



Are Schumpeter's Innovations Responsible? A Reflection on the Concept of Responsible (Research and) Innovation from a Neo-Schumpeterian Perspective

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Abstract

Responsible research and innovation (RRI) has gained significant traction in recent decades. However, the previous discussions on RRI have overlooked the economic dimension of innovation, which is encompassed by the perspective of Neo-Schumpeterian economics (N-SE). This paper aims to bridge the gap between the theories of responsible innovation (RI) and RRI and the underlying assumptions of N-SE. We seek to clarify the concept of responsible (research and) innovation — R(R)I. N-SE inherently recognizes the involvement of diverse stakeholders, including society and the public sector, as entrepreneurs driving and implementing innovation while assuming responsibility for its effects and consequences. In this respect, N-SE aligns with the responsible innovation concept discussed within the R(R)I framework. The paper addresses the fundamental question: What are the shared areas of interest between R(R)I and N-SE? This exploration enhances our understanding and facilitates the practical implementation of R(R)I in the context of N-SE, thereby promoting ethical, socially beneficial, and sustainable technological advancements.

Keywords Responsible innovation · Responsible research and innovation · Neo-Schumpeterian economics · Schumpeter, Public sector · Society

Introduction

Nowadays, in the knowledge-based economy, we are witnessing increasing attention on responsibility of innovations paid by companies, scientists, and policy-making institutions. This translates into systemic, long-range solutions supporting various

Neo-Schumpeterian Economics and Neo-Schumpeterian Evolutionary Economics in this paper are treated identically.

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activities, whereas responsible innovation (RI) refers to the concept of developing and implementing new ideas, technologies, products, or services in a way that takes into consideration the potential social, ethical, environmental, and economic impacts they may have. It involves a proactive and holistic approach that considers the entire life cycle of an innovation, from its inception to its ultimate deployment and beyond. It also emphasizes the need to align innovation with broader societal goals and values and to anticipate and mitigate any negative consequences (Stilgoe et al., 2013).

On the other hand, the term “research and innovation” is commonly used in the public domain. For example, the Seventh Research Framework Programme (FP7) and Horizon 2020 Programme (H2020) implemented by the European Commission (EC) in 2007–2020 had a total budget exceeding 135 billion Euros allocated specifically to research and innovation.

The concept of “research and innovation” has been the primary focus of FP7, while the emphasis in H2020 is placed on “responsible research and innovation” (RRI). Even though the concepts of RI and RRI have been extensively used, as well as Schumpeterian and Neo-Schumpeterian approaches to innovations, surprisingly very few publications focusing on RI and RRI also consider the Neo-Schumpeterian Economics (N-SE)¹, based on the theories created by J. A. Schumpeter. Eventually, Schumpeter was one of the first who reflected on innovations in many fields, such as the theory of economic development, business cycles, or entrepreneurship (Schlaile et al., 2018). This lack of publications linking RI, RRI, and N-SE became an inspiration to undertake this research topic.

Based on the results of the initial literature review, which highlighted a research gap in the integration of Neo-Schumpeterian economics (N-SE) with responsible (research and) innovation — R(R)I, the main objective of this paper is to investigate the potential common areas of interest between R(R)I and N-SE. We believe that there is a notable lack of consideration for the responsibility of innovations based on economic foundations, where N-SE could play a pivotal role. Identifying this gap served as the catalyst for initiating our discussion paper on RI and RRI within the framework of N-SE.

Consequently, this article presents a summary of our observations and reflections on this topic. To ensure a comprehensive understanding of N-SE’s fundamental elements, we primarily rely on the widely cited article by Hanusch and Pyka (2006) titled “Principles of Neo-Schumpeterian Economics.” This source serves as a reliable basis for our analysis. In this article, we aim to explore whether innovations related to RI and RRI align with the principles of the Neo-Schumpeterian approach. Furthermore, we examine the role of society and the public sector as key actors in promoting responsibility in the context of N-SE.

The primary research method employed to achieve our objective was a systematic literature review (SLR), following the combined approaches of Denyer and Tranfield (2009), Rowley and Slack (2004), and Snyder (2019), and utilizing the PRISMA diagram by Haddaway et al. (2022). As previously mentioned, the initial literature review successfully identified the existing research gap. While both responsible (research and) innovation and the Neo-Schumpeterian approach to innovations have been extensively discussed in the literature, no studies were

found that combined or compared these two concepts or examined the role of public actors as entrepreneurs within this context.

Conducting a search using relevant keywords to bridge this gap resulted in only three sources from ScienceDirect. However, upon analysing the texts, it was determined that they did not provide the necessary level of detail for our study as they merely mentioned the two approaches without delving into a comprehensive analysis. Considering the significant impact of public interventions, such as EU-funded initiatives, on shaping contemporary innovations (as measured, for instance, by the Regional Innovation Scoreboard), we recognized the importance of addressing this gap through our proposed article.

Due to the limitations encountered in analysing the existing literature directly related to our specific topic, we opted to divide the literature review into two separate rounds. This approach allowed us to individually identify the key insights for R(R)I and N-SE, respectively. Subsequently, we synthesized the results and developed a new research field that helps organize the theory of innovations within the context of public interventions and actors.

