Addressing societal challenges through the simultaneous generation of social and business values: A conceptual framework for science-based co-creation

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ABSTRACT

The paper focuses on a key uniqueness of the simultaneous generation of social and business value - across science, technology and society - involving academics, businesses, policy makers, innovation intermediaries, NGOs and citizens that share and integrate assets in developing solutions to address economic and societal challenges.

By contrasting with a broad literature using the term 'co-creation' to denote close working relationship between actors, the paper outlines a conceptual framework explaining how the diversity of agents involved, their motivations and goals, and incentive structures in which they operate impact on science-based co-creation. This multidimensional perspective is discussed with regard to the scope of innovation, reach and types of values that are generated, and the distinctive features to be considered when both social and business value are at the core of collaboration.

Policy implications to support science-based co-creation are discussed with regard to the rationale for public interventions and the critical dimensions of policy implementation and assessment. It highlights that policy design aiming at supporting societal challenges through co-creation should address mechanisms to integrate tangible and intangible inputs, define suitable operational models and enhance specific capabilities and practices.

JEL Codes: O14, O31, O33, O38

Keywords: R&D collaboration, Industry-Science Linkages, Triple Helix, Knowledge Triangle Co-creation, social values, open innovation

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1. Introduction

In recent years, increased attention has been placed upon collaboration aimed at enhancing the application of science through co-creation among universities, businesses, government, intermediaries, and society (Jones et al. 2013; Chesbrough and Di Minin 2015). The studies that have discussed these forms of collaboration are focused on analysing how science-based co-creation enables the generation of either economic value (Etzkowitz et al. 2008, Fuchs and Schreier 2011; Grimaldi and Grandi 2005; Levine and Prietula 2014 among others) or social value (Trencher et al. 2017, Trencher et al. 2014, Van Veen et al. 2013, Reeger and Bunders 2009 among others). Although social and business values may potentially be competing (Battilana and Lee, 2014), some authors argue that the integration of social and business missions enables the simultaneous generation of both values (Santos 2012; Pache and Santos, 2013; Ebrahim et al. 2014). Notwithstanding the several dimensions explored by the literature so far, scant attention is paid to how science-based co-creation *simultaneously generates* business value and social value.

Against this backdrop, this paper aims at conceptualising the determinants of such a process, with special attention paid to the types of value generated, the specific inputs to co-creation provided by the various actors involved in such a process of interaction, the intentional dimension of engagement and the potential impact of external factors in influencing the co-creation initiative. This effort is needed in order to single out the distinctive characteristics of science-based co-creation that, as presented in our analysis, demand policy initiatives, but are so far scarcely addressed in the policy debate. We notice that, in line with the emergence and widespread acceptance and diffusion of the open innovation paradigm, collaborative innovation related activities – across all the stages of the innovation process – have achieved considerable popularity (Gassmann et al. 2010). Early conversations around open innovation predominantly highlight how external inputs could boost companies' innovation projects. With a focus mainly on the user-centric perspective (Von Hippel and Krogh 2006), several contributions then discuss the economic value generated by the interactions between producers and consumers for product and service development (Jones et al. 2013; Chesbrough and Di Minin 2014) and product/service design (Adner and Kapoor 2010; Gemser and Perks 2015; Hienerth et al. 2014; Miles et al. 2017; Perks et al. 2012). A number of studies, on the other hand, made progress in enhancing our knowledge on how university involvement in co-creation generates social value, especially through engagement in rural/local/regional development, social interventions, the solution of environmental issues, and the realisation of sustainable development and societal transformation by working closely with multiple actors from society and academia (Trencher et al. 2017, Trencher et al. 2014, Van Veen et al 2013, Reeger and Bunders 2009). These studies have discussed how universities with societal stakeholders co-create knowledge, especially through mutual learning in a community of practice model, motivations for these actors to collaborate with universities and factors influencing the co-creative potential of the university (Cervantes and Meissner 2014; Trencher et al. 2017, Trencher et al. 2014, Van Veen et al. 2013).

