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Anticipatory responsible innovation. Futures construction in the face of the techno-economic imperative¹

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ABSTRACT

The call for the development of more responsible research and innovation has increasingly permeated European Union research and development policies. Specifically, under the auspices of approaches such as "Responsible Research and Innovation" (RRI) and "Open Science", these policies conceive of the need to make innovation dynamics radically open and debatable, even with regard to the underlying preferences and expectations shaping them. Responsibility has thus been conceived in eminently anticipatory terms, that is, in terms of collectively taking care in the present of the futures enabled through innovation practices. This normative conception, which emphasises the politicisation of the ways futures are constructed through innovation and goals they are oriented towards, is nonetheless realised within a context where the prevailing way of approaching the future with regard to innovation systems is highly committed to a capitalist imperative of technological progress and economic growth. This article argues that while anticipation – understood as an interventive practice – can deploy valuable responsabilisation heuristics, their degree of disruptiveness, or openness, may depend on how such interventive practice engaging with futures deals with this techno-economic commitment, or imperative.

Keywords: Anticipation; Responsible Innovation; RRI; Open Science; Anticipatory Ambivalence; Socio-Technical Futures.

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INTRODUCTION

Research and innovation policies have shown a growing interest over the past two decades in promoting "responsible innovation" dynamics that transcend mere expert assessment and evaluation of risks and "collateral impacts" associated with – often seen as autonomous – scientific and technological progress (von Schomberg & Hankins, 2019). In this regard, for example, "Horizon 2020", the 8th European Union (EU) Framework Programme for Research and Innovation (2014-2020), claimed to address responsibility according to a Responsible Research and Innovation (RRI) approach, whereby innovation processes are conceived as susceptible to being radically open and debatable, even with regard to the preferences and expectations underlying them (European Commission, 2013). Similarly, the following, more recent 9th EU Framework Programme, "Horizon Europe" (2021-2027), claims to adhere to an "Open Innovation, Open Science, Open to the World" perspective, arguably committed to radical knowledge sharing and promoting robust science-society coproduction commitments and dynamics in the era of globalised information and communication technologies (European Commission, 2019a).

This *a priori* commitment to opening-up the actual dimension of innovation processes and their goals – including ways and conditions to achieve them – to public scrutiny would open the door to the possibility of problematising the mechanisms that deliberately narrow and reify the socio-technical futures considered desirable and plausible, and whereby current scientific-technological practices are legitimised and modulated (Jasanoff & Kim, 2015). In this respect, the issue of more inclusive governance of socio-technical futures seems to have become a characteristic attribute of Responsible Innovation (Stilgoe *et al.*, 2013, p. 1570) and other well-established related approaches such as Technology Assessment (Grunwald, 2019), which aim to democratise research and innovation.

The future is thus considered a key element within innovation dynamics. This implies that any serious attempt to democratise research and innovation practices and trajectories must allow for the problematisation and broadening of the set of socio-technical futures at stake. In this respect, it has been argued that anticipation, broadly understood as a practice characterised by the use of the future to orient present actions, functions as an interventive resource to democratise future representations that colonise and orient the present (Arnaldi, 2018; Stemerding *et al.*, 2019; Yoshizawa, 2019). Here, for instance, anticipation aims to engender alternative practices for action, challenge the *status quo* and enhance emancipation (Withycombe *et al.*, 2019). According to Guston (2008, p. vi), Anticipatory Governance is "a broad-based capacity extending through society that can help individuals and

institutions act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible".²

However, this article argues that while anticipation – understood as an interventive socio-epistemic practice – can deploy valuable heuristics to responsabilise innovation, the degree of disruptiveness, or openness, of such heuristics would be severely limited by the prevailing manner of approaching the future in the context of innovation systems such as the EU. These systems are very much dominated by a techno-economic imperative. This means that research and innovation's predominant (and *de facto* almost indisputable) mission is to achieve certain prefixed industrial and economic milestones. Such an imperative expresses a strong commitment to a technocratic and economicist vision of technological progress, and aligns with a techno-capitalist ideological approach (Beckert, 2016; Godin, 2016; Shelley-Egan *et al.*, 2020). Anticipation's disruptive potential will thus depend on how it is conceived and used under such conditions. In this sense, it proves crucial to analyse whether – and how – anticipatory practices enable futures envisioning capable of critically scrutinising the techno-economic imperative's normative base and building alternative relations between innovation and economic dynamics.