A systematic literature review (SLR) should be conducted according to a robust and replicable research procedure, focusing on a specific research objective, to synthesize various perspectives and approaches (Armitage & Keeble-Ramsay, 2009). Piper (2013) suggests that an SLR can yield multiple outcomes, and in the field of economics, different approaches may collide. The final outcome of an SLR should encompass three elements: assessment, summary, and identification of gaps or shortcomings for future research.

To commence the SLR, we performed the initial literature review and identified the research gap, which guided the design of the review procedure. The following keywords were used for the search:

Round 1:

- “evolutionary economics” or “responsible innovation*” or “responsible research and innovation*”, in abstract,
- published to 2023,
- accepting “in press” papers, articles and books,
- English language sources,
- only full-text records (according to academic subscription, search engines: ScienceDirect, Springer, EBSCOhost),
- PDF files only.

Round 2:

- “neo-schumpeter*” or (“Schumpeter*” and “innovation*”), in abstract,
- the other conditions as in round 1.

Altogether, in round 1, 448 papers were identified; after removing duplicates, the remaining 424 papers’ abstracts were scanned. The remaining 247 papers were analysed (text analysis), and 59 were included in the elaboration of the results.

Altogether, in round 2, 416 papers were identified; after removing duplicates, the remaining 398 papers' abstracts were scanned. The remaining 89 papers were analysed (text analysis), and 23 were included in the elaboration of the results.

Finally after rounds 1 and 2, 82 papers were included for the following sections that present the outcomes of the analysis.

RI, RRI, or R(R)I?

In our view, the current state of knowledge on responsible innovation lacks a clear understanding of fundamental terms. Within this field, the notions of RI and RRI are considered most significant. However, there is limited focus on the concept of innovation itself and its economic implications. RI and RRI are multifaceted concepts that encompass ethical, philosophical, political, economic, and scientific dimensions, emerging from the discourse on the interplay between science and society (Stilgoe et al., 2013).

There are a few differences between the RI and RRI concepts. Starting from the origin of the concept, the RI concept has strong academic roots while RRI was developed by the European Union's (EU) policymakers to create sustainable, inclusive growth and prosperity to address the societal challenges of modern economies. Introducing the RRI concept by the European Commission (EC) was considered as an attempt to rethink research and science as public goods (Felt, 2014). The idea assumes that research can, in fact, become the driver in addressing the so-called "grand challenges" of our time and play a major role in solving crucial present-day problems observed in the public domain. Consequently, RRI should be a source of insights and solutions beneficial to society (Bardone & Lind, 2016; Gardner & Williams, 2015; Schomberg, 2013; Sutcliffe, 2011).

However, both concepts have their roots in previous thoughts on the concepts of appropriate innovations and inclusive innovations. For example, Karl Marx considered the labour-process community to support innovations, especially in highly innovative and therefore, dynamic and vulnerable sectors. Today, his conventional account about the community is considered in work organization, explaining community-based innovations like soft skills corporate culture or teamwork (Adler, 2015). Just as Karl Marx's political economy has influenced the field, the theories of Fritz Schumacher on appropriate technologies have also contributed to innovation theory and are today used to explain for instance dynamics of sharing global value chains (Foster & Heeks, 2013).

In the present context, the understanding of innovation encompasses various dimensions, including inclusive innovations and the systems of innovations (SoI) framework. Additionally, the establishment of research and development structures plays a crucial role, particularly in the context of fostering innovation in developing countries (Chataway & Wield, 2000; Kaplinsky et al., 2010). It is important to note that research and innovation are not always considered public goods but are frequently influenced by regulatory framework elements that provide incentives and engagement (Levidow & Papaioannou, 2018).

The better developed direction in innovation-related research is the inclusive innovation concept described by Foster and Heeks as “processes of innovation that specifically encompass those on lowest incomes” (Foster & Heeks, 2013, p. 334). Development is perceived here as socio-economic inclusion, and the needed actors are intermediaries in the innovation diffusion process being research and development brokers and innovators themselves. Inclusive innovation is often compared with responsible innovation (Chataway et al., 2014; Harsh et al., 2018). The inclusiveness is part of the EC’s RRI concept together with the sustainable development (Nazarko, 2020). The economic aspect of inclusive innovations was addressed in the literature. The loose relations between inclusive innovation and Neo-Schumpeterian economics were first indicated by Papaioannou and Srinivas (2019). According to them, moral and political values should converge with industrial priorities.

The leading role in the inclusive innovation-related literature is played by technology, mainly emerging technology (Harsh et al., 2018). However, the socio-economic dimension should be embedded in the technological innovation to meet the needs of people, especially in developing countries (Srinivas & Sutz, 2008). A prominent place on the map of concepts about inclusive and responsible innovation has been taken by the discussion of the Collingridge dilemma of social control of technology, anticipating and controlling the potential consequences of emerging technologies (Ribeiro et al., 2018). The development of this theory was coinciding in time with the development of formal technology assessment (TA) methods.

