Technology in the Age of Innovation: Responsible Innovation as a New Subdomain Within the Philosophy of Technology

Lucien von Schomberg[1] (iD) · Vincent Blok[2]

Abstract

Praised as a panacea for resolving all societal issues, and self-evidently presupposed as technological innovation, the concept of innovation has become the emblem of our age. This is especially reflected in the context of the European Union, where it is considered to play a central role in both strengthening the economy and confronting the current environmental crisis. The pressing question is how technological innovation can be steered into the right direction. To this end, recent frameworks of Responsible Innovation (RI) focus on how to enable outcomes of innovation processes to become societally desirable and ethically acceptable. However, questions with regard to the technological nature of these innovation processes are rarely raised. For this reason, this paper raises the following research question: *To what extent is RI possible in the current age, where the concept of innovation is predominantly presupposed as technological innovation?* On the one hand, we depart from a post-phenomenological perspective to evaluate the possibility of RI in relation to the particular technological innovations discussed in the RI literature. On the other hand, we emphasize the central role innovation plays in the current age, and suggest that the presupposed concept of innovation projects a techno-economic paradigm. In doing so, we ultimately argue that in the attempt to steer innovation, frameworks of RI are in fact steered by the techno-economic paradigm inherent in the presupposed concept of innovation. Finally, we account for what implications this has for the societal purpose of RI.

Keywords Technological innovation · Responsible Research and Innovation · Philosophy of innovation · Philosophy of technology · History of innovation · Techno-economic paradigm

✉ Lucien von Schomberg
   lucien.vonschomberg@wur.nl

Extended author information available on the last page of the article

1 Introduction

Dating back to Ancient Greek views on *techne*, and travelling through the works of philosophers such as Francis Bacon and Martin Heidegger, the history of Western philosophy unmistakably denotes a rich variety of reflections relating to technology. While this philosophical interest in technology continues to be carried through by a range of contemporary thinkers, ongoing research on technological assessment has paved the way for a new but surely related concept: innovation. Praised as a panacea for resolving all societal issues, and self-evidently understood as *technological* innovation, the concept has become "the emblem of the modern society" (Godin 2008; Nowotny 2008). This is especially reflected in the context of the European Union, where it is considered to play a central role in both strengthening the economy and confronting the current environmental crisis (European Commission 2015).

With global issues such as economic inequality and climate change becoming increasingly urgent, the pressing question of today is how we can steer technological innovation into the "right" direction.[1] To this end, recent frameworks of Responsible Innovation (RI) emphasize the need to ensure the ethical acceptability and societal desirability of emerging technologies in an inclusive and democratic way (Owen et al. 2012, European Commission 2015). A commonly used framework of RI features the importance of four dimensions: anticipation, reflexivity, inclusion, and responsiveness. In this view, innovators and institutions should anticipate the possible outcomes of emerging technologies, reflect on what their moral responsibilities are, and engage with all types of stakeholders including the general public, and all of these in response to the values and changing circumstances of society. Together, these dimensions present several governance mechanisms and management practices that are claimed to enable more responsible innovation (Owen et al. 2012; Stilgoe et al. 2013).

While the RI literature focuses on the governance of innovation processes, little thought goes to what innovation itself means conceptually (Blok and Lemmens 2015; Von Schomberg and Blok 2018). Both EU policy makers and researchers continuously discuss how to enable outcomes of innovation processes to become more desirable and responsible, but rarely raise questions with regard to the *technological nature* of these processes. What understanding of technology does the concept of technological innovation presuppose? To what extent does this understanding of technology affect the way we innovate today, and consequentially, what implications does it have for the societal purpose of RI? How can the concept of technological innovation be critically assessed from the perspective of the philosophy of technology? These questions call for an investigation in which RI becomes both a subdomain within the philosophy of technology, and a domain in which the philosophy of technology can contribute significantly.

It is against this background that this paper raises the following research question: *To what extent is RI possible in the current age, where the concept of innovation is predominantly presupposed as technological innovation?* As a first step, we elaborate on the rise of technological innovation, both within and beyond the RI literature. In this respect, we learn that even though the concept is widely considered in light of an intrinsic relation between technology and the market, the emergence of RI urges

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[1] This question is also the result of the negative impacts technological innovation has caused in the past, such as nuclear waste (Cf. von Schomberg 2019).

innovation to go beyond the sole intent of generating commercial value (Section 2). In light of the philosophy of technology, we then bring into question to what extent the concept of innovation—presupposed as technological innovation—*can* shift away from its current commercial orientation. On the one hand, we depart from a post-phenomenological perspective to evaluate the possibility of RI in relation to the particular technological innovations discussed in the RI literature. On the other hand, we emphasize the central role innovation plays in the current age, and suggest that the presupposed concept of innovation projects a techno-economic paradigm. In doing so, we ultimately argue that in the attempt to steer innovation, frameworks of RI are in fact steered by the techno-economic paradigm inherent in the presupposed concept of innovation. Finally, we account for what implications this has for the societal purpose of RI (Section 3).

2 The Rise of Technological Innovation[2]

In this section, we show that while innovation originally had a political meaning it only recently developed into the concept of technological innovation, which essentially prioritizes the ideals of technological and its commercial exploitation. We go on to describe the emergence of RI as an attempt to shift away from the commercial exploitation of innovation, thereby reawaking its political origins. This ultimately brings us to question whether this attempt is feasible in practice, where the concept of technological innovation remains to dominate both within and beyond the RI discourse.

