinal argument favouring the state intervening in innovation policy. Moreover, state intervention creates conditions for developing appropriate selection processes and diversity, ensuring the system's evolution along the best trajectory (Bach, Matt, 2005).

4. Climate for innovation vs innovation for the climate

Flagship examples of standards adopted at the national and international levels include the report of the US Panel on Invention and Innovation, known as the Charpie Report (United States Department of Commerce, 1967) and the OECD guidelines for collecting and interpreting technological innovation data known as the Oslo Manual (OECD, 1992). Despite a quarter of a century separating them, both showed an interest in technological innovations and their significant impact on the company's competitive performance. The definition of innovation in this framework is consistent with innovation's economic objectives. In the Charpie Report, innovation translates the invention into the market. The Oslo Manual 1992 understands innovation as implemented technological changes. The Oslo Manual continues to see the essential function of innovation as a drive for productivity, growth, and prosperity (OECD, 1992, 2018). It considers supporting economic and social changes in response to national and global challenges an additional issue. It states that users of innovation data may be interested in innovation's social and environmental impacts, but it lists them after productivity, profits and jobs. It also explains that the very definition of innovation does not require positive consequences. In particular, the innovation may harm safety, health, or the environment (OECD, 2018, p. 69). At the same time, these areas are listed among the performance targets for which management is responsible and in which managerial abilities to innovate are manifested (OECD, 2018, p. 108). Another modification observed in the analytical interpretations of data on innovation by the OECD concerns the status of the environment. It is no longer considered a public policy category. “Society and the natural environment” has become a separate fifth component of the external environment for business innovation (OECD, 2018, p. 147). Among the channels through which this element directly or indirectly impacts the company's innovative activity is public acceptance of innovation, corporate social responsibility, system-wide social changes, such as the transition to a low-carbon economy,

and changes in the area of the impact of business activities on the environment, such as "green" innovations and adaptation to climate change (OECD, 2018, p. 148).

Fougère and Harding (2012) define the instrumental approach in the Charpie Report and Oslo Manual as "managerial," contrasting it with the "sociological" approach proposed by Rogers in the early 1960s. Rogers (2003) links innovation with human behaviour. According to him, for an idea to be considered a technological innovation, a potential adopter must perceive it as new.

In contrast to mainstream economic thinking, Rogers highlights the consequences of innovation for diffusion participants, which he analyses across three dimensions: 1) the functional effects of innovation; 2) its potential to trigger a chain reaction; and 3) how quickly it is recognised by members of society. Consequently, he distinguishes three categories of innovation impact: 1) desirable/undesirable, 2) direct/indirect and 3) anticipated/unanticipated. However, the researcher mentions ecological research conducted by some rural sociologists after 1975 only in the context of various currents' contributions to the development of innovation diffusion theory. Rogers references environmental protection issues mainly in several case studies in his book. One of the examples is particularly insightful. Rogers uses it to illustrate the steps in the innovation decision-making process, pointing to the shift in standards fifty years after he began studying innovation diffusion. A farmer once considered a "laggard" for refusing to use chemicals due to their environmental impact is now regarded as a "super innovator" as their activity represents organic farming.

When sustainability is established as a criterion, innovation is assessed on a spectrum, ranging from those innovations that hinder sustainable development to those that actively contribute to it. The ends of the scale illustrate the two opposing roles that innovation can play in sustainability. Comparing the science and policy agendas in innovation over the past decades, we see a shift in focus from mitigating "bads" to creating "goods". The development of research and the scientific community around the relationship between innovation and ecological and social aspects of human life that occurred over the last two decades has led to "the responsible innovation" trend (Prest et al., 2002). In the organisation management discipline, sustainable innovation has been integrated with the spirit of entrepreneurship into the company's development strategy mainly through network activities, mobilising stakeholders or changing the business model (Lazaretti et al., 2020).

Governing innovation as part of sustainability is a challenging issue. One example is the diffusion of green technologies through government subsidies, which have a regressive effect, exacerbating income inequality (Vona, 2021). Moreover, the tension between sustainability's environmental and social dimensions overlaps with the cost increase caused by green regulations and the resulting loss of competitiveness, a central issue in management analyses. Furthermore, even if it is possible to harness environmental standards to achieve the company's performance goals through innovation, there is a cost on the social side, as evidenced by the decline in labour contribution, as described by Porter and Linde (1995). Other key aspects of

the sustainable innovation-economy relationship include spatial, temporal, and sectoral differentiation in the distribution of the effects of innovation. An empirical analysis of the Norwegian coastal shipping sector illustrates this differentiation (Bach et al., 2021). The study shows how low- and zero-carbon technologies, such as biodiesel and liquefied biogas, face structural and institutional barriers despite their technical compatibility with existing fossil fuel systems. These include high costs, limited fuel availability, and insufficient policy incentives, which hinder broader adoption. The case demonstrates that technological alignment alone does not guarantee sustainability transitions without supportive innovation policies.