What is more, the EC’s RRI concept, in particular, addresses the need for social development, social justice, and the equitable distribution of outcomes derived from science, technology, and innovation. This concept aligns seamlessly with the ongoing discussion in the research community regarding the implementation of RRI from the perspective of funding and managing institutions (Moan et al., 2023) which likely prompted the EC’s intention to facilitate and accelerate change through a European agreement on the reform of the research performance evaluation system (Ong et al., 2023). The governance mechanisms should be formal, centralized, and regulatory (Ribeiro et al., 2017). However, this approach fails to address marginalized communities, which makes it challenging to apply on its own in a governance framework. However, the “Collingridge qualities” are perceived as the ones to be deliberated in RRI (Genus & Stirling, 2018). In turn, according to the dilemma of societal alignment, the public and various actors (both private and public sectors) should focus on societal needs and on generating public value (Ribeiro et al., 2018).

Whereas the research on RI focuses on the question: how is it possible to direct technology and innovation towards socially expected results? (Owen et al., 2013). An essential aspect of this debate is the democratization of innovation, as a result of public stakeholder engagement in the preparation and implementation of new solutions (Stilgoe et al., 2013; Wong, 2016). The main rules of RI partly overlap with the guiding principles of earlier concepts, mostly related to technological development, such as ELSI/ELSA (Ethical, Legal and Social Aspects of technology) and TA (Stirling, 2008), science and technology studies (STS), and anticipatory governance (Barben et al., 2008).

The foundations of the RI concept — e.g. STS, TA, and ELSI/ELSA or social innovations — suggest a specific origin in the debate about the relationships

between science and society (Genus & Stirling, 2018; Murphy et al., 2016; Owen & Pansera, 2019; Stilgoe et al., 2013). The basic theories of responsibility in science and RI were presented much earlier than the idea of RRI (Popper, 1959; Edsall, 1975; Longino, 1990; Shrader-Frechette, 1994; Reiser & Bulger, 1997; Kitcher, 2001). Moreover, they have some other roots — RI is more theoretical, while RRI is more practical. This could potentially be one of the main reasons for considering RI and RRI as two separate concepts. However, as we show in the further part of the paper, there are common areas of these concepts that make it possible to consider them in conjunction.

Surprisingly, despite the quite long history, the research on RI is still on an initial stage. Nevertheless, the evaluation of responsible innovations is a well-described area in the literature. The already published papers also contain the definitions of the conceptual dimensions of RI, i.e.: anticipation, inclusion (inclusive deliberation), reflexivity, responsiveness, care, and sustainability (Owen et al., 2013; Stilgoe et al., 2013), which also are the “Colligridge qualities.” RI is “taking care of the future through collective stewardship of science and innovation in the present” (Stilgoe et al., 2013, p. 1570). As RI is based on the foundations of TA, we assume that society should take an active role in democratic deliberation on the responsibility of innovation assessment (von Schomberg, 1999). Then, in our view, combining responsibility and innovation in one joint concept on the ground of current and future scientific and societal challenges does not clearly correspond with the classic theory of innovation emerged as a separate area of study at the crossing of (among others): the economics of growth, political economy, industrial organization, microeconomics, and regional economics.

In turn, the concept of RRI is much “younger.” Rene von Schomberg initiated RRI as a policy discourse, which was adopted by the EC’s “Science in Society” and “Science With and For Society” programmes (Owen et al., 2013; Owen & Pansera, 2019). Thus, in the current research, the most common definition of RRI states:

Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society) (Von Schomberg, 2013, p. 63).

RRI is fundamentally a cluster of ideas for promoting science governance, which focuses primarily on responsible processes as opposed to those that are not supervised responsibly (Burget et al., 2017). In turn, the EC proposed five distinct “RRI keys” which have become an essential frame in the “Science With and For Society” programme within H2020. These are public engagement, open access, gender equality, science education, and ethics (Regulation (EU), 2013). A sixth key, governance, was added to the five initial.

So, are the RI and RRI distinct or similar? Even if sometimes the above-mentioned keys are radically different from aspects proposed in RI-related papers, a more in-depth analysis of the RRI keys and RI conceptual dimensions shows many commonalities. What is a common area for RI dimensions and RRI keys is the “social aspect”

of innovation. RRI or RI might even be considered as a “science social responsibility” concept, in particular among research funding actors (Khan et al., 2016; de Jong et al., 2016). However, the RRI keys represent a very selective approach rather than a coherent discourse and do not substantively engage with innovation, or innovation systems (Owen & Pansera, 2019). RRI is apparently a divergence from earlier models of research governance (Burget et al., 2017; Landeweerd et al., 2015), as it focuses more on the public value and meaning of research and innovation; awareness of the broader context of research together with the plurality of positions and interests in the public domain; responsiveness to problems and opportunities as they arise, instead of focusing on outcomes; a reflexive attitude that would address broader issues concerning underlying elements including human ignorance and finitude (Bardone & Lind, 2016).

We agree with Owen and Pansera’s (2019) analysis of the commonalities and differences between RI and RRI, including the fact that they address different actors. We argue that in the RRI conceptualization, “stakeholders” are used as a key word meaning societal actors without literally specifying who they are, why their participation is decisive, what exactly is their contribution, and why they should be engaged in the innovation process. In the RI concept, the group of actors includes, among others, researchers and innovators, funding agencies, policymakers and government bodies, industry and businesses, civil society organizations, citizens and user communities, ethics and social science experts, education, and training institutions. What is more, RI is a broader term, including not only actors and the innovation notion itself but also the process of its creation, being a forerunner of new solutions.