2.1 The Political Origins of Innovation

In its broadest sense, to innovate means to introduce changes and new ideas. Changes and new ideas can be introduced in science and technology, but also in other fields, such as management and education. Despite this broad scope, there are very few investigations with regard to what innovation means conceptually (cf. Godin 2008, 2015, 2016; Bontems 2014; Blok and Lemmens 2015; Blok 2019). Instead, almost any study related to innovation both within and beyond the RI literature, self-evidently presupposes the concept of innovation in terms of technological innovation. That is to say, it has become exceptionally common to connect innovation with the field of emerging technologies (Timmermans and Blok 2018).

Interesting to note, however, is that technological innovation is not merely concerned with the creation of new technologies, but ultimately refers to technologies that contribute to the market (Godin 2015). Throughout the last 60 years, mainstream economics has predominantly taken over the discourse of innovation. The concept is now said to first and foremost pertain to the business world, and even is claimed to originate in a tradition of economic analysis (Staudenmaier 1985; Cajaiba-Santana 2013). Consequentially, innovation is currently described as "the development of new ideas into marketable products and processes" (Stoneman 1995, p. 2); its significance lies in delivering value to consumers (Carlson and Wilmot 2006). The

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[2] This section is largely based on the findings made by von Schomberg and Blok (2018).

commercial dimension of technological innovation is further illustrated by the popular saying of American industrialist J. Paul Getty: "True innovation is coming up with a product that the customer didn't even know they needed." For this reason, technological innovation can also be referred to as commercialized innovation.

The current dominance of technological innovation is further confirmed when considering the common distinction made between incremental innovation and radical innovation. At the level of incremental innovation, one specifically refers to improved technologies, i.e., technologies that have been there before, but that are now transformed to supposedly work more efficient. An example would be the iPhone 8 replacing the iPhone 7. At the level of radical innovation, one speaks of completely new to the world technologies, such as the first integrated navigation system. Noticeably, the latter is claimed to be in the hand of startups and entrepreneurs which set up "the competitive dynamics which *characterize* innovation" (Bessant 2013, p. 5, own emphasis).

Innovation has not always been understood as something technological and commercial. In fact, the concept of innovation originally emerged in Ancient Greece with a political meaning, where it was essentially understood as "introducing change into the established order" (Godin 2015, p. 5). This is reflected in works such as Plato's *Laws* (7.797b) and Aristotle's *Politics* (10.xii.1316b), in which it refers to either cultural change or changes specifically brought to political constitutions (Cf. Plato 1988; Aristotle 1984). In the fourth century, the concept of innovation made its entry into the Latin vocabulary. Initially, it meant a form of renewing or returning (Ladner 1959). For instance, in a religious context, it implied a return to the purity of the soul (Godin 2015). Centuries later, the concept of innovation was used in a similar vein to refer to the renewal of laws (Machiaveli 1992). However, the concept of innovation predominantly continued taking place within a political context as it was mainly defined in terms of revolutionizing the established order. This was the case all the way up to the period from the Reformation to the nineteenth century, where the concept represented radical changes that ruined, troubled, and discontented the State (cf. Burton 1976). For a large part of our history, innovation is thus comprehended as a political concept used to denote anything or anyone that threatens the order, and has very little to do with the way we generally understand innovation today.[3]

Nevertheless, in the nineteenth century, the concept of innovation starts to receive a more positive meaning (Bontems 2014; Godin 2015). This is primarily because innovation now steadily enters a context in which progress and utility is celebrated. In response to this new context, innovation becomes an honorable concept (Godin 2015). While in the preceding centuries, the term innovation is mostly found in religious and political pamphlets, it now gradually appears in books, scientific journals, and general magazines. In this upcoming literature, the concept no longer carries a subversive tone, and instead refers to the successes made in mathematics, mechanics, astronomy, geography, and basically all the useful arts and sciences (Cf. Pigott 1792; Robinson 1782). Interestingly, in this period, the concept of innovation does not yet concern any relation between technology and the market. It may denote new technologies such as mining (Blavier 1806) and printing (Comte 1877), but is by no means constrained to them, let alone to their commercial value.

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[3] For a detailed account on the intellectual history of innovation, see Godin (2015). *Innovation contested: The idea of innovation over the centuries*. New York: Routledge.

It is only after the rise of the more specific ideals of technological and economic progress that the concept of innovation evolves into our techno-economic understanding of innovation. To be sure, as soon as the domain of mainstream economics becomes more prominent, the field of commercialized technologies is brought into the innovation discourse. Specifically after the Industrial Revolution, the commercial value of new technologies becomes increasingly recognized. The latter has ultimately led political economists such as Joseph Schumpeter to popularize the concept of technological innovation, according to which innovation becomes commonly associated with technological goods and products, overshadowing the original political character it once had.

From this brief history of innovation, we learn that as long as the world is seen and understood as a stable order, innovation is considered a danger to this order and thus widely categorized as a pejorative concept. It is for this reason that Plato for instance despises innovation in music and even in children's toys, as he believes this could lead to the embracement of new habits that eventually cause political instability (Plato 1991). As soon as the ideal of stability of the world makes place for the idea of progress, both in the field of technology and beyond, innovation gradually starts to receive a positive connotation. In this period, a new piece of literature is considered just as much an innovation as a new technology is. The Industrial Revolution and the rise of mainstream economics ultimately led to the current dominance of technological innovation, a concept that intrinsically relates technology with the market (Fig. 1). In this respect, the creation of the iPhone or the drone is a typical example of current innovations.