The scope and meaning of anticipation must therefore always be analysed and elucidated in relation to the specific and situated socio-political contexts where anticipatory practices take place. It is according to these contexts, and the ways in which anticipation operates within them, that anticipation can tend to act either as a *disruptive* tool – i.e., at the disposal of the critical-reflexive openness of socio-technical systems – or, on the contrary, as a *limiting* element – i.e., focused on orienting science and technology governance towards normative milestones that are prefixed and impervious to debate. In this respect, this article identifies and characterises this ambivalent feature of anticipation in relation to its potentially dual, "disruptive-limiting" role in the context of innovation systems such as the EU's. The economic imperatives underlying EU research and innovation policies seem to hinder the development of more disruptive, or open, anticipatory practices, which are characteristic of more radically inclusive interpretations of proposals such as RRI or Open Science (Gerber *et al.*, 2020).

To this end, this article is structured as follows: first, the emergence and meaning of RRI and Open Science in the context of EU innovation system is explained.

² The four pillars of Anticipatory Governance are: foresight, engagement, integration, and "ensemble-isation" (or coordinated mobilisation of the three previous pillars). Anticipation, or critical engagement with the future, is explicitly operationalised through foresight, which "aims to enrich futures-in-the-making by encouraging and developing reflexivity in the system" (Barben *et al.*, 2008, p. 986).

It argues that there is a dominant tendency within this system to make certain interests and values prevail (as well as certain assumptions about their desirability and feasibility) in relation to innovation and its dynamics, which seems to limit the inclusive and transformative potential of such proposals. On the basis of this analysis, the relevance of anticipation in scientific-technological modulation processes is then discussed, including the possibility of conceiving and articulating anticipatory governance mechanisms intentionally aimed at fostering the critical-collective construction of future representations and promoting alternative courses of action accordingly, *in the present*. These considerations go hand in hand with recognition of the aforementioned situated and necessarily ambivalent character of anticipation, and of the difficulties associated with attempts to promote eminently disruptive, or inclusive, anticipatory dynamics in the context of innovation systems. They are systems that are highly committed to – and constrained by – the techno-economic imperative linked to the ideology of techno-industrial developmentalism. Finally, the main conclusions are presented.

RESPONSIBLE INNOVATION IN TIMES OF RRI AND OPEN SCIENCE

The EU innovation system has radicalised its narratives on “responsible innovation” over the last two decades to the extent that its most recent formulations conceive it in terms of the degree of inclusiveness, or integration, of a heterogeneity of actors and publics (Eizaguirre *et al.*, 2017; Macnaghten, 2020).

Thus, the 8th Framework Programme for Research and Innovation, “Horizon 2020” (2014-2020), via its RRI approach linked to the “Science with and for Society” (SwafS) initiative, set its deliberative intention and capacity as the main characteristic of a responsible innovation process, implying that even the values, motivations and expected benefits of innovations should be subject to public scrutiny (European Commission, 2013). This would involve transcending the dominant institutional tendency to impose regulatory frameworks on technological innovations whose social justification is unproblematised (Felt *et al.*, 2007; Owen *et al.*, 2013). According to the European Commission (EC), RRI “allows all societal actors (...) to work together during the whole research and innovation process” (European Commission, 2013, p. 4).

The most recent 9th EU Framework Programme, “Horizon Europe” (2021-2027), also recognises the need to promote “better linkages between scientists, citizens and policy-makers” (European Commission, 2018a, p. 74). “Horizon Europe” is in fact conceived as a means of promoting a radically open, or participatory and transparent, innovation system characterised by “the three Os”: “Open Innovation, Open Science and Open to the World”. This “open” initiative aspires to facilitate free access to

knowledge and knowledge sharing, "where new knowledge is created through global collaborations involving thousands of people from across the world and from all walks of life" (Moedas, 2015, p. 1) in order to achieve scientific excellence and innovative efficiency (Bogers *et al.*, 2018; European Commission, 2016, 2019a).

However, it seems pertinent to question the meaning and transformative scope of this type of initiatives in view of the risk of their instrumentalisation by an innovation system whose ultimate, or main, objective appears to be the industrial exploitation of knowledge (Godin, 2016; Shelley-Egan, Gjefsen & Nydal, 2020). In other words, it is worth questioning the motivations and types of imperatives guiding such initiatives (Fiorino, 1989). Their transformative, or "opening-up", potentials, should not therefore be reified, nor taken for granted. Rather, light should be shed on how the framings, power instantiations and instrumentalisation dynamics pervading innovation systems tend to foreclose, or "close down", the emergence of alternative ways of appraising and executing technological progress (Stirling, 2008).