If the RI and RRI are overlapping, the following questions arise: How to analyse RI and RRI: together or separately? How to analyse them considering their commonalities? Even though RRI is a young concept, it is developing quite rapidly. Owen and Pansera (2019, p. 39) claim that RRI includes multi-actor and public engagement, enabling easier access to scientific results framed around the “3 Os” of “open innovation, open science, open to the world.” Assumptions of “3 Os” coincide with the RI’s conceptual dimensions approach. This applies to both the inclusiveness dimension where researchers make a strong case for involving stakeholders into science and innovation processes, anticipation where emphasis is placed on opening the innovation visions to broader public, and responsiveness focused on the impact of public engagement in the innovation responsibility assessment process.

Following this “3 Os” lead in 2019, the EC initiated a strategic planning process for implementing the research and innovation framework programme — Horizon Europe, which is based on the concept of the “missions” (and not as previously on the RRI’s “keys”). This last development is relevant to our discussion on RRI and Neo-Schumpeterian approaches, as the concept of missions has been developed by Mariana Mazzucato who can be considered a Neo-Schumpeterian thinker (Mazzucato, 2018).

Whereas RI and RRI overlap in various areas, such as ethical considerations (Stilgoe et al., 2013; von Schomberg, 2013); social impact and sustainability (Owen et al., 2013); anticipation, reflexivity, and inclusive governance (Owen et al., 2013; von Schomberg, 2013), and education, research, and public engagement (Stilgoe et al., 2013), we argue that RI and RRI share common fundamentals and can be analysed together. Therefore, in the following sections, we focus on the common

aspects of RI and RRI, reflect on these concepts in relation to N-SE, and analyse both concepts together as R(R)I — Responsible (Research and) Innovation.

R(R)I and Neo-Schumpeterian Economics

Considered one of the most prolific economists of our age, Joseph Alois Schumpeter has taken a permanent place in the pages of the history of economic thought, and his theories have recently been booming interest among researchers. Schumpeter also made significant contributions to the development of science methodology by emphasizing that any analysis of a larger system must begin with a consideration of the motives and behaviour of individuals (methodological individualism) and repeated beliefs about the need to create each economic theory cumulatively, as in other fields of science. Schumpeter focused on the entrepreneur's nature (Schot & Edward Steinmueller, 2018). He was the first to formulate the main concepts underlying theories, often called the post-Schumpeter trend or Neo-Schumpeterian Economics (N-SE). Now, this trend is one of the main directions in evolutionary economics, represented among others by R. R. Nelson, S. G. Winter, G. Silverberg, G. Dosi, C. Freeman, and N. Rosenberg. For the purpose of this study, we decided to base this discussion paper on the publication of Hanusch and Pyka (2006), who define Neo-Schumpeterian Economics as dynamic processes causing qualitative transformation of economies driven by the introduction of innovation in their various, multifaceted forms.

When considering the R(R)I concept, its crucial component, namely the innovation idea in the strict sense, should be reviewed more thoroughly. Because of its numerous definitions, it became a “buzzword” overused in the public and research domain. Again, it should be stressed that Schumpeter was one of the first (if not the first one) who introduced the concept of innovation to economics. According to Schumpeter (1983, 1986, 1994), innovation is defined as follows: (1) launch of a new product/service or a new kind of already known product/service; (2) application of new methods of production or sales of a product or offering service (not yet proven in the industry/market); (3) opening of a new market (the market for which a branch of the industry/market was not yet represented); (4) acquiring of new sources of supply of raw material or semi-finished goods; (5) new industry/market structure such as the creation or destruction of a monopoly position; (6) application of the new organization of industry. This definition of innovation is probably the most transparent and unambiguous. From the perspective of innovations' responsibility, the crucial fact is that concentration on products and services provides the innovation notion market connotations.

On the other hand, if there is no effective market positioning and cash flows associated with the transactions, in which products or services take part, we cannot call it an innovation. This leads to another interesting innovation definition proposed by the Massachusetts Institute of Technology (MIT). It is described by the simplest equation that innovation equals invention multiplied by commercialization (Aulet, 2016). This relationship provides the opportunity to consider sensational inventions multiplied by a failure to commercialize (marked with zero) for lack of innovation (zero-score innovation). This applies even in the case of universities where creating

innovations in the frame of universities knowledge production is relevant, justified, and important but this has not been, is not, and will not become the core of its function (van Rooij, 2014).

But what if there is “responsible” invention labelled as “responsible” because it may solve future problems or address the grand challenges of our time, but lacks the possibility of commercialization? In such cases, can we still discuss its successful implementation? Who should be the principal responsible “innovation agent” in this scenario (Bolz, 2017)? These are genuine questions in a rapidly changing technological environment. We argue that Schumpeter’s approach may provide a solid foundation for reflecting on this matter. We are aware that the N-SE theory is not entirely developed and still requires the creation of new methods due to the complexity of the issue and its relative youth. Additionally, it is worth noting that the N-SE is not a homogeneous school of economics, and the scholars associated with N-SE present different approaches, such as the role of actors in creating innovations and planning their diffusion (Papaioannou & Srinivas, 2019).

However, Schumpeter’s economics often emphasizes innovation and its creation process, which is influenced not only by stakeholders other than those affiliated to companies but also by philosophical considerations and other actors, which can encompass social values related to responsibility. As a result, Schumpeter’s approach may share commonalities with the R(R)I concept, but a detailed discussion is necessary, just as it is for N-SE.