2.2 The Emergence of RI

To a certain extent, ongoing research under the heading of RI reawakens the political origins of innovation. While still associating innovation with the field of emerging technologies, the RI discourse urges these technologies to go beyond the sole purpose of creating commercial value. Instead, they should primarily focus on generating the "right" impact, especially with regard to today's grand societal challenges, such as for instance climate change and world poverty (von Schomberg 2013). Given the complexity of these grand challenges and the indeterminacy of the right impact, recent

Historical Period	Ideal	The Concept of Innovation
+/- 450 BC – AD 300	The ideal of maintaining stability	Understood in terms of cultural and political change brought to the established order
+/- AD 300 – AD 1800		Understood in terms of revolutionizing the established order
+/- AD 1800 – AD 1950	The ideal of achieving progress in all types of spheres of society	Understood in terms of the successes made in various fields (e.g. mechanics, mathematics, geography, astronomy, science)
+/- AD 1950 – Today	The ideal of achieving technological progress while generating economic value	Understood in terms of technological innovation

Fig. 1 An overview of the concept of innovation throughout history

frameworks of RI attempt to shift the focus toward formulating a political discourse of innovation, and implementing it in practice (cf. Owen et al. 2013). Other than the four dimensions described in "Introduction," these frameworks highlight, for example, the importance of democratically determining the purposes of innovation (Owen et al. 2013), and typically argue how placing innovation processes within the values of the European Union will enable outcomes to become ethically acceptable, sustainable, and societally desirable (von Schomberg 2013).

Yet, while the entire RI discourse focuses on conceptualizing and operating the dimensions of "responsible" innovation, the question of innovation itself is rarely raised. Instead, the concept of technological innovation remains to prevail throughout the literature (Von Schomberg and Blok 2018). For example, in *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*—a central book in the RI literature—the included texts continuously alternate between the words "innovation" and "technological innovation," as if they are self-evidently the same. In discussing the impact of innovation, it is argued that "*technological* innovations are unpredictable" (von Schomberg 2013, p. 55, own emphasis). Similarly, it is claimed that while innovation involves a "process of bringing something new into the world" (Grinbaum and Groves 2013, p. 119), in order to achieve responsible innovation, we have to reflect "on the ethical significance of *technological* innovation" (p. 119, own emphasis).

Beyond the usage of the word technological innovation, the RI literature also adheres to its technological and commercial connotation. This is for instance the case in "A Vision of Responsible Research and Innovation" (2013), written by Rene von Schomberg, who introduced the concept of RI at the level of the European Commission and thereby plays a dominant role in the RI discourse. Here, he places innovation within a distinction that immediately presupposes that innovation is necessarily technological. On the one hand, he discusses mere technical inventions, and specifically refers to introduction of new technologies, such as Bartolomeu's "machine for sailing through the air" (p. 52). On the other hand, von Schomberg discusses modern innovations. Also in this respect the usage of the term technology keeps prevailing. Furthermore, while Bartolomeu's machine is referred to as a "mere" technological invention, "modern innovations are distributed through market mechanisms" (von Schomberg 2013, p. 54). To put it differently, modern innovations do not just refer to emerging technologies, but rather to technological *products* that are essentially shaped by the successes they make on the market. This connection between innovation and commercialized technologies is further demonstrated by the particular innovations that von Schomberg discusses, such as genetically modified organisms (GMOs), video-gaming technology, the electronic patient record system (EPRS), nanotechnology, and body-scanning technology. His vision on innovation is reflected in official documents of the European Commission, in which these technologies are considered to be the main innovations to shape the future (cf. Matter 2011).

The presupposed concept of technological innovation is also dominant in EU-funded RI governance projects such as ProGReSS (Coles 2014a) and Res-AGorA (Lindner et al. 2016). To be sure, ProGReSS has delivered reports in which it investigates how research funding can steer innovation toward positive results, mainly with regard to societal desirability. Upon closer examination, these reports unquestioningly account for the societal desirability of technologies that are particularly

economically beneficial (Coles 2014b). These specifically include synthetic biology, nanotechnology, and information and communications technology (ICT). Although Res-AGorA strategically differs from ProGReSS, most attention is also dedicated to the "what is responsibility?" aspect of RI. Conversely, the "what is innovation?" aspect is barely explored. Instead, the ethics formulated once again concern economically beneficial technologies. That is to say, they developed the Responsibility Navigator, which is supposed to guide innovation processes through the application of ten principles, most of which are illustrated and placed within the context of market-based technology (Cf. Von Schomberg and Blok 2018).

The above analysis shows that while the concept of innovation is rarely considered as an object of reflection, it is generally presupposed as technological innovation. Noticeably, the term itself implies that not all innovations are technological. In this sense, we have shown that innovation is in fact a very broad concept, and originally contains a fundamentally political connotation. Similarly, the term implies that not all technologies are innovative. In this sense, we have shown that in the current age, in order for a technology to be considered as an innovation it ultimately needs to generate commercial value. In other words, we currently share a techno-economic understanding of the concept of innovation. Even though emerging frameworks of RI now attempt to shift away from this techno-economic understanding of innovation, the concept of technological innovation remains to prevail throughout both the literature and policy documents. This brings into question whether innovation—presupposed as technological innovation—*can* shift away from its current commercial orientation. To what extent is it possible to operationalize the dimensions of RI within a context where innovation is understood in light of an intrinsic relation between technology and the market? For instance, reflecting upon the ethical significance of technologies could be jeopardized by the self-interested pursuit of economic welfare. Similarly, inclusion and deliberation may proceed strategically in function of maximizing one's own profit, while responsiveness may easily amount to window dressing.