The significance of furthering our knowledge about science-based co-creation generating dual value thus lies not so much in the interaction dimension *per se*, but in the mechanisms and specific factors affecting the process of the simultaneous creation of business and social values as a joint effort of independent interacting actors, aligned in sharing a goal and contributing

with their own specific resources. With regard to society, multiple social values matter when taking into account the outcomes of innovation processes. Values, in the plural, remind us of the different perspectives in assessing the business and social impact of any action, (see Stark 2017, Bollier, and Helfrich 2019, Bowels and Carlin 2020a,b) and of innovation in particular. The economic value generated through science-based co-creation involves increasing access to new markets (Huang and Yu, 2011), producing new goods and services (Lee et al, 2012), and implementing efficient processes (Cervantes 2017; Rosli et al. 2018) among others, whereas social values refer to improvements in conditions for society (Reale et al. 2017), cultural development (Walter et al. 2007), and the addressing of unemployment, poverty, and environmental degradation (Cassity and Ang, 2006; Rau et al. 2018).

While the generation of economic and social values involves competing rationales, initiatives that are formed to generate a combination of both values have significant policy relevance, especially in relation to the social, economic and environmental challenges addressed in the UN sustainable development goals (SDGs) (United Nations, 2015) [1]. These challenges are increasingly targeted by policies that foster the interaction among science, industry and society in a broadest sense.

In Section 2, the paper discusses how to position science-based co-creation determinants and mechanisms in related streams of literature. Section 3 presents an ontology of science-based co-creation: the entities being analysed (with regard to their characterising features), their interrelationships, and the levels of interactions. Such a conceptual framework enables the singling out of the specific dimensions that must be addressed in terms of opportunities and incentives – at the micro, meso, and macro levels of interactions – and specific features of co-creation processes that need policy interventions supporting science-based co-creation, discussed in Section 4. Section 5 concludes the paper and outlines further research developments.

2. Positioning Science-Based Co-Creation in Related Streams of Literature

The economic literature focuses on co-creation from different perspectives: from the simultaneous creation of economic and social values in a local production system, to the debate about linking science and application. In this section, we review the literature looking at the objectives of collaboration, the interaction mode (from transfer of knowledge to co-creation) and the level of interactions, the centrality of science (from low to high), and the prominent value that is generated. Table 1 provides a brief comparison of such key features emerging from the survey of the literature, listed from the oldest to the most recent contributions.

[1] "The Sustainable Development Goals are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all UN Member States in 2015 as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals." https://www.un.org/sustainabledevelopment/development-agenda/

Table 1: Comparing the Domains of Literature Related to Science-Based Co-Creation

Streams in the literature	Predominant objective of collaboration	Level of analysis of the interaction	The role of universities/science in the interaction	Prominent type of value generated
Industrial Districts Brusco 1982; Becattini 1990, 2002; Asheim 1996; Russo 1996	Economic development	System (industrial district) performance	User-produced interaction with less focus on universities	Social embeddedness of economic activity supporting and orienting economic value generation
Innovation Systems Lundvall 1992; Nelson 1993; Edquist 1997; Mowery & Oxley 1995	Economic development	The nation or region affected by the systemic interactions	Universities as a component of the system, producing an output for other organisations	A country's (or region's) innovative performance aimed at economic development
Clusters Porter 1998	Economic development	Groups of organisations (e.g., localised supply chains)	Local university-business interactions are prominent	Mainly economic value for regional development
R&D Collaboration Katz and Martin 1997; Hagedoorn et al. 2011; Cunningham and Link 2015	Technology development and commercialisation	Organisations directly involved in the process and the network generated by their interactions	Research and development-based interactions with universities	Joint innovation for economic gains
Triple Helix/ Quadruple Helix Etzkowitz and Leydesdorff 2000; Carayannis and Campbell 2012	Technology development and commercialisation Social innovation	Institutional spheres of university, industry, government and society and their interactions	Dynamic interactions between institutions, with university at the core	University and science's contribution to innovation and economic development
User-centric Co-creation and related evolutions Von Hippel and Krogh 2006; Jones et al. 2013; Chesbrough and Di Minin 2014; Levine and Prietula 2014	Economic development Technology development and commercialisation	The network directly involved in the process (both individual networks and organisations)	User-producer interaction less focused on universities	Mainly business value generation
Open Innovation Chesbrough 2006; Enkel et al. 2009; van de Vrande et al. 2009; Trott and Hartman 2009	Economic development Technology development and commercialisation	Firms, projects, and teams directly involved in the process	A wide array of interactions, including knowledge transfer, exchange and co-creation, in which universities contribute to business innovation	Mainly business value generation. Regional and national innovation performance aimed at economic development
Knowledge/technology transfer Mowery et al 2004; Mowery 2007	Economic development Technology development and commercialisation	The network directly involved in the process (both individual networks and organisations). Impact of universities and research institutes on the economy	Universities as the producer of knowledge, transferred to other organisations	Mainly business value generation
Knowledge Triangle OECD 2003; Unger et al. 2017, 2020	Technology development and commercialisation	The units directly involved in the process, Third Mission of universities	Dynamic interactions between institutions, with universities at the core	University and science's contribution to economic innovation
Sustainable/Social Co-creation Reeger and Bunders 2009; Van Veen et al 2013; Trencher et al. 2014; Trencher et al. 2017	Social innovation	The network directly involved in the process (both individual networks and organisations) with a significant involvement of society and university	University's social contribution at the core	Mainly social value generation