Since the redevelopment of Schumpeter’s view on innovation as a driver of the capitalist economy (e.g. Schumpeter, 1983, 1986, 1994), in N-SE, there has been an ongoing effort to recognize innovation as a driver of socio-economic amendments (e.g. Dopfer, 2001, 2005; Hanusch & Andreas, 2007; Pyka & Andersen, 2012; Witt, 2003, 2008, 2014; Papaioannou & Srinivas, 2018; Radosevic, 2022). Contemporary perception of innovation in the strict sense in the R(R)I literature often seems to be narrower (Blok & Lemmens, 2015). Innovation cannot be perceived as a simple, linear model with clear postponements from invention to impact, and where accountability for such impacts can be traced. It should always be treated as a complex, collective, and dynamic phenomenon (Owen et al., 2013). Therefore, it is possible to cross-reference the N-SE and R(R)I with its focus on responsibility and social impact. From this point of view, innovation is an endogenous process emerging from the (inter)actions of interdependent heterogeneous agents in a complex system (also including such actors as society as a whole and the public sector), where the outcomes are often characterized by fundamental uncertainty (Blok & Lemmens, 2015; Pyka, 2014). This forms the basis for the discourse on the role of R(R)I in N-SE theory.

N-SE concerning sustainable development and diverse innovations provides a framework for approaching issues of “collective agents” (Schlaile et al., 2018). These agents play a significant role in processes related to innovations. Thus, according to N-SE (Hanusch & Pyka, 2006, p. 278):

[...] Displayed equation the outcome of evolutionary processes is determined neither *ex ante* nor as the result of global optimising, but rather is due to true uncertainty underlying all processes of novelty generation, and so allows for

openness towards future developments a feature of evolutionary theories which makes them ideal for analysing innovation processes. Not surprisingly, in evolutionary economic theories, learning and the cognition of economic actors are central. Bounded-rational actors learn and search experimentally in uncertain and permanently changing environments. The feature of path dependency corresponds well to the cumulative nature of building up knowledge. Additionally, innovation is considered as a process spurred collectively by many different actors. Heterogeneity of actors is an important source of novelty [...].

Firstly, “economic actors,” “stakeholders,” and “collective agents” participate in the innovation creation process. Research on innovation is made in networks and aims to capture aspects of joint agents (stakeholders). It means that there is not only one isolated single-player inventor, innovator, or entrepreneur. On the contrary, the innovation process is perceived as “a multi-player game” (Bessant, 2013). In this view, the notion of innovation in N-SE encompasses, besides the scientific and technological innovation, other dimensions as well, such as institutional, organizational, social and political (Hanusch & Pyka, 2006).

Secondly, according to Hanusch and Pyka (2006), the N-SE perspective involves the “multi-player agents” implementing innovations, classified in three essential pillars: public sector, industry, and financial markets. However, stakeholders’ perspectives can vary, leading to distinctions such as global companies, SMEs, start-ups, spin-offs, communities, societies, consumers, and grassroots groups (Kuzma & Roberts, 2018; Long et al., 2019). While all these stakeholders fall under the umbrella of the three main sub-groups (public sector, industry, and financial markets), the loose approach by Hanusch and Pyka necessitates adjustments in the N-SE concept. This may involve expanding the stakeholder catalogue, or enhancing or adjusting the group of pillars with reality. These adjustments pose new potential research challenges. In this regard, the N-SE’s concept notion of “collective agents” can be interpreted as “societies” of micro-entities, which “cooperate” more strictly, thereby achieving structural stability. Furthermore, organizations such as business enterprises or innovation networks can also be considered as “societies” (for example the so-called business societies, business environments, and business ecosystems).

Society in N-SE as a Responsibility Actor

The primary questions that arise from the R(R)I and N-SE cross-analysis are as follows: Who decides about the responsibility of innovations? The government? The parliaments? The society — recipients of innovation? Individual customers? Potential ones or real ones? How is this process of deciding about the responsibility of innovations going on? At first glance, the N-SE concept does not attempt to address these aspects, while the R(R)I literature offers the opposite trend.

Hanusch and Pyka (2006) proposed a comprehensive N-SE framework based on innovation, anchored in open and uncertain socio-economic systems, whereas the socio-economic system is included in the assumptions of N-SE. It can be assumed that determining innovation as “responsible” means that products or services are

minimizing the risk of negative consequences for society. This is because Neo-Schumpeterians clearly defined “uncertainty” as the unpredictability of the outcome, which is convergent with the R(R)I assumptions of an uncertain future. At this point, another question arises: Which innovation can be described as responsible and which not? In our view, in specific cases, we are dealing with a kind of paradox. Between smooth development and radical changes in the economy, between the competitive position of entrepreneur and Schumpeter’s “creative destruction,” many examples of products or services can be defined as questionable as to be or not to be responsible. Sometimes, the questionable responsibility effect arises already at the design stage, while others when using the innovation.