3 Technological Innovation and the Possibility of RI: an Investigation for the Philosophy of Technology

In order to adequately evaluate the possibility of achieving RI, in this section we engage with the philosophy of technology to reflect on the concept of technological innovation in two ways. First, we depart from a post-phenomenological perspective to account for the particular technological innovations RI focuses on, and reflect to what extent they enable desirable and responsible outcomes. Second, we emphasize the central role innovation plays in the current age, and show how the specific techno-economic mode in which the concept of innovation is self-evidently presupposed at the same time projects a techno-economic paradigm, which in turn limits the possibility of RI.

3.1 RI and the Focus on Particular Technological Innovations

Throughout the last two centuries, when the philosophy of technology gradually emerged as a distinct discipline, technology was largely considered as a singular overarching process, and philosophically discussed in terms of its relation to, for

instance, morality (Jonas 1984), politics (Winner 1980, 1983), and truth (Heidegger 1977). Because these theories do not account for how particular technologies differ from one another in numerous ways, a recent branch of the philosophy of technology asserts that instead of analyzing its relations to philosophical issues other than technology, the philosophy of technology "must make technology a foreground phenomenon and be able to reflectively analyze it in such a way as to illuminate features of the *phenomenon of technology itself*" (Ihde 1993, p. 38; original emphasis). In light of this view, contemporary philosophers of technology aim to empirically analyze particular artifacts, especially with regard to their concrete usage and the context in which they are used (Verbeek 2005). The popularity of this view is reflected in the theme of the latest *Society for Philosophy and Technology* conference, which was specifically dedicated to the way in which concrete artifacts work. By narrowing the scope to concrete artifacts, this contemporary view of technology is also characterized as an ontic account of technology (Zwier et al. 2016). Despite what critics say (Cf. Feenberg 2009; Kaplan 2009; Scharff 2012; Smith 2015; Zwier et al. 2016), an ontic account of technology does not mean to disregard the effects technology has on other domains, as long as these effects are studied strictly in relation to the particular technology that causes them, and not attributed to technology as such. In *Moralizing Technology: Understanding and Designing the Morality of Things*, Peter-Paul Verbeek provides some compelling examples that illustrate this latter point:

> Speed bumps, to use a favorite example of Bruno Latour, help us make the moral decision not to drive too fast near a school. Ultrasound scans help us to ask and answer moral questions about the lives of unborn children. Energy-saving lightbulbs take over part of our environmental conscience. Coin locks on supermarket pushcarts remind us to return each cart neatly to its place. Turnstiles tell us to buy a ticket before boarding a train. Current developments in information technology show this moral significance more explicitly. With the development of ambient intelligence and persuasive technology, technologies start to interfere openly with our behavior, interacting with people in sophisticated ways and subtly persuading them to change their behavior […]. (Verbeek 2011, pp. 1–2)

In mediating the human–world relation, concrete technologies thus give shape to the moral decisions we daily take. For this reason, Verbeek calls for an ethical framework that conceptualizes the moral significance of such technologies.

Similarly, the RI discourse aims to incorporate an ethical framework into the process of particular innovations. That is to say, as we have seen in the previous section, RI typically focuses on concrete innovations within the field of, for instance, synthetic biology, nanotechnology, and ICT. To be sure, the emergence of RI suggests that these innovations are not always that responsible. Due to the potential harmful impact they have on society and the environment, the idea of RI is to ensure that innovation is ultimately steered democratically into a responsible and desirable direction. Even though RI may face some complications with regard to anticipating future outcomes (Grunwald 2014; Nordmann 2014), the technological innovations it focuses on do show to play a significant role in, for example, the conservation of nature. In the face of an accelerating pace of environmental damage, they

can for instance provide new ways for wetlands, forests, and diverse species to be in harmony with a wide range of modern, human settings (Kareiva et al. 2011). Similarly, the introduction of green nanotechnology is shown to enhance environmental sustainability in at least two respects. First, it enables clean technologies that "minimize potential environmental and human health risks associated with the manufacture and use of nano-technology products" (Shah et al. 2014, p. 157); and second, it inspires the "replacement of existing products with new nano-products that are more environmentally friendly throughout their lifecycle" (Shah et al. 2014, p. 157). Another example of a particular innovation which promises responsible and desirable outcomes includes the electrolysis of water, which is shown to be vital in generating hydrogen, a transport fuel which is likely to overcome the concerns related to greenhouse gas and other polluting emissions (Badwal et al. 2014). The optimism illustrated here indicates that, at least at the ontic level, the concept of technological innovation enables the desirable future that frameworks of RI call for.

3.2 RI in the Age of Innovation

The question is whether we should limit our understanding of technological innovation to an ontic approach. Although the concept certainly refers to its representing innovations, it is also described as the very "emblem of the modern society" (Godin 2008, p. 5), and therefore suggests to be an underlying determinant of the current age. Praised as a panacea for resolving all types of challenges (Godin 2008), it has become an integral part of the way we think and do things today (Este 2013). This is confirmed by the numerous books that emerge in all types of fields, all of which explicitly refer to our age as the age of innovation (cf. Janszen 2000; Araya and Peters 2010; Ingham 2015; Tarkenton 2015; Katsoni and Stratigea 2016; Ben-Haim 2018; Goldberg 2018). Today, innovation is all-pervasive, where innovators like Elon Musk and Steve Jobs are heralded the same way scientists and artists were in previous times. In this respect, the development of innovative products and services is often seen as a major concern at the firm level: not to innovate is to die (Freeman 1982). This is also the case for institutions such as the Organization for Economic Co-operation and Development and the European Union, both of which consider it self-evident that "most current social, economic and environmental challenges require creative solutions based on innovation" (OECD 2010; cf. European Commission 2010). Noticeably, the European Union launched the Innovation Union, which emphasizes the significance of innovation in increasing European prosperity in terms of stimulating both economic growth and environmental sustainability. For reasons as these, innovation is thus said not only to determine new emerging artifacts and services at an ontic level, but to define our very epoch (Nowotny 2006, 2008; Blok 2019).