Source: authors' elaboration on De Silva et al. 2020

The concept of *industrial districts*, which was originally explored by Alfred Marshall to interpret the spatial agglomeration of industries (Marshall 1923), re-emerged in the early 1980s to explain the socio-economic dynamics of local production systems and innovation processes in the Third Italy, characterised by networks of specialised small and micro firms and medium-

large companies, with very high growth rates for exports. In industrial districts, user-producer interactions foster innovative processes, but industry-science interactions are not a core issue. Even though industrial districts' literature focuses on social value creation (Brusco 1982; Becattini 1990, 2002) because of the essential embeddedness of economic activity in social interactions (Granovetter 1985), the emphasis upon industrial production (Russo 1996) means that science-based relationships involving a wide array of actors to co-create dual values have received less attention (Asheim 1996; Becattini et al. 2008).

The *National Innovation System* (NIS) approach conceptualises the origin and diffusion of innovation by considering the overarching institutional setup of countries or regions. Lundvall (1992), Nelson (1993), Mowery and Oxley (1995) and Edquist (1997) describe and analyse the latter from a macro perspective. The NIS approach provides a clear indication of the importance of dynamic linkages among institutions, with science as a component of the system and government as a facilitator. However, NIS literature lacks the emphasis upon dual value co-creation.

Cluster theories, as postulated in Porters' seminal work on *industrial clusters* (1998), enhanced our understanding of the geographic concentration of interconnected companies and institutions, with local university-business interactions playing a prominent role. However, the main focus of the cluster literature has been on businesses, whereas government, universities, think tanks, vocational training providers, and other institutions were considered as suppliers of support services (Porter 1998). This major focus on business innovation places less emphasis upon explaining how societal value is generated through close interactions between actors.

R&D collaboration among businesses and between science and industry (Katz and Martin 1997; Hagedoorn et al. 2011; Cunningham and Link 2015) seems to closely resemble co-creation, but these collaborations are still often aimed at predominantly generating innovation for businesses with the involvement of academics through contract research on R&D projects, and a relative lack of focus on social value creation. However, the latter – social value creation – must be treated with care, since such values might be relevant not only to individual categories of beneficiaries, but to a population living in a country or in a given area with access to the collective goods that have been created, and metrics and time profiles to measure their impact should be defined accordingly.

Triple Helix model (Etzkowitz and Leydesdorff 2000) literature highlights how a wide array of institutions dynamically interact and generate new institutional and social settings for the production, transfer and application of knowledge. It focuses on the application and exploitation of research in the "triple helix" (government-industry-university), which was extended by Carayannis and Campbell (2012) to the "quadruple helix" (government-industry-university-civil society). Yet, while the initial model mainly focuses on the generation of economic value, the extended approach focuses on the generation of social value.