Plenty of problems are associated with assessing whether an innovation is responsible. It depends on the point of view. What is considered as responsible innovation may be different not only among different stakeholders groups but also in various economic systems, cultural circles, or societies. In fact, the taxonomy of different groups, which may have contrasting perspectives and opinions, is wide and complex. Even society can be perceived divergently: as local, national, regional, and global. From an axiological point of view, delivering some solution for society can be assessed as necessary and responsible to one stakeholder, and irresponsible to another. It depends on the values perceptions of the actors. From one perspective, innovation can be seen as an added value, profit, rate of return, increasing competitive position, oligopolization, or monopolization generated by innovations. From another perspective, innovation can be seen as taking care of the future through collective stewardship of knowledge and research at present (Stilgoe et al., 2013). In some societies, specific innovations are perceived as questionable regarding responsibility. This applies in particular to atomic energy, biofuels, glyphosate, palm oil, fracking, genetic modification, disposable/unamendable electronics or consumer goods, carbon offsets, DDT — dichlorodiphenyltrichloroethane, financial derivatives, sub-prime mortgages, or high-frequency trading. In the TA process, particular “benefits” and “negative consequences” intersect with each other, like in the case of artificial intelligence and robotics, biotechnologies, geoengineering, neurotechnologies, space technologies, or even 3D printing. The “public perception” or “stakeholder opinions” cannot determine whether an innovation is responsible or not.

As mentioned before, innovation is a commercialized or more widely, implemented, invention which takes the form of a product or service. Then how can society perceive innovation in the economy? In neoclassical economics, innovations are understood merely as exogenous events or “shocks” — and thereafter, the system again moves towards equilibrium. According to this theory, society can only influence on innovation at the customer level. The remaining role is taken up by the state and taxation system. According to Schumpeter, innovation may be caused by out-of-equilibrium acting and conditions. Considerations on the society and responsibility of innovation may be reflected in Schumpeter’s definition of the “creative destruction” concept (Schumpeter, 1943). In this framework, innovation may be positive to one agent and negative to another at the same time, which is a kind of paradox, as mentioned above. This fact causes considerable complexity to the process of interpretation of responsibility from a societal point of view. Schumpeter’s creative destruction makes innovation “ambivalent.” In other words, innovation in creative destruction processes is transforming itself

from one (deconstructed) to another (new one) creatively. Additional questions arise at this point: Are innovations in “creative destruction” processes responsible or not? Does the source of financing (private and public funds) affect the responsibility of innovations? Are free market assumptions or perhaps state interventionism a better model for generating responsible innovations? What is the balance of benefits and losses for society due to the “creative destruction” action? What roles and interactions of stakeholders would enhance the understanding of how N-SE and R(R)I can be integrated?

The conceptual dimensions of RI mentioned before are helpful in the above considerations. Particular attention should be paid to inclusion. In fact, inclusiveness is a key theme in research on R(R)I, which makes a strong case for involving stakeholders in science and innovation processes. So far, they do not discuss how to make science more inclusive and tackle barriers that prevent marginalized scholars from participating in knowledge production and societal meaning-making (Koch, 2020; Thapa et al., 2019). Many research followers of R(R)I concept see inclusion as the “ongoing involvement of society.” What is crucial at this point is that discussed responsible process of implementing innovations should proceed without wasting taxpayers’ money or time simultaneously. An example of such an approach may be for example implementation of ESG (environmental, social, and governance) requirements in the economy (Alda, 2021), developing food production systems (van Mierlo et al., 2020), reinforcing of social entrepreneurship (Lubberink et al., 2019), or digital health innovations (Naughton et al., 2023).

Considering the assumptions of N-SE, in our view, either Schumpeter nor Neo-Schumpeterians reflect on the essence of responsibility of innovation and the role of society in this matter. However, in his late works, Schumpeter recognized the possibility that the state or government agencies could act as an entrepreneur and generate innovations (Schumpeter, 1943, 1947). Based on N-SE’s framework of “collective agents” concerning sustainable development and diverse innovations, we may consider an opportunity to reflect on the role of the public sector concerning the R(R)I concept.

The Public Sector in N-SE as a Responsibility Entrepreneurial Actor

There is a strong need for a better understanding of how Schumpeter’s perception of the entrepreneur translates into the role of the public sector in the responsible innovation concept. In his “second entrepreneurship theory” presented in his work “Business Cycles” (1939) and four articles “The Creative Response in Economic History” (1947), “Theoretical Problems of Economic Growth” (1947), “Economic Theory and Entrepreneurial History” (1949), and “The Historical Approach to the Analysis of Business Cycles” (1949), Schumpeter states that an entrepreneur does not have to be a person (which is a radical departure from his earlier recognition of entrepreneur as an outstanding individualist). The entrepreneur can be either a country (or state) or its agency that can act as an entrepreneur (Śledzik, 2013). However, the state and/or government is not a sharp example of the entrepreneur but rather a seasonal, temporary one. We may risk a statement based predominantly on Mazzucato’s papers (Mazzucato, 2013, 2018) or the EC publications (with its

programmes based on the RRI) that in N-SE theory the state might also be considered as an entrepreneur. However, the role of those is to enable innovations and develop a framework to encourage other actors to create innovations. A few examples exist where the state can behave like a Schumpeterian entrepreneur. In this case, we talk about public institutions supporting pro-innovation activities, about funds (e.g. EU funds) directed at development through innovation, but ultimately we consider the distribution of taxpayers' money.