If we take this idea into serious consideration, it means that the human–world relation is not only mediated by particular innovations, but also by the specific techno-economic mode in which we self-evidently presuppose innovation in this age of innovation. On the one hand, particular technological innovations certainly differ from one another in numerous ways, and they thus mediate the human–world relation each in their own way. For example, while a drone changes the way we conduct war, the smartphone changes the way we communicate. On the other hand, the technological innovations that are most prevailing in the literature all tend to share a techno-economic paradigm, i.e., they are techno-economically oriented (Von Schomberg and Blok 2018). While there are of course other forms of innovation, such as social innovation and

attitudinal innovation, these are generally less considered in the innovation discourse. This is analogous to a distinction Gilbert Simondon (2017) makes between minor and major technologies. Major technologies are those we mostly discuss, while minor technologies are those we tend to overlook. The point we illustrate here is that the techno-economic nature of the innovations that are dominant in both the innovation discourse and RI discourse can be related to the current age of innovation, in which the human–world relation is ultimately techno-economically mediated.

The techno-economic mediation at stake can also be explained in light of what Heidegger calls Enframing (Heidegger 1977). To be sure, in *The Question Concerning Technology*, Heidegger claims that technology as Enframing is not itself something technological, but entails rather a mode of understanding the world around us and of our relation to it. This mode is to be understood in terms of a calculative ordering according to which we represent, arrange, transform, organize, manipulate, and mobilize reality. Under the sway of technology, all things become fungible, disposable, and changeable energy that stands in reserve for whatever purpose we decide upon. For example, the river Rhine comes to be perceived as a source of energy or a tourist attraction, and forests in terms of cubic meters of timber.

> Enframing is the gathering together that belongs to that setting-upon which set upon man and puts him in position to reveal the real, in the mode of ordering, as standing-reserve. (Heidegger 1977, p. 24)

Heidegger further explains that because Enframing presents this mode of calculative ordering as self-evident, it has fatally absorbed and disabled all other possible modes of existence. In other words, due to Enframing calculative ordering is the only mode in which reality is to be experienced, overshadowing the possibility of any other mode.

In similar vein, we argue that while the concept of innovation in its all-pervasive sense is precisely a way of enabling new possibilities, the dominant mode of calculative ordering constrains us to the self-evidence of technological innovation.[4] Even though innovation is about creating change in the broadest sense possible, and RI is about exceeding the market, the concept of innovation remains presupposed as technological innovation and commercial innovation. As a result, the scope of innovation is limited to the field of commercial or at least commercializable technologies, and tied to an intrinsic relation between technology and the market. This explains why a range of other forms of innovation, such as social innovation (e.g., fair trade) and attitudinal innovation (e.g., lifestyle interventions), are often excluded from the RI discourse. That is to say, these forms of innovation are dominated by their technological and commercial alternative. For example, debates concerning meat overconsumption are often restricted to the potential benefits and implications of in vitro meat, instead of also considering innovative ways of empowering non-meat protein sources.

The ambiguous relation between the ideal of RI (i.e., exceeding the market in order to serve society) and its practice (i.e., implicitly adhering to a techno-economic view on innovation) brings the possibility of RI into question. Even though particular

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[4] While the main focus of this paper is to show how the way we self-evidently presuppose innovation disables the infinite possibilities in which we can account for reality and its uncertainties, in future research we investigate in what way innovation could precisely be about enabling these possibilities.

technological innovations are shown to enhance responsible and desirable outcomes, the techno-economic paradigm in which these innovations are embedded is arguably incompatible with the ideal of overcoming today's societal and environmental issues. The imperative of maximizing economic growth is claimed to be the main cause of today's increasingly unequal distribution of wealth (cf. Rolston III 2012; Naudé and Nagler 2016), and as "the root cause of many environmental problems" it stands "in direct conflict with sustainability" (Huesemann and Huesemann 2011, p. 256). This is confirmed by the relatively recent increases in waste disposal, pollution, water shortage, deforestation, global warming, loss of biodiversity, natural resource depletion, and public health issues; increases that can be seen as an effect of the techno-economic paradigm of innovation (Huesemann and Huesemann 2011; Purdy 2015).

One way in which the techno-economic paradigm of innovation affects the possibility of RI is reflected in the power imbalances that take place during the innovation process. That is to say, while RI to a certain extent presupposes an agreement with regard to today's global issues, such as global warming and world poverty, in practice the numerous stakeholders included in the innovation processes often have different definitions of these issues, and different ways of solving them (cf. Kroesen et al. 2015). These differences are chiefly because of contrasting motives and agendas of, for instance, for-profit and non-profit organizations (Yaziji and Doh 2009). Due to power imbalances—the engineers who create the technology and the companies that finance it tend to have more power than, for example, the wider public—the disparities among stakeholders are not often collectively solved and usually result in conflict (Bryson et al. 2006). As a result, in reality, innovation processes adhere much more to the dominant ideals of technological and economic progress than they do to the common ground from which the RI literature departs.