Significantly, RRI has also been characterised according to a limited set of dimensions (namely: public engagement, gender equality, open access to research, science education, and ethics) that are subordinate to achieving the goals of "mak[ing] science more attractive (...), raise the appetite of society for innovation, and open up further research and innovation activities" (European Commission, 2013, p. 4). Under this "practical" characterisation (i.e., RRI "in practice" [European Commission, 2013, p. 4]), public participation, for example, has been conceived as being aimed at "reinforcing public confidence in science" (European Parliament and Council of the EU, 2013, p. 106).³ Similarly, it is argued that "[t]he European Union will not remain competitive at the global level unless it promotes Open Science, and relatedly, Open Innovation" (European Commission, 2018b, p. 4), which might also be indicative of a risk of excessive instrumentalisation of the "open" ideal (Mayer, 2015), whereby citizens are mainly represented as actors with "a central and transversal role to play in bringing innovation to the market" (European Commission, 2016, p. 17).⁴

These proposals in favour of more radically inclusive, or "open", responsible innovation must therefore be measured in light of the fundamental tension between

³ The "Horizon 2020" website dedicated to Public Engagement in Responsible Research and Innovation expresses itself in similar non-disruptive, or "normalising", terms. See: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/public-engagement-responsible-research-and-innovation> (consulted on 11 February 2021).

⁴ Citizen science is presented as one of the pillars of Open Science (European Commission, 2018b; Mendez *et al.*, 2020), as an activity that "aims to encourage the inclusion of non-institutional participants, in other words the general public, in the scientific process" (European Commission, 2016, p. 53), and that aspires to "re-direct research agendas towards issues of concern to citizens" (European Commission, 2016, p. 54). At the same time, however, "Citizen Science is often linked with outreach activities, science education or various forms of public engagement with science as a way to promote Responsible Research and Innovation" (European Commission, 2016, p. 54).

the demands for more socially responsible techno-industrial progress and the political and epistemic dynamics that are firmly committed to developmentalism and competitiveness (Owen & Pansera, 2019; Rodríguez *et al.*, 2019; Stirling, 2016; von Schomberg & Blok, 2021).

Arguably, this tension is made even more evident and aggravated by the dominant institutional tendency to minimise its scope by assuming that techno-industrial progress is compatible with a broad set of socio-environmental considerations. This is in line with the use of a prefixed normative framework (namely: "Promotion of scientific and technological advance", "Competitive social market economy", "Promotion of social justice", "Sustainable development", "Quality of life, high level of protection" (von Schomberg, 2013, p. 58)),⁵ and the possibility of its harmonisation, which seems to be taken for granted. This relates to the fact that research within "Horizon 2020" and "Horizon Europe" is not organised according to disciplinary criteria but – as recommended by the Lund Declaration (2009) – according to "a challenge-based approach" (Council of the EU, 2013, p. 966), where "[r]esearch and innovation are key drivers of sustainable growth and industrial competitiveness, and they will contribute to finding solutions to today's problems" (European Commission, 2018a, p. 17). Such challenges, in all their heterogeneity (i.e., economic, social, environmental and health-related), could thus all be solved (via science and technology leadership) together in a constitutively compatible way (e.g., ERA Expert Group, 2008, p. 36). In EC terms:

"(...) Horizon Europe will strengthen the Union's scientific and technological bases in order to help tackle the major global challenges of our time and contribute to achieving the Sustainable Development Goals (SDGs). At the same time, the programme will boost the Union's competitiveness, including that of its industries. (...) Europe's success increasingly depends on its ability to transform excellent scientific results into innovation that have a real beneficial impact on our economy and quality of life (...)" (European Commission, 2018c, p. 1).

"Having it all at once" therefore seems possible here. It is considered that the unwavering commitment of innovation systems to the techno-economic imperative – whereby technological development is conceived as a key element for economic growth and competitiveness, and therefore an absolute priority – is compatible with other interests and concerns (moreover, it would follow that incompatibility in its strict sense is not even an option). This techno-economic imperative arguably frames the series of interests and concerns appraised inside innovation systems (Godin, 2016; Shelley-Egan *et al.*, 2020).

⁵ This prefixed normative framework emanated from the 1992 EU Treaty, or "Maastricht Treaty" (von Schomberg, 2013, p. 56-58).