While in Rosenberg (1963) the interactions between users and producers of capital equipment was the key to explaining the direction of technical change, the *user-centric perspective* proposed by Von Hippel and Krogh (2006) focuses on the economic value generated by the interactions between producers and consumers in orienting product and service development (Jones et al. 2013; Chesbrough and Di Minin 2014). Interaction is an innovation management tool for service industries by means of consumer and stakeholder involvement in product/service design (Adner and Kapoor 2010; Perks et al. 2012; Hienerth et al. 2014; Gemser and Perks 2015; Miles et al. 2017). Building upon the shifting perspective of innovation processes, from the linear model to the interactive models underlying the previously mentioned contributions, the

open innovation literature at the onset of its introduction paves the way to understanding how companies make use of the inflows and outflows of knowledge, technologies and resources for innovation (Chesbrough 2006). Open innovation practices range from outside-in and inside-out to coupled processes that involve 'co-creation with (mainly) complementary partners' (Enkel et al. 2009). While earlier discussions on open innovation literature have often referred to the transfer of external inputs to enhance firms' innovation, the recent focus on co-creation has stressed the mutual interaction between actors but still with a special emphasis on how the interaction generates business value predominantly in the context of user-centric innovation, open source projects (Von Hippel and Krogh 2006; Payne et al. 2007), virtual communities/platforms, and multi-disciplinary projects (Enkel et al. 2009).

Interactions at the micro and meso levels – as an important driver of innovation – have been the central elements of the *knowledge/technology transfer* (Mowery et al. 2004; Mowery 2007) paradigms. These streams of literature focus upon the interactions between universities and businesses as a means of reducing the gap between science and the market, which also leads to the emergence of terms such as 'technology transfer' and 'knowledge transfer', to name the most frequently used ones (Meissner and Erdil 2018). A myriad of hard activities (e.g., patenting, licensing and spin-off firm formation) and softer initiatives (e.g., academic publishing, grantsmanship and contract research) are discussed in detail in the literature (Philpott et al. 2011). Yet, the predominant focus has been on generating business value from knowledge and/or technologies vested within universities. As a result, the outcome of these interactions is often measured in terms of funding secured by third parties to engage in the interaction or the extent to which business challenges are resolved, with no attention to the potential social and business values that could be generated through engagement with other parties (Meissner 2017).

Bridging knowledge/technology transfer and "triple helix" thinking, the "entrepreneurial university" model – as the central element of the *Knowledge Triangle* (Unger et al. 2017, 2020) – emphasises both the actor and the functional perspectives, i.e., entrepreneurial education, entrepreneurship and commercialisation activities, such as university-based start-ups and patenting activities. The value generated in this framework is the contribution of universities and science to economic innovation.

Civic universities or *sustainable/social co-creation* are too extensions of the *Triple Helix* model, as they try to institutionalise the innovation focus of universities, both in the teaching and research functions but more importantly with regard to the engagement of universities with their local communities (Etzkowitz et al. 2008; Gokhberg and Meissner 2016; Borlaug and Aanstad 2018; Erdil et al. 2018). In contrast to the linear pipeline model of innovation, it emphasises linking the different functions of universities together with the different actors in the surrounding innovation eco-systems (i.e., a place-based dimension) (Meissner and Carayannis 2017). It pays special attention to university's involvement in co-creation for social value generation (Reeger and Bunders 2009; Van Veen et al. 2013; Trencher et al. 2014; Trencher et al. 2017). These studies have discussed how universities engage with societal actors in rural/local/regional development, sustainable development, and societal transformation. While sustainable or social co-creation closely resembles science-based co-creation, such studies lack the focus upon dual value generation through co-creation.

From different perspectives, the reviewed literature refers to the innovation ecosystem as an evolving set of interacting actors, activities, artefacts and institutions that are important for the innovative performance of an actor or a population of actors (Granstrand and Holgersson

2020). Despite embracing many different actors and their interaction modes, not all the reviewed contributions specifically address the role of science or science-based co-creation with a specific discussion about how different actors in an innovation ecosystem work together to simultaneously generate both business and social values as a means to enhance the use of science. As will become explicit in the framework below, the objectives for the generation of social and business values should ideally be incorporated in the objectives of co-creation by means of designing and defining the scope of collaborative activities for all parties engaged in such endeavours.