The techno-economic paradigm of innovation also has implications for achieving the transparency among stakeholders RI calls for. To be sure, this call for transparency is compromised by the competitive advantage a new technology requires in order to flourish on the market (Blok and Lemmens 2015; Brand and Blok 2019). To accomplish this competitive advantage, companies depend on information asymmetries, meaning that they seek for additional knowledge about certain opportunities that other companies are unaware of. In the context of RI, companies search for such information with regard to solving both existing and anticipated global issues. However, transparency among the included stakeholders naturally implies a reduction of these information asymmetries, thus taking away the very foundation of competitive advantage. Therefore, in so far the concept of innovation adheres to a techno-economic paradigm, the idea of enabling transparent collaboration among all stakeholders included in the innovation process is simply naïve (Blok and Lemmens 2015).

Moreover, while the techno-economic paradigm of innovation somewhat takes for granted that outcomes of innovation processes can be calculated and foreseen, in practice they are often shown to be unpredictable. Even though unexpected societal and environmental consequences may be reduced when the different dimensions of RI are incorporated in the innovation process, this is not guaranteed (Rammert 1997). For example, during the process of developing biofuel, the included stakeholders concluded that since this type of fuel is locally produced, inherently renewable, and less polluting, its introduction is both responsible and desirable. Nevertheless, as a consequence of the increased demand for biofuels, farmers were forced to cultivate more crops for biofuel production, which in turn led to an increase in the price of food. This increase in the price of food was unexpected and

now brings into question if the introduction of biofuels was in fact responsible and desirable, especially given that people in developing countries were badly affected by this unforeseen outcome (Blok and Lemmens 2015). This example illustrates that the ideals of RI cannot be achieved insofar as outcomes of technological innovations are unknown. Unknown outcomes are in fact a vital characteristic of technological innovation (Rammert 1997), contrary to what the techno-economic paradigm suggests.

Hence, because the innovation processes at stake in the RI discourse adhere to the techno-economic paradigm and, as a result, come with fundamental power imbalances, information asymmetries, and unpredictable outcomes, the ideal of RI to steer such processes becomes problematic.

4 Conclusion

The departure point of this paper lies in the observation that while the current age is marked by the concept of innovation, little thought goes to what innovation means conceptually. Instead, it is self-evidently presupposed as technological innovation, which denotes both a technological and commercial connotation. In Section 2, we inquired into the rise of technological innovation and learned that historically the concept has little to do with technology, let alone with the market. Originally, the concept of innovation was political, and essentially referred to changing the political order. Only with the rise of mainstream economics did the concept of innovation become understood in light of an intrinsic relation between technology and the market, particularly in the period of the last 60 years. Conversely, in response to current global issues such as climate change and epidemics related to lifestyle diseases, ongoing research on RI now emphasizes the political role of innovation. That is to say, they call for innovation processes to exceed economic purposes, and to primarily serve societal and political purposes. At the same time, however, we have shown that the concept remains presupposed in terms of technological innovation as it continues to prevail both in the RI literature and in policy documents.

Against this background, in Section 3, we engaged with the philosophy of technology to investigate what implications our techno-economic understanding of innovation has for the possibility of RI. In this respect, we provided two reflections. First, at an ontic level and from a post-phenomenological perspective, we accounted for particular technological innovations and for how these mediate the human–world relation each in their own way. In mediating the human–world relation, we demonstrated that these innovations also carry ethical significance. That is to say, some may result to be more ethically acceptable and societally desirable than others. Accordingly, the purpose of RI is to ensure that innovation processes are steered into a responsible and desirable direction. As such, the technological innovations RI focuses on show to play an important role in confronting, for example, loss of biodiversity and pollution. Second, at an ontological level, we emphasized the central role innovation plays in the current age, and demonstrated how the specific techno-economic mode in which the concept of innovation is self-evidently presupposed at the same time projects a techno-economic paradigm. This led us to argue that, parallel to Heidegger's view on technology as Enframing, the dominant mode of calculative ordering constrains us to the self-evident techno-economic paradigm of innovation. This disables the possibility of other ways in which we can think of innovation. Accordingly, even if RI attempts to exceed the market, the concept of innovation remains technologically and

economically oriented. That is to say, the particular innovations that currently dominate the RI discourse share—despite their differences—a techno-economic paradigm. The implications of the techno-economic paradigm are reflected in the innovation processes, which ultimately come with fundamental power imbalances, information asymmetries, and unpredictable outcomes.

Hence, even though RI provides a critical analysis of innovation at the ontic level (i.e., concerning the introduction and usage of particular innovations), it still lacks a critical analysis at the ontological level (i.e., concerning the techno-economic paradigm of innovation). Therefore, RI is in need of a fundamental reflection that not only exposes the techno-economic paradigm of innovation—which we did in this paper—but that also explores an alternative concept of innovation which addresses the public good beyond the current privatization wave. The political origins of innovation that we encountered in Section 2, along with the political ends that the RI literature explicitly prioritizes, suggest that we should inquire into a political orientation of innovation. A crucial task of this inquiry would be to account for what such a political orientation of innovation precisely entails at the ontic level, and how it relates to the current techno-economic paradigm of innovation at the ontological level.

References

Araya, D., & Peters, M. A. (2010). *Education in the creative economy: knowledge and learning in the age of innovation*. New York: Peter Lang Publishing.

Aristotle (1984). *The complete works of Aristotle* (J. Barnes, Trans). Princeton: University Press.

Badwal, S., Giddey, S., & Munnings, C. (2014). Hydrogen production via solid electrolytic routes. *ChemInform.* https://doi.org/10.1002/chin.201427236.