Therefore, this ideal of equilibrium, or harmony, would not conflict with initiatives such as RRI or Open Science, with all their attributed disruptive potential. Rather, the ideal would be reinforced, given that "RRI fosters the creativity and innovativeness of European societies" (European Commission, 2013, p. 4), "open science will (...) increase the innovation potential of results generated by Union funding" (European Commission, 2018c, p. 14) and, ultimately, "(...) when partners from across academia, industry, public authorities and citizen groups are invited to participate in the research and innovation process [according to an open science policy], creativity and trust in science increases"⁶.

In this respect, it is worth considering the need to analyse the way in which – albeit seemingly paradoxical at first sight – a political approach where responsibility is related to inclusivity and heterogeneity restricts, or limits, the capacities and will to develop alternative ways of innovating and relating to science and technology – precisely because it goes hand in hand with a normative horizon whose content and compatibility are prefixed. Thus, rather than posing a "postmodern" or "ideologised" threat to scientific autonomy and the authority of expert knowledge (e.g., Kuntz, 2012, 2017), such inclusivist initiatives seem to serve a certain triumphalist, or radically enlightened, image of science and technology: they are entrusted with the mission of leading the resolution of major socio-environmental challenges by assuming, as a matter of principle, the capacity to satisfy a heterogeneous set of values and challenges without incurring traumatic renunciations, as noted above.

THE FUTURE, AND SCIENCE AND TECHNOLOGY GOVERNANCE

The actions and programmes mobilised in the EU around initiatives such as RRI and Open Science are implemented via a set of public policies that are often vulnerable to tensions, as seen. This stands in the way of achieving the objectives linked to more responsible research and innovation processes, i.e., processes that are more open to the consideration of a plurality of issues, interests and criteria (Novitzky *et al.*, 2020). Coordinated action to promote inclusive research and innovation practices must thus take into consideration and value such difficulties under whose terms these practices acquire a constitutively *ambivalent* character. This is because they can be interpreted and function both as enabling, or "disruptive", resources, and as elements subordinate to a set of imperatives and assumptions that constrain their potential to bring about substantive changes in the trajectories of techno-industrial progress.

⁶ European Commission: "The EU's open science policy"; available at: https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/open-science_en (consulted on 29 January 2021).

In this context, the issue of purposes and motivations proves fundamental. That is, the desirability of inclusively responsible science and innovation *per se* is not the only consideration to be taken into account; some link must be established with for what *purpose* such openness is encouraged, i.e., with the *rationale* for making science and innovation more open. In this regard, and, in particular, the question of objectives, and their associated representations of the future, proves critical when analysing the meaning and scope of this trend towards openness (Jasanoff & Kim, 2015). Given that "Horizon 2020" and "Horizon Europe" approach research to solve societal challenges and demands, it is appropriate to consider how these challenges and demands are determined, as well as the proposals to address them.

This requires attention to be focused on the socio-technical futures construction and establishment processes that progressively guide (responsible) science and technology governance. Such futures are generally presented by the institutional domain as highly promising in socio-economic terms and, in this sense, function as orientational, legitimising and promotional elements of their associated innovation dynamics (Jasanoff & Kim, 2015; Schiølin, 2020). This, of course, does not imply that the futures are impervious to controversy surrounding both their alleged benefits and their potential health, environmental and social risks (Jasanoff, 2016).⁷ Future representations and the normative assumptions accompanying them are thus a constitutive element of scientific-technological development, just as they are a constitutive element of modern societies (which are marked by a clear rationalistic-calculative impetus) where such developments unfold (Giddens, 1990; Hölscher, 1999).

The performative character of socio-technical futures in the present is explained in light of the phenomenon of anticipation. Anticipatory action (both individual and social) is considered by Anticipation Studies to be any action performed – whether consciously or unconsciously – on the basis of a representation, or model, of the future (Poli, 2017; Poli & Valerio, 2019). According to this definition, every socio-technical system can be considered an anticipatory system, insofar as it is co-inhabited by a series of future representations that influence the network of heterogeneous actions which jointly and progressively constitute its co-production and co-evolution (Konrad *et al.*, 2016; Lösch *et al.*, 2019).