3. Conceptual Framework for Co-Creation

Given its being a long-established form of industry-science cooperation, collaborative research frequently pops up in the academic and political discussions. Yet, science-based co-creation needs a revised conceptual framework to study a specific form of collaboration mechanism that involves individuals (a) associated with different organisations (b) working closely together by integrating their complementary assets, in order to (c) simultaneously generate social and business values across science, technology and society. Accordingly, co-creation assumes close working relationships not only at the organisational level, but also among individuals associated with a wide array of organisations including universities, businesses, government, intermediaries and society. In our understanding, the specific forms of collaborative research with two or more partners – often called research consortia, research alliances and research networks, as well as research public-private partnerships – might engage in co-creation if the aforementioned unique criteria are met. We are not proposing that co-creation is a new phenomenon, but, in this paper, we intend to provide a cohesive conceptual basis for enhancing our understanding of this specific form of collaboration and of the determinants of dual value creation. It should be noted that co-creation is not a substitute for internal R&D by interacting organisations (e.g., business, university, government, or intermediary organisation), but a complementary interaction mechanism that is suitable for addressing challenges across the business and social domains, and that no single firm nor academic research unit would see the ability or desire to independently deal with.

The distinctive features of science-based co-creation will be discussed in this section, including the endogenous mechanisms and the exogenous factors affecting it. Focusing upon interactions at micro, meso and macro levels, in what follows we outline the relevant entities and the types of interactions in science-based co-creation (Section 3.1), the determinants of co-creation and the mechanism through which they generate social and business valueы (Section 3.2), and the dimensions to be considered in the analysis of the dual values generated by co-creation (Section 3.3).

3.1. Agents' Interactions in Science-Based Co-Creation

During science-based co-creation projects, individuals are co-players, working together closely. The attempt to generate both social and business values can be challenging due to the need to couple competing goals, behaviours and practices (Pache and Satos 2013). The literature has clearly highlighted the difficulties associated with the simultaneous achievement of social and business goals, since actors have to bridge potentially conflicting aims and divergent stakeholder interests (Pache and Santos 2013; Ebrahim et al. 2014). Yet, at the individual level, close and tight interactions could address this challenge (De Silva et al. 2019). These individuals might be from different organisations, including those with both for-profit and not-for-profit motives. Their closeness increases the chances of aligning social and business objectives

through the whole process of science-based co-creation (De Silva and Rossi 2018). Their heterogeneity (in terms of expertise, attributions, or access to particular agents or artefacts) and aligned directedness (in having a common goal to achieve through co-creation) are the preliminary conditions for the emergence of a generative relationship supporting innovation. In addition, mutual directedness is reinforced by recurring patterns of interaction, opportunities to engage in joint activities, and appropriate permissions for alignment (Lane and Maxfield 1997).

The focus on interactions involving individuals and not only organisations means that the conceptualisation of co-creation places a strong emphasis upon enhancing our understanding of the influence of incentives, micro-foundations of capabilities and skills, leadership, motivation, commitment, relationship building and management, and so on that are specifically conducive to interactions between individuals coming from different backgrounds to simultaneously generate social and business values across science, technology, and society itself (Lee et al. 2019; Paradkar et al. 2015; De Silva et al. 2020). During co-exploitation projects, diverse actors (both private organisations and public administrations) often create separate and independent (i.e., independent of actors' organisational associations) social or physical structures (e.g., accelerators, social innovation labs and living labs, among others) supporting the alignment of social and business goals. In addition, new agents might be identified during the process, and the success will depend on actors' ability to work with one another during the integration process (Spithoven et al. 2011) and to cope with uncertainties emerging during the process (Lane and Maxfield 1996).

When targeting the simultaneous generation of social and business values (i.e., in comparison with the generation of one form of value), it is of paramount importance to combine different assets, including knowledge, resources and networks (in contrast with knowledge and technology transfer, where the focus is upon acquisition rather than integration of missing resources and competences). Joint identification of specific goals entails parties creating and shaping the specific opportunities to meet their objectives and to ensure to each other's commitment. These opportunities are co-exploited by actors through multiple channels that involve the execution of operational level strategies to integrate their complementary assets. Within this framework, it appears that co-creation benefits from some specific conditions: close relationships possibly started from the beginning of the process, a careful thinking by partners about the assets (specifically needed for what outcomes) that they can integrate in the process, an agreement on the intellectual property rights associated with the use of assets (when relevant).