In the context of Neo-Schumpeterian thinking, the mention of responsibility and society is only briefly touched upon (Hanusch & Pyka, 2006, p. 284–285):

The existence and necessity of a public sector can be explained within the Neo-Schumpeterian approach again by the persistence and inevitability of uncertainty accompanying every kind of innovation [...]. Ex ante, it is impossible to know who will win and who will lose the innovation game. [...] An individual as a member of society can agree on a social contract to deal with the peculiarities and imponderables of innovation processes. This social contract then has to be executed by a state authority. In the Neo-Schumpeterian context, sure enough the social contract also applies to firm actors and entails both support for uncertain innovation activities as well as social responsibilities in the case of innovative success.

To be more precise, in the latest publications of Schumpeter, there are mentions that the state, or tax-state (as Schumpeter defined it), can function as an entrepreneur. In Hanusch and Pyka's "Principles of Neo-Schumpeterian Economics," the expectations of state/public sector are to support consumption, production of goods towards future growth, and labour-qualification transfer from old to new industries (Hanusch & Pyka, 2006).

When considering the challenges posed by high-tech or innovative technologies, we may question whether the role of the public sector should be limited to being an inter-temporal redistribution agent. In a knowledge-based economy, new risks and benefits emerge, and the concept of "responsible innovation" becomes relevant. In the case of new risks, R(R)I can redirect technologies to minimize the impact of uncertainties. On the other hand, new benefits can have societal implications, leading to social innovation. At this point, it is important to note that N-SE somewhat overlooks the active involvement of society in the innovation process. However, upon analysing the foundations of R(R)I and N-SE, we can infer that both concepts address society and the public sector as common stakeholders. N-SE assumes a dynamic role for society in the public sphere. Nevertheless, N-SE does not explicitly highlight the specific actions that the community should undertake in implementing innovation or "responsible innovation."

When considering the public sector in N-SE as a responsibility actor, one can refer to RI conceptual dimensions, especially to inclusion and anticipation. Barben et al. (2008) mention the importance of engaging public stakeholders in the early stages of innovation transfer to positively influence technological development. However, there have been significant criticisms regarding the limited ability to enhance public agency in technological choices and the potential distortion of innovation trajectories through public engagement in R(R)I (Stirling, 2008; Stilgoe et al., 2013; Yu et al., 2023). This

is one of the main challenges related to the proposal to involve public stakeholders in the innovation responsibility assessment process. Inclusion, anticipation, and responsiveness of innovation systems in economies seemed to be the solution to this problem. According to Pellizzoni (2004), it is crucial to consider how innovations or systems of innovation can be formed to be as responsive as possible. Highlighting the link to inclusion, he suggests that responsiveness involves modifying courses of action while acknowledging the deficit of knowledge and control (Burget et al., 2017). In light of this, we argue that the following activities meet the requirements of both the R(R)I conceptual dimensions and the functioning of N-SE: broader public involvement in the innovation process and research process; increasing public awareness of the opportunities offered by science, technology, and innovation in solving contemporary and future problems; identifying methods to ensure effective cooperation between public collective agents and society; presentation of the value of scientific research and innovation; enhancing public access to research results (generated with taxpayers' funds); incorporating ethical considerations and the R(R)I conceptual dimensions; presentation of new innovative solutions and their potential applications.

Considering the points discussed above, it is possible to assume that a triple-helix approach can be found within N-SE theory. However, we argue that the connection between N-SE and R(R)I concepts can be further strengthened by adopting a quadruple or quintuple-helix approach (Leydesdorff, 2012; Carayannis & Campbell, 2021; Morawska-Jancelewicz, 2022). This expanded approach adds “civil society” and the “media- and culture-based public” as additional stakeholders to N-SE. Furthermore, the quintuple-helix approach can be enhanced by including social entrepreneurs, activists, citizen science, frugal innovations, bricoleurs, and assemblers. These additions broaden the scope of actors and factors involved in innovation processes. It is worth noting that R(R)I initiatives within public sectors may serve as examples of potentially misdirected innovation policies. An economy focused on open innovation policies, funded by taxpayers' funds, aligns with the assumptions of Schumpeter's approach to the entrepreneur as a key actor. This perspective stands in contrast to the traditional industrial policy model. Neo-Schumpeterians propose a growing share of public expenditures on infrastructure, education, and research (which should lead to long-term economic growth). We argue that this emphasis on public investments opens up a space for reflection on the public sector's role in the creation of responsible innovations. In line with this, a new approach has recently been proposed by a scholar within the N-SE framework, referring to the “entrepreneurial state,” which de facto has been promoting and facilitating most long-term research and innovation policies in industrialized countries (Mazzucato, 2013).

Concluding Remarks

In conclusion, the literature on responsible innovation still lacks a precise definition. However, it is clear that innovations must address societal needs. Furthermore, there are instances where certain innovations are rejected by society due to their focus on high returns and profits, despite causing long-term harm to society, the environment, and living conditions. For instance, the exorbitant prices of drugs for rare diseases or

environmental damage caused by certain industries. Nevertheless, the practice of R(R)I can offer valuable insights, particularly when it involves diverse actors with distinct roles and perspectives working together to implement innovation policies (Declich, 2019).