Konrad *et al.* (2016) show that two cases of anticipatory practices can be distinguished. On the one hand, some anticipations occur *de facto* in socio-technical

⁷ The case of strategic emerging technologies is particularly significant in this respect. This is an area where tensions between highly enabling scientific-technological novelty and concerns and reticence about the futures associated with this novel (and uncertain) potential are particularly pronounced (Alvial-Palavicino & Konrad, 2019; Rodriguez, 2018).

systems. Here anticipations represent the constellation of actions and decisions that, informed by future representations such as visions (Lösch *et al.*, 2019) imaginaries (Jasanoff & Kim, 2015) and expectations (Alvial-Palavicino & Konrad, 2019; Borup *et al.*, 2006), help shape research and innovation commitments and trajectories. On the other, certain other anticipations take on an explicitly normative-instrumental character. In this second case of anticipatory practice, the future is intentionally and interventively mobilised (according to explicitly designed methodological criteria and aims) in order to promote more responsible innovation (Arnaldi, 2018; Selin, 2011). According to this latter instrumental-interventive version, anticipation becomes an instrument, or resource, that serves to modulate (somewhat) "more responsible" innovation. However, different paradigms, or normative models, of responsibility co-exist around what is considered "being responsible", configuring different functional modes of engagement with the future and, therefore, different modes of operationalising anticipation (i.e., of "using the future") (Adam & Groves, 2007).

The mainstream mode of anticipatorily governing innovation systems has technocratic flavours, which consist of articulating actions defining governance on the basis of expert-based models of the future, whose objective is to project the system's future state as accurately as possible. This anticipatory activity can be carried out for various purposes, such as changing the course of events to prevent the predictive model from being fulfilled, or developing adaptive strategies that seek to reduce or accelerate forecasted impacts.

Understood under this predictivist model, anticipation has been considered within innovation systems as a particularly useful instrument to promote the development of these systems that is sensitive to their potential impacts and consequences. A fairly clear example of this is risk analysis of techno-industrial developments, which seeks to assess and manage *ex ante* both socio-technical accidents (e.g., Perrow, 1984), and progressive and cumulative health and ecological impacts (e.g., Cranor, 2017). Thus, risk analysis points directly to the evils of progress – allowing, or legitimising, its critique and regulation – (Delogu, 2016) while at the same time denoting, under its institutionalized form, the – disputable – assumption that the risks of techno-industrial progress can be foreseen and regulated (i.e., controlled) without having to forgo economic growth and consumerism (Dickson, 1984, p. 261-306).

There are, however, alternative ways of using anticipation. Thus, within certain approaches that are committed to developing more inclusive and responsible research and innovation dynamics, anticipatory activity does not seek to be based on models of the future with predictive pretensions, and explicitly aims to distinguish itself from such models (Stilgoe *et al.*, 2013, p. 1571; Barben *et al.*, 2008, p. 985). Many

of the scholars and practitioners, who now – more or less tentatively (Kuhlmann *et al.*, 2019; Fisher, 2019) – promote the use of anticipation as part of their respective innovation governance models, recognise the complexity of carrying out predictivist claims (e.g., Guston & Sarewitz, 2002). They also point to the counterproductive nature of these predictive claims, given their tendency to shield the normative assumptions that, *de facto*, underlie them (e.g., Sarewitz *et al.*, 2000). Anticipation is, instead, conceived of here as a practice aimed at the collective problematisation of future states deemed *(im)plausible* and *(un)desirable* (Guston, 2014; Selin, 2011) in order to generate a series of capability-building heuristics that enable a more reflexive intervention in the present (Konrad *et al.*, 2016, p. 479-483; Ramos *et al.*, 2019; Rip, 2018, Chapter 2). Understood in this way, it is not surprising that anticipation is considered a defining dimension of Responsible Innovation. In fact, Responsible Innovation is defined in terms of "taking care of the future through collective stewardship of science and innovation in the present" (Stilgoe *et al.*, 2013, p. 1570).

It should be noted, however, that this last characterisation of anticipation can acquire various degrees of radicality depending on the diversity of anchoring assumptions considered *prefixed* in practice (i.e., not susceptible to scrutiny, as seen in the following section). This disruptive version of anticipation is by no means alien to ambivalences either.