3.2. Determinants of Science-Based Co-Creation

Many different forms of science-based co-creation projects have been analysed in the literature, including those happening at joint research labs (Gassmann et al. 2010), living labs (Domingue 2011; Kokareva et al. 2018; Kommonen and Botero 2013), technology platforms (von Krogh and von Hippel 2006; West 2003)**,** accelerators (Grimaldi and Grandi 2005) and social innovation labs (De Silva and Wright 2019), among others. Beyond the variety of organisational forms, they differ in terms of scope and mission, involving different determinants of success in generating social and business values. It follows that the focus is upon three types of determinants, namely: (a) the decision to engage in co-creation, (b) inputs to co-creation offered by actors, and (c) the management of co-creation.

With regard to each determinant, we shall consider several factors and their interconnections. Moreover, we shall discuss the direct linkages among the determinants and several feedback loops that may occur even within a single project (i.e., as a result of ongoing and final evaluations), not to mention the ones that, together with learning effects, might be induced by the

process activated at a larger scale, which contributes to enhancing the success/failure of the project.

(a) Decision to engage in co-creation

Organisations should carefully make decisions about objectives to be achieved through co-creation and those to be achieved through other forms of engagement. Among the different aspects that would influence this decision, we have identified four key factors, namely: the scope of the challenge addressed, the urgency of response, objectives/motivation of associated organisations and individuals, and incentives for engagement in co-creation.

First, when the *scope of the challenge* to be addressed requires diverse expertise and resources and having a broader impact – such as responding to sustainable development goals – and is likely to result in generating both social and business values, co-creation seems to be an ideal mechanism. This is because co-creation enables individuals associated with organisations in an ecosystem to work together closely to integrate their resources and expertise. On the other hand, if the challenge addressed can be dealt effectively with internal resources or through a resource exchange, co-creation might not be a good option. Hence, organisations should perform a careful evaluation of which objectives should be addressed through co-creation and those that should be addressed internally or through other forms of interactions. In this regard, the intended types of social and business values co-created plays an important role. The different outcomes of science-based co-creation might include inventions, prototypes, algorithms, formulas, recipes, experiment protocols, patents, licenses, training, and education programmes among many others (Meissner and Sultanian 2007). The scope of the challenge has a strong impact upon the form of collaboration between the partners, for example, the duration, investment, commitment, and exploitation potential, to name a few. Furthermore, the scope and objectives of co-creation impact the form and intensity as well as sustainability of collaborative activities with respect to their long-term impact.

Second, when an *urgent response* is required (e.g., the COVID-19 coronavirus pandemic as a recent striking case), which may be unlikely to be dealt by a single organisation and would require the generation of both social and business values (Bowels and Carlin 2020b), co-creation might play a better, more suitable role. The involvement of multiple parties will also enable distributing the risks, which are likely to be associated with matters that require urgent responses.

Third, the *alignment between the objectives* of co-creation and that of individual organisations is a critical determinant of dual value. While organisations could influence the design of the objectives of a co-creation initiative, it is important that each party separately monitors and evaluates the alignment between individual objectives and the ones intentionally targeted (or emerging) in the process (Lane and Maxfield 1997). This is mainly due two main conditions: not all the actors might be involved in the initiative's initial joint identification stage (thereby requiring actors joining at the co-exploitation stage to decide whether their involvement in the initiative is worthwhile). Even if they are involved in the initiative from the beginning, each organisation has to internally decide upon the types of objectives to be achieved through co-creation and those to be fostered through other forms of engagement as well as ways of alignment amid the changing objectives. This alignment would then influence the involved parties and the inputs they provide, which in turn impact the types of value co-created.

Fourth, *incentives provided* by each organisation to individuals associated with co-creation would determine their commitment and engagement, which would then influence the value co-

created. As this involves working closely with external parties associated with different organisations that have different objectives, more effort would be required from co-creators, since there is a high risk of failure. Thus, organisations should consider such risks when evaluating the performance of, and rewarding, individuals involved in co-creation. With respect to organisations, it is also likely that incentives provided by government and policy framework for co-creation would influence the engagement by organisations and co-created values.