Ben-Haim, Y. (2018). *The dilemmas of wonderland: decisions in the age of innovation*. Oxford: Oxford University Press.

Bessant, J. (2013). Innovation in the twenty-first century. In R. Owen, M. Heintz, & J. Bessant (Eds.), *Responsible innovation* (pp. 1–25). London: Wiley.

Blavier, M. (1806). Observations sur l'emploi du Charbon de houille dans le traitement du minerai de fer, à la forge à la Catalane. *Journal des mines, 19*, 135–166.

Blok, V. (2019). Towards an ontology of innovation: on the new, the political-economic dimension and the intrinsic risks involved in innovation processes. In N. Doorn & D. Michelfelder (Eds.), *Routledge handbook of philosophy of engineering*. New York: Routledge (forthcoming).

Blok, V., & Lemmens, P. (2015). The emerging concept of responsible innovation. Three reasons why it is questionable and calls for a radical transformation of the concept of innovation. In B. Koops, J. van den Hoven, H. Romijn, T. Swierstra, & I. Oosterlaken (Eds.), *Responsible innovation 2: concepts, approaches and applications* (pp. 19–35). Dordrecht: Springer.

Bontems, V. (2014). What does innovation stand for? Review of a watchword in research policies. *Journal of Innovation Economics & Management, 15*(3), 39–57.

Brand, T., & Blok, V. (2019). Responsible innovation in business: a critical reflection on deliberative engagement as a central governance mechanism. *Journal of Responsible Innovation., 6*(1), 4–24.

Bryson, J., Crosby, B., & Stone, M. (2006). The design and implementation of cross-sector collaborations: propositions from the literature. *Public Management Review, 66*, 44–55.

Burton, H. (1976). *For God and the king*. New York: Norwood.

Cajaiba-Santana, G. (2013). Social innovation: moving the field forward. A conceptual framework. *Technological Forecasting and Social Change, 82*, 42–51.

Carlson, C., & Wilmot, W. (2006). *Innovation: the five disciplines for creating what customers want*. New York: Crown Business.

Coles, D. (2014a). *Innovation for society: how innovation is driven towards societal desirability through innovation policies*. Report for FP7 Project "Progress". Resource document. http://www.progressproject.eu/project-deliverables/.

Coles, D. (2014b). *RRI country requirements matrix: nanotechnology, synthetic biology*. ICT, Report for FP7 Project "Progress". Resource document. http://www.progressproject.eu/project-deliverables/.

Comte, A. (1877). *Cours de philosophie positive* (Vol. 6, 4th ed.). Paris: J.B. Baillière et Fils.

Este, R. A. (2013). *Raising the alarm: an examination of innovation and philosophical denial*. Rotterdam: Sense Publishers.

European Commission (2010) Europe 2020. Flagship Innovative Innovation Union. Resource document. https://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication-brochure_en.pdf.

European Commission. (2015). Horizon 2020: work programme 2016-2017: Science with and for Society. Resource document. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-swfs_en.pdf

Feenberg, A. (2009). Peter-Paul Verbeek: review of what things do. *Human Studies, 32*(2), 225–228.

Freeman, C. (1982). *The economics of industrial innovation*. Cambridge: MIT Press.

Godin, B. (2008). Innovation: the history of a category. Resource document. http://www.csiic.ca/PDF/IntellectualNo1.pdf.

Godin, B. (2015). *Innovation contested: the idea of innovation over the centuries*. New York: Routledge.

Godin, B. (2016). Technological innovation: on the origins and development of an inclusive concept. *Technology and Culture, 57*(3), 527–556.

Goldberg, E. (2018). *Creativity: the human brain in the age of innovation*. Oxford: Oxford University Press.

Grinbaum, A., & Groves, C. (2013). What is "responsible" about responsible innovation? Understanding the ethical issues. In R. Owen, M. Heintz, & J. Bessant (Eds.), *Responsible innovation* (pp. 119–142). London: Wiley.

Grunwald, A. (2014). The hermeneutic side of responsible research and innovation. *Journal of Responsible Innovation, 1*(3), 274–291.

Heidegger, M. (1977). The turning. In *The question concerning technology and other essays*. New York: Harper and Row.

Huesemann, M., & Huesemann, J. (2011). *TechNoFix. Why technology won't save us or the environment*. Gabriola Island: New Society Publishers.

Ihde, D. (1993). *Philosophy of technology: an introduction*. New York: Paragon House.

Ingham, P. C. (2015). *The medieval new: ambivalence in an age of innovation*. Pennsylvania: University of Pennsylvania Press.

Janszen, F. (2000). *The age of innovation: making business creativity a competence, not a coincidence*. London: Financial Times Prentice Hall.

Jonas, H. (1984). *The imperative of responsibility: in search of an ethics for the technological age*. Chicago/London: University of Chicago Press.

Kaplan, D. M. (2009). What things still don't do. *Human Studies, 32*(2), 229–240.

Kareiva, P., Lalasz, R., & Marivier, M. (2011). Conservation in the Anthropocene. In M. Shellenberger & T. Nordhaus (Eds.), *Love your monsters: post-environmentalism and the Anthropocene* (pp. 26–35). Oakland: Breakthrough Institute.

Katsoni, V., & Stratigea, A. (2016). *Tourism and culture in the age of innovation*. New York: Springer.

Kroesen, J., Darson, R., & Ndegwah, D. (2015). Capacities, development and responsible innovation. In B. Koops, J. van den Hoven, H. Romijn, T. Swierstra, & I. Oosterlaken (Eds.), *Responsible innovation 2: concepts, approaches and applications* (pp. 201–222). Dordrecht: Springer.