THE AMBIVALENT POTENTIAL OF ANTICIPATION, AND THE TECHNO-ECONOMIC IMPERATIVE

Anticipation can be used both to support the dynamics of radically inclusive RRI, or "open"-like responsible innovation and to promote more instrumentalised variants limited by certain predefined regulatory frameworks and practices (Ruggiu, 2019). In fact, the meanings and performative potentials and inclinations of responsible innovation normative initiatives are, in general, constitutively contextual. This means that the transformative capabilities of their defining principles, which include anticipation, can arguably be understood as being a function of the manners in which such principles are approached and used in accordance with different preferences, commitments and power relations. Responsible innovation frameworks and principles are therefore constitutively *ambivalent*. They can both help to "open up" research and innovation practices to a more plural set of perspectives and concerns and help to "close them down" on the basis of certain pervasive technocratically-oriented assumptions (e.g., "value-free" science, a sharp "expert/lay" epistemic divide, and instrumentalised public participation), and always according to particular "context and implementation" conditions (Stirling, 2008, p. 268).

Anticipation can thus act both as an "opening-up", or *disruptive*, element as well as a "closing-down", or *limiting*, element depending on how it deals with the prevailing situated framings and dynamics. Thus, the disruptive variant of anticipation would use the collective problematisation of a system's future states in order to facilitate the emergence of alternative courses of action, while the limiting version would assume the desirability and plausibility of certain future scenarios from the outset in order to proceed with the problematisation of potential impacts (both positive and negative) that could occur during the realisation of such scenarios. Therefore, in contrast to "disruptive anticipation", aimed at "opening-up" the range of action alternatives in the present, "limiting anticipation" focuses on exploring both the different consequences that could emanate from the realisation of a given future project, and the possible contingencies that may affect (e.g., impede, hinder or enhance) its achievement.

The ambivalent feature of the abovementioned "anticipatory heuristics" is merely a reflection of the tensioned nature of innovation systems in their dealings with responsible innovation and its demands. This ambivalence is ultimately evident in the divergent ways in which anticipation operates in the context of innovation systems that are highly committed to a set of techno-economic imperatives at the disposal of techno-industrial developmentalism, and its associated economic growth. There is therefore an urgent need to analyse the way in which this "disruption-limitation" ambivalence is expressed in relation to such imperatives. Ultimately, the disruptive or limiting degree of anticipatory activity is a function of the system's (in)capacity to develop anticipatory resources that enable the critical-reflexive re-elaboration of its normative foundations, which constrain the degree of openness of socio-technical alternatives.

Understood from a radically inclusive, or open, perspective, anticipation means, as mentioned, "opening-up" the discussion to the plurality of future projects that the various social actors might hold. This discussion is precisely the resource expected to feed the process of imagining alternatives for action (Lehoux *et al.*, 2020). The plurality of future visions and projects held by the heterogeneous social actors (i.e., the diversity of different knowledges, expectations, interests and normativities) is used as a heuristic resource to provide orientation and enrich the present (Grunwald, 2013). According to this disruptive conception, anticipation can be characterised as a practice directed towards the collective problematisation of future states.

In this vein, anticipatory knowledge here is not knowledge about the future *per se* (as pointed out above), i.e., "is not about seeing into the future (prudence) or saying what the future is going to be (prediction) or estimating the chances of a certain outcome (probabilistic forecasting)" (Foley *et al.*, 2018, p. 228). Thus, rather than

aspiring to mitigate and eliminate uncertainty about the future, disruptive anticipatory knowledge embraces (both empirical and normative) uncertainty. The future is not a space to be epistemically and technically conquered. Rather, it is a politically open, debatable reality. So, the value of anticipatory knowledge, now, lies in its ability to facilitate the identification of alternative ways of acting by producing heterogeneous representations of socio-technical futures. Producing such heterogeneous futures representations depends on the full consideration and interrelation of a diversity of different knowledges, values and political preferences. This implies that the robustness of anticipatory knowledge may arguably be understood as a function of the level of integration, or inclusiveness, of anticipatory processes. In these terms, anticipation would then be a genuine source of robust knowledge, namely, knowledge "able to withstand variety and interference", and produced through "interactions and struggles" (Rip, 2018, p. 21).

Based on this understanding of anticipatory knowledge, the epistemic legitimisation of futures representations does not rely on the probabilistic production and assessment of future scenarios. Rather, it relies on the less constraining demand of plausibility (Selin, 2011; Wiek *et al.*, 2013). Plausibility thus turns into a crucial epistemic device as it enables the envisioning and consideration of futures that would otherwise be excluded under a probability-based stance (Ramírez & Selin, 2014). Plausibility navigates between the probable and the possible; it is more inclusive than probability and more constrictive than possibility. Even though plausibility conceptually enables a broader and richer set of future scenarios to be considered, the extent and detail of such scenarios will depend on the variety of assumptions embraced (or not) when determining plausibility in practice. In this sense, the extent of variety and detail of scenarios is conditioned by the understandings of "the (im)plausible" and "the (un)desirable" (not) actually considered and mobilised during plausibility negotiation processes. Thus, the reception of plural conceptions concerning "the (im)plausible" and "the (un)desirable" is the epistemic device that enables futures to be opened up (Urueña, 2019).