(b) Inputs to co-creation by actors

On the basis of the reasons for engagement in co-creation, the needs of the initiative as well as each party's individual resources, actors should provide tangible and intangible resources to be integrated into the project. The understanding of their contribution to the innovation outcome of collaborating partners, which is largely neglected in the open innovation literature, is critically important in relation to co-creation: this is expected to play a significant role where partners are likely to contribute to the initiatives with different types of resources (Müller-Seitz and Sydow 2012).

Among many intangible resources, the competence, capabilities, knowledge and skills of various partners appear as a key determinant. It not only requires staff to be formally qualified of at both ends, but also includes a tacit dimension (which is made of attitudes, beliefs and norms). Among others, these factors make up the underlying culture of an institution, which in turn influences the entity's readiness and willingness to enter co-creation and its impact upon dual value creation. In other words, culture is more than an individual's attitudes, as it also involves the readiness and usefulness of an institutions' service functions (such as legal, accounting, and human resources among others) for co-creation. Furthermore, institutions might be eager to engage in co-creation but limit the choice of potential partners to a pre-specified range that often refers to reputation of partners. For example, public research institutions might be tempted to prefer partners with exceptional reputations in society and business in order to take advantage of reputational spillovers for themselves. A similar effect might appear in co-creation, involving academic partners either mainly or exclusively. What co-creation needs is networks that evolve in terms of the competences of the various partners, which are either already in place or might emerge because of the collaborative process. On the contrary, actors with a comparable reputation might provide additional inputs for co-creation but pose serious obstacles to the involvement of organisations with less strong reputations, thereby hampering the enhancement of the generative potential that might come from more diverse actors.

Although well identified at the beginning of the collaboration, the types of inputs offered by parties and the access to inputs shared in the patterns of interactions might evolve in the co-creation project, and this can, in turn, affect the project outcome.

(c) Managing co-creation

Four main overarching key factors associated with the management of co-creation influence dual value generation: 1) the operational model; 2) practices and capabilities; 3) digital infrastructures; and 4) intellectual property rights. These factors would influence any form of collaboration, and we outline their specific influence upon the nature of the dual value co-created.

The *operational model* (including business model and partnership model) should ensure economic sustainability and generation of dual value by means of generating financial revenues and improving social well-being paired with financial sustainability. Many innovative co-creation operational models creatively build upon the complementarities of financial and social

objectives so that initiatives are socially and financially sustainable and generate social and business values (De Silva et al. 2020).

The *capabilities and practices* that seem to work for co-creation are different from those that work for other forms of collaboration. For instance, when structuring capabilities are important for knowledge transfer, relational capabilities are of significant value for co-creation. Also, the type of dynamic capabilities required for co-creation seems to vary depending upon the stage of co-creation. While the capabilities of individuals directly involved in co-creation seem to play a major role during early and growth stages, as the initiative scales up, their effort to improve the skills and capabilities of future co-creators (i.e., those who might only be indirectly involved in it currently) has been found to be important. In addition, during the initial stages, the building and strengthening of mutual trust is crucial and has often been achieved by adopting blurring boundary spanning practices. In this regard, geographical, institutional and cognitive proximity between individuals is conducive to sustainable co-creation, and they would have different impacts upon co-creation outcomes. For instance, cognitive proximity would be more important to generating new knowledge by integrating the knowledge bases of different individuals, while institutional proximity would be more important for addressing specific business and social challenges. It often appears challenging to establish trust between individuals without direct personal interaction, and this is most important in cases where the individuals involved are not familiar with the institutional background of one another. Having trust and personal level interactions increases the partners' commitment to co-creation. As co-creation evolves, it might be possible that, due to the changes in the internal or external environments, the interests of some organisations with which individuals are associated concerning co-creation may decrease. Yet, past research has found that relational proximity and associated trust minimise such negative impacts. The individuals' capabilities of engaging in co-creation are also determined by institutional characteristics such as scientific and educational expertise, the cultivation of entrepreneurialism, opportunities for training, the degree of autonomy, and management capabilities of the institution with whom they are engaged as well as the surrounding environment, comprising potential partner companies and institutions, support received from the public funding system, and political strategies (Meissner 2017).