Ladner, G. B. (1959). *The idea of reform: its impact on Christian thought and action in the Age of the Fathers*. Cambridge: Harvard University Press.

Lindner, R., Kuhlmann, S., et al. (2016). *Navigating towards shared responsibility in research and innovation. Approach, process and results of the Res-AGorA Project*. Karlsruhe: Fraunhofer ISI.

Machiaveli, N. (1992). *The prince* (N. H. Thompson, Trans. New York: Dover Publications.

Matter. (2011). *A report on responsible research and innovation*. Resource document. http://ec.europa.eu/research/science-society/document_library/pdf_06/rri-report-hilary-sutcliffe_en.pdf.

Naudé, W., & Nagler, P. (2016). *Is technological innovation making society more unequal?* Resource document. https://unu.edu/publications/articles/is-technological-innovation-making-society-more-unequal.html.

Nordmann, A. (2014). Responsible innovation, the art and craft of anticipation. *Journal of Responsible Innovation, 1*(1), 87–98.

Nowotny, H. (2006). The quest for innovation and cultures of technology. In H. Nowotny (Eds.), *Cultures of technology and the quest for innovation* (pp. 1–38). New York: Berghan Books.

Nowotny, H. (2008). *Insatiable curiosity: innovation in a fragile future*. Cambridge: MIT Press.

OECD. (2010). *Innovation and the development agenda*. Paris: OECD.

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: from Science in Society to Science for Society, with Society. *Science and Public Policy, 39*(6), 751–760.

Owen, R., Bessant, J. R., & Heintz, M. (2013). *Responsible innovation: managing the responsible emergence of science and innovation in society*. London: Wiley.

Pigott, C. (1792). *The Jockey club, or a sketch of the manners of the age*. London: Printed for H. D Symonds.

Plato. (1988). *The laws of Plato* (1st ed.) (T. L. Pangle, Trans.). Chicago: University of Chicago Press.

Plato. (1991). *The republic of Plato* (2nd ed.) (A. Bloom, Trans.). New York: Basic Books.

Purdy, J. (2015). *After nature: a politics for the Anthropocene*. Harvard: University Press.

Rammert, W. (1997). Innovation im Netz. Neue Zeiten für Innovation: heterogen verteilt und interaktiv vernetzt. *Soziale Welt, 48*(4), 394–416.

Robinson, R. (1782). On innovation. In *Arcana: the principles of the petitioners in eight letters to a friend* (pp. 55–63). London: n.p.

Rolston III, H. (2012). *A new environmental ethics: the next millennium for life on Earth*. New York: Routledge.

Scharff, R. C. (2012). Empirical technoscience studies in a Comtean world: too much concreteness? *Philosophy & Technology, 25*, 153–177.

Shah, M., Bhat, M., & Davin, J. (2014). *Nanotechnology applications for improvements in energy efficiency and environmental management*. Hershey: IGI Global.

Simondon, G. (2017). *On the mode of existence of technical objects*. Minnesota: Univocal Publishing.

Smith, D. (2015). Rewriting the Constitution: a critique of 'postphenomenology'. *Philosophy & Technology, 28*(4), 553–551.

Staudenmaier, J. M. (1985). *Technology's storytellers*. Massachusetts: MIT Press.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy, 42*(9), 1568–1580.

Stoneman, P. (1995). *Handbook of the economics of innovation and technological change*. Oxford: Wiley-Blackwell.

Tarkenton, F. (2015). *The power of failure: succeeding in the age of innovation*. Washington: Regnery Publishing.

Timmermans, J., & Blok, V. (2018). A critical hermeneutic reflection on the paradigm-level assumptions underlying responsible innovation. *Synthese*. https://doi.org/10.1007/s11229-018-1839-z.

Verbeek, P. P. (2005). *What things do: philosophical reflections on technology, agency, and design*. Pennsylvania: Penn State University Press.

Verbeek, P. P. (2011). *Moralizing technology: understanding and designing the morality of things*. Chicago and London: University of Chicago Press.

Von Schomberg, R. (2013). A vision of responsible research and innovation. In R. Owen, M. Heintz, & J. Bessant (Eds.), *Responsible innovation* (pp. 51–74). London: Wiley.

Von Schomberg, R. (2019). Why responsible innovation? In R. Von Schomberg & J. Hankins (Eds.), *The international handbook on responsible innovation. a global resource*. Cheltenham: Edward Elgar Publishing.

Von Schomberg, L., & Blok, V. (2018). The turbulent age of innovation. *Synthese*. https://doi.org/10.1007/s11229-018-01950-8.

Winner, L. (1980). Do artifacts have politics? *Daedalus, 109*, 121–136.

Winner, L. (1983). Technè and politeia: the technical constitution of society. In P. T. Durbin & F. Rapp (Eds.), *Philosophy and technology* (pp. 97–111). Dordrecht/Boston/Lancaster: D. Reidel.

Yaziji, M., & Doh, J. (2009). *NGOs and corporations: conflict and collaboration*. Cambridge: University Press.

Zwier, J., Blok, V., & Lemmens, P. (2016). Phenomenology and the empirical turn: a phenomenological analysis of postphenomenology. *Philosophy and Technology*. https://doi.org/10.1007/s13347-016-0221-7.

Affiliations

Lucien von Schomberg[1] · Vincent Blok[2]

[1]   Philosophy Group, Wageningen University, Hollandseweg 1, 6706 KNWageningen, The Netherlands

[2]   Philosophy Group, Wageningen University, Hollandseweg 1, 6706 KNWageningen, The Netherlands