Anticipation and negotiation of "the (im)plausible" and "the (un)desirable" will not, however, be free of resistances. Anticipation can only be an efficient and realistic tool if it takes into account that, from the very outset, governance processes and forms "are not without tensions" (Siune *et al.*, 2009, p. 4). This is due to the fact that the degree of (im)plausibility and (un)desirability is decided contextually, as pointed out above. Thus, the anticipatory heuristics' degree of radicality (in terms of "disruption-limitation") will, among other factors, depend heavily on the elements considered prefixed when alternatives are envisioned (i.e., elements delimiting *ex ante* the domain of futures under consideration) (Urueña, 2019). In this sense, questioning which assumptions constrain these anticipatory mechanisms within innovation governance

proves a crucial issue, as does how, by whom and why they are mobilised and established as such.

One normative element that frames, constrains and limits what is considered (im)plausible is the techno-economic imperative. This imperative characterises innovation systems such as the EU's, as seen. These systems are firmly based on the ideology of techno-industrial developmentalism and the constitutively related assumption of absolute (and, on principle, unquestionable) harmony, or compatibility, between the different concerns and interests analysed above. Any anticipatory futures-building process constrained by this imperative (whether consciously or unconsciously assumed) will reflect socio-technical assemblages where innovation systems are geared towards maximising economic growth. This ideological frame limits, or impoverishes, the future. Conceived as an achievable, or "designable", state of affairs, the future under industry-driven anticipatory thinking and practice is not approached as an opportunity to reflect on and debate alternative socio-technical scenarios and trajectories or new normative horizons. Instead, it serves the purpose of pre-legitimising certain techno-industrial priorities and projects, precisely under the assumption that the future itself is susceptible to being instrumentally (i.e., technically) mastered and controlled (Nordmann, 2010, 2014).

Anticipation can only become a disruptive practice if it is able to envision alternative futures where relations between innovation practices and the market are articulated through alternative values that reach beyond economic rationalisation. In other words, only anticipatory practices capable of challenging the prevailing plausibility frameworks that take the techno-economic imperative for granted will take on a radically disruptive character. The degree of success of anticipatory heuristic practices could in turn modulate the socio-technical arrangements, revealing different gradients of intensity (i.e., they could modulate the socio-technical arrangements according to different gradients of openness and closure). Although anticipation is seen as an emancipatory interventive instrument, it should be interpreted within the complex socio-technical network where it emerges and intended to prove effective. Anticipatory disruptive practices aim to be functional within networks where forces typically resistant to change exist, and where actors tend to perpetuate the status quo (Withycombe *et al.*, 2019). The broad capitalist anchoring and *momentum* of our societies will not only hinder the envisioning and emergence of alternative modes of relations between innovation and the market, but also the very conception of "uses of the future" that are not framed and pragmatically oriented towards increasing profit (Beckert, 2016).

In this sense, even the more disruptivist forms of anticipation (i.e., those working under the less constraining epistemic register of plausibility) are vulnerable

to ambivalences. Such anticipations may trigger the opening-up of the future with regard to certain aspects while, at the same time, they may close it down in relation to certain other aspects. For instance, problematising the potential future impacts associated with nanotechnologies may obscure the relevant debate on whether nanotechnologies are desirable in themselves. The occurrence of nanotechnology would be taken for granted here (i.e., in principle, it would be considered plausible), implying that any future scenario excluding nanomaterials would *de facto* be ignored. Thus, the apparently disruptive anticipatory exercise would in fact align with more committed pro-nanotechnology policy and industry narratives (which, in turn, are often guided by the techno-economic imperative).