The findings in the realm of innovation support and generation within the broader economy further enhance the helix concept by including various responsible actors (Carayannis & Campbell, 2021). These actors encompass academia, universities, higher education systems, government, political systems, industry, firms, the economic system, civil society, media- and culture-based public, arts, artistic research, art-based innovations, the natural environment, and the societal and economic natural environments (knowledge society and knowledge economy).

Regarding the objectives of this study, the theoretical and empirical implications, as well as the limitations of the research, and propositions for further research are offered in the following.

Theoretical Implications

As a result of the study, we argue that conceptual dimension of innovation needs to be emphasized more in the R(R)I concept. An evaluation of 82 articles revealed a lack of sufficient discussion on R(R)I within the context of N-SE theory. This indicates that limited attention has been given to the R(R)I concept within the N-SE framework. As the actors and conceptual dimensions of R(R)I were identified, the study also reviewed the structure of N-SE, with a particular focus on the public sector and society. Hanusch and Pyka (2006) state that innovation is a collective process involving various actors and encompasses social and political dimensions. Similarly, in the RI concept, society plays an active role in democratic deliberation regarding the responsibility of innovation assessment. The proposed R(R)I concept aims to govern innovation in a more democratic and responsible manner, addressing stakeholder needs, solving contemporary problems, and tackling grand challenges. It calls for direct societal intervention in the implementation of science and innovation in the economy. This proposed concept aligns with the recognition of the state or the entire public sector as an entrepreneur, as advocated by Schumpeter's theories and N-SE assumptions, providing society with an opportunity to participate in the innovation process. In summary, the R(R)I concept closely relates to N-SE, and further in-depth research can shed more light on their similarities, contributing to the development of both concepts. The theoretical findings of this study can serve as a basis for investigating other aspects of R(R)I and N-SE across various fields.

Empirical Implications

In terms of empirical implications, this study represents the first systematic exploration of responsibility aspects within Neo-Schumpeterian Evolutionary Economics. The findings highlight the need to upgrade the roles of public actors, society, civil

society, and even media- and culture-based actors in initiating and implementing innovation processes to renew the existing system solutions from an N-SE perspective.

Furthermore, the study points out that solely focusing on economic values, such as increasing company value, brand value, and return on investment, which are important from an N-SE and general economic standpoint, may raise questions regarding responsibility among stakeholders, particularly from a societal perspective. Stakeholders have the power to effectively influence the strategic decisions of innovative enterprises, emphasizing the importance of finding a compromise and balance that meets legal requirements and stakeholder needs.

Moreover, in practice, there is a risk that the R(R)I concept could be used as a mere facade, resulting in actions such as “washings” (Jones, 2019), including greenwashing (ecology), pinkwashing (breast cancer), bluewashing (human rights), rainbow-washing (LGBTQ issues), CSR-washing (overall social and environmental impacts), or ESG-washing (overall environmental and social impacts). This contrasts with research endeavours, such as investigating the relationship between health expenditure, CO₂ emissions, and economic growth (Dritsaki & Dritsaki, 2023).

In conclusion, the empirical implications of this study highlight the need to enhance the roles of public actors and societal stakeholders in innovation processes, strike a balance between economic values and responsibility, and mitigate the risks that undermine responsible innovation efforts.

Limitations and Further Research

While R(R)I is a valuable concept, it is important to recognize its limitations and identify areas for further research from an N-SE perspective. Our main limitation lies in the practical implementation of R(R)I principles in the economy. Translating ethical considerations and stakeholder engagement into tangible practices can be complex and context-dependent. Further research can explore effective strategies, tools, and frameworks to facilitate the integration of the R(R)I concept into real-world settings.

R(R)I emphasizes stakeholder involvement. However, there is a need for more research on how to meaningfully engage diverse stakeholders throughout the innovation process. This includes addressing challenges such as power imbalances, inclusivity, and methods for effective participation. Furthermore, assessing the impact and effectiveness of R(R)I initiatives in the N-SE context can be a significant challenge.

Developing appropriate metrics and evaluation frameworks to measure the outcomes, societal benefits, and ethical performance of responsible innovation practices is an area that requires further research (Kalpazidou Schmidt, 2023).

R(R)I is often discussed in the context of Western societies. Further research is needed to understand the applicability and relevance of responsible innovation principles in diverse cultural, social, and economic contexts. This includes exploring the role of local knowledge, cultural values, and indigenous perspectives in shaping responsible innovation practices in N-SE.

While R(R)I recognizes the need for governance and regulation, further research is required to develop regulatory frameworks that balance the promotion of responsible

practices while fostering Schumpeter's innovation and competitiveness. This involves exploring the effectiveness of existing regulatory approaches and identifying mechanisms to integrate R(R)I principles into policy and regulatory processes.

Author Contribution All authors contributed to the study conception and design. Material preparation and data collection were performed by Karol Śledzik, analysis was performed by Karol Śledzik, Agnieszka Szmelter-Jarosz, Evanthia Kalpazidou Schmidt, Krzysztof Bielawski, and Andrea Declich. The first draft of the manuscript was written by Karol Śledzik, Agnieszka Szmelter-Jarosz and Evanthia Kalpazidou Schmidt. All authors commented on previous versions of the manuscript and approved the final manuscript.

Declarations

Ethical Conduct This work has not published previously, that is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English, or in any another language, including electronically without the written consent of the copyright holder. This research does not involve human participants and/or animals.

Conflict of Interest The authors declare no competing interests.

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