It is important to note that, at the level of global political agreements (such as the declarations and action plans undertaken by the United Nations), the natural environment has been considered essential for the enjoyment of fundamental human rights since the beginning, i.e., for nearly half a century (United Nations, 1973). A similar perspective on the natural environment is shared by economists within the ecological trend, as evidenced by the declaration from the late 1980s that introduced the then-niche journal Ecological Economics (Constanza, 1989). Regrettably, when the "symmetry" between various forms of capital is assumed, it complicates the search for solutions to conflicting goals.

Innovation directly serving sustainability resonates with the choice of strong sustainability over weak, a distinction the reader found in the literature on sustainability (Skene, Murray, 2017). It starts with the conviction that when combining nature with society's governance, we should prioritise matters of nature (Ehrlich, 1989). Skene and Murray (2017) position "sustainable development" between the economics of the environment and ecology.

Oswald and Stern (2019) urge the economics community to focus on researching growth driven by rapid technological change, which will help mitigate climate risks and the existential crisis. In their view, economics should remain open, incorporating significant social and ecological challenges into its subdisciplines and drawing on ideas from other social sciences, such as ethics and philosophy. For them, innovation represents an opportunity on which the necessary changes depend. Without an explicit emphasis on the pace of change, as advocated by Oswald and Stern, the transition towards sustainability, though shown by Lobo et al. (2025) to be facilitated through activities of intermediaries within existing socio-technical regimes, might pose a risk to fulfilling urgent sustainability goals, especially those with deferred outcomes.

5. Conclusions

In economics, multiple paradigms are recognised that reflect the diversity in interpreting human behaviour. Some economists challenge this perspective. We observe efforts to define universal laws in economics. In this context, we can notice a convergence with Kuhn's broader

concept of paradigms or interpretations so vast that any scientific revolutions seem impossible within them.

Assumptions are central in economics, where fundamental laws are not as in the natural sciences. This foundation inevitably leads to competing research methods supported by institutions and various schools of thought. The multidimensional nature of economics also results in parallel interpretations, with different scientific communities operating within diverse conceptual frameworks and engaging in puzzle-solving efforts that focus on limited research interests. Furthermore, there is no precise sequence to the paradigmatic differentiation. Therefore, adapting Kuhn's vision to this challenge necessitates accepting the possibility of paradigms' coexistence, both in its concept's narrow and broad senses. One should remain sceptical about the likelihood of a shared paradigm emerging, given the fragmented nature of "normal science" and, conversely, the limited potential of mainstream economics.

Evidence from Kuhn's theory suggests that the paradigm shift in innovation policy displays characteristics of a scientific revolution, characterised by the emergence of anomalies (sustainability challenges) that prompt recognition of new solutions and the gradual adoption of a new economic framework despite resistance from established norms. The positivist ideal of an economy free from value judgments and the accumulation of "real" knowledge on managing the economy more efficiently was confronted with ecological and social imperatives. Viewing the shift through the broad Kuhn paradigm facilitates understanding the transition towards sustainability and its meanings and implications. As there is a shift in the disciplinary matrix of beliefs and symbols, the paradigm shift encounters resistance. This change encompasses the entire discipline of economics. In the context of innovation, the innovation bias obscures the radical nature of the transition. Not all its sources have become obsolete, but new ones have emerged to realise the goal of sustainability. The scale of the change is immense, as highlighted by the example of the farmer from Rogers' work. We can also observe that politics is crucial in the relationship between innovation and development.

We are facing a qualitative anomaly regarding a shift in the innovation paradigm. As we observe, the traditional approach endangers economic stability. The foundation of the new approach involves rethinking the three primary dimensions of sustainable development. The model illustrating the relationship between the economic, social, and environmental dimensions of development, which offers three binary options, should transition to a model resembling a nested system where the economic sphere (financial and manufactured capital) is encompassed within the social sphere (intellectual, social relationships, and human capital), which, in turn, operates within the confines of the ecological sphere (natural capital).

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