It is therefore important to recognise that the transformative potential of anticipation as an instrument of intervention is significantly constrained by the broader framework of understanding and action within which it aims to become operational in order to foster more responsible innovation. In this sense, the European innovation system's commitment to anticipation, on the basis of which the EC argues, for example, that "[RRI] implies anticipating and assessing potential implications and societal expectations with regard to research and innovation" (European Commission, 2013, p. 4), seems to reflect the limiting-type version of anticipation rather than the disruptive variant. Thus, for example, the SwafS line of research "Developing Inclusive, Anticipatory Governance for Research & Innovation" claims to serve the development of "scenarios regarding possible future RRI activities and how these activities are perceived by science and society" (European Commission, 2017, p. 8-9) in order to "contribute to inclusive and anticipatory governance in the context of strategic priority-setting for future R&I (funding) policy in Europe" and help "the strengthening of the research and innovation ethics framework" (European Commission, 2017, p. 9), meaning that anticipation is subordinate to a mapping of the various actors' perception with respect to the RRI framework itself, and limited to a set of prefixed priorities that are impervious to criticism. Another SwafS research initiative, "Building the knowledge base for SwafS", on the other hand, addresses anticipation as a resource linked to the exercise of examining the ways science and society co-evolve. This includes analysis of potential social attitudes towards this very co-evolution, provided that "[u]nderstanding the co-evolution of science and society will help proactive and anticipatory policy making" (European Commission, 2019b, p. 43), so anticipatory activity seems to be identified here with a strategy for minimising socio-technical uncertainty.⁸

⁸ This does not mean that some characterisation of anticipation with open and disruptive traits cannot be found within the EC. For instance, according to certain discourses within the EC, research and innovation should "play an ever-more important role in creating the future we want", by "opening the

Promoting radically more responsible innovation requires recognising this ambivalence of anticipation as a tool for modulating "responsible" practices and analysing different "uses of the future" and the rationale underlying them. At the same time, this ambivalence needs to be studied in a context where, despite the existence of various narratives seeking a more radical opening-up of innovation systems (articulated in more disruptive conceptions of anticipation), the disruptive potential of these narratives is limited in number and scope by innovation dynamics which are significantly compromised by the techno-economic imperative characterising modern capitalist societies.

CONCLUSION

Anticipation, when acting as an interventive resource aimed at enabling the problematisation and collective production of representations of socio-technical futures legitimising and guiding current scientific-technological practices, is able to function as a heuristic tool with the potential to promote more responsible research and innovation dynamics. This responsibility, in line with a certain type of more radical interpretation of recent proposals for "responsible innovation", such as RRI or Open Science, within the EU's innovation system framework, is defined in terms of inclusiveness and openness with respect to the interests, means and goals underlying research and innovation dynamics (i.e., with respect to the processes and elements determining what lines of scientific and technological action should be promoted and the milestones they should be oriented towards).

This article has sought to show, however, that this "responsible heuristic", serving to facilitate radically open and heterogeneous debate on the very purposes and interests underlying innovation systems, must necessarily be approached by taking into account that the anticipatory heuristic's degree of "disruptiveness" or "limitation" will depend on the way in which anticipation, as an interventive practice, plays out in the context of innovation systems such as the EU's. These systems, which are deeply committed to economic-industrial developmentalism and the subsequent instrumentalisation of science and technology dynamics, pursue the achievement of certain milestones related to economic growth and competitiveness.

This techno-economic imperative thus acts as an element that constrains and limits the envisioning of alternative futures; it represents, in other words, the system's (in)capacities to develop anticipatory resources that enable the critical-reflexive re-

discussion on future research and innovation policy and investment, and (...) promoting engagement and participation by society in the policy process" (Moedas, 2017, p. 7).

elaboration of its normative foundations. These foundations are based on the assumption of absolute (and, on principle, unquestionable) harmony, or compatibility, among different societal concerns and interests with regard to techno-industrial progress, its problems and the unquestionable and urgent *de facto* quest for economic development and profit. In this sense, it has been argued that there is therefore the need to analyse whether – and how – anticipatory practices enable futures envisioning capable of critically scrutinising the techno-economic imperative's normative base, and of building alternative relations between innovation and economic dynamics.

All of this implies that the scope and meaning of anticipatory practice must always be approached in relation to the specific socio-political contexts where this practice takes place. Depending on these contexts, anticipation will tend to act either as a *disruptive* instrument (i.e., serving critical-reflexive openness of socio-technical systems) or, on the contrary, as a *limiting* element (i.e., focused on orienting the governance of science and technology towards prefixed normative milestones that are impervious to debate).

This article has therefore proceeded to identify and characterise this ambivalent feature of anticipation in relation to its potentially dual, "disruptive-limiting" role in the context of EU innovation system. This is a context where the dominant, economicist imperatives severely hinder the possibility of developing more disruptivist anticipatory practices (i.e., practices in line with the most radically inclusive interpretations of "responsible innovation" proposals such as RRI or Open Science).

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