The involvement of multiple partners who co-create shared value may give rise to *intellectual property (IP)* issues. Whether a clear IP strategy for co-creation would be critical depends upon the stage of co-creation, the types of actors involved in the initiative and the type of objectives (De Silva and Wright 2019). Arranging IP agreements in advance, however, is a sensitive issue, and should thus be devoted careful consideration. For example, companies in science-based industries – such as pharmaceutical companies – have greater reliance upon patents. Yet, some pharmaceutical co-creations seem to allow any partner in the collaboration to commercialise IP, but as their co-creation partners are coming from research organisations, the only party that has the potential to commercialise the discovery is the pharmaceutical company. As researchers in such co-creation projects are provided with opportunities to publish the majority of their work, they are satisfied with the pharmaceutical partner commercialising the IP. Hence, partner selection is considered as a way to manage potential IP-based conflicts. In some instances, it has been found that during the early stages of the co-creation, open or informal IP rights are used, while, at a later stage – when the co-creation outcomes can be clearly defined – the partners agree upon the distribution of formal IP rights. All in all, the adopted IP strategies influence the types of co-created value.

Digital infrastructures such as platforms, technologies, communication mechanisms, remote working facilities, data integration, and sharing mechanisms that enable actors working remotely to integrate their resources to co-create value play a significant role as essential components in creating common goods.

3.3 Social and Business Values Generated by Co-Creation: Relevant Dimensions

The most significant feature of co-creation is the simultaneous generation of dual value. In this context, 'value' means gains – in the form of business and social benefits – by parties collaborating in co-creation as well as their key stakeholders (i.e., those for whom the involved parties intend to generate value and who benefit through spillover effects), the generation of which is not possible by working independently or other forms of innovation. What is unique about science-based co-creation is the combination of social and business missions creatively with science so that each initiative is able to generate both social and business benefits. The three main dimensions that characterise the types of dual value created are the scope of innovation, its reach and its prominence.

First, science-based co-creation generates dual value involving a different scope of innovation, ranging from technological development to capability development. Co-creation may generate value in the form of technology (e.g., products, machines, equipment, software, and materials), knowledge (e.g., handbooks, training programs, data bases, property rights/patents, published research reports or articles, construction plans/blueprints, and market knowledge), know-how (e.g., recipes, algorithms, protocols, experiments' results, and scientific process), and capabilities (e.g., entrepreneurial, innovative, scientific, managerial, and relational, capabilities). Each initiative results in a combination of tacit and codified results. Tacit knowledge is developed through continuous interaction over the course of collaboration and forms a long-term spillover between the individuals and organisations involved. Since the innovative pathways for these various forms are different, the effect of the determinants of co-created value would depend upon the scope of innovation.

Second, the resulting value could reach either a broader or more focused group of recipients. For example, a corporate accelerator or an open lab could adopt strict criteria for selecting start-ups and researchers, respectively, with whom to collaborate, thereby generating value for a select, focused group of individuals (Pauwels et al. 2016). At the same time, a social innovation lab could be open for many actors to join, thereby generating broader value for all parties involved (Pollitt and Hupe 2011). Yet, even though partner selection involves strict criteria, when the scope of the challenges a co-creation initiative addresses is broader (e.g., developing the fin-tech industry or pharmaceuticals for neglected diseases in the developing world), co-created value might reach a broader group of recipients.

Third, while each co-creation initiative generates both social and business values, these values are not commensurable and produce impact on different temporal horizons. For instance, a fin-tech accelerator is likely to generate business value by improving the profitability of the financial services sector (von Hippel and Krogh 2006; Prahalad and Ramaswamy 2004; Payne et al. 2007). At the same time, it may also generate 'indirect' social values in the form of fulfilling capability/skill gaps in the financial technology sector, thereby strengthening the relevant competence base of a location which may turn out to be an important element of local knowledge-intensive business investment related decisions. Hence, different co-creation initiatives could have different positions on the dual value spectrum, with one end concerning predominantly business value creation (with indirect social value) and the other end focusing upon social value

creation (with some indirect impact upon business value). Here, what is important is understanding that even though a science-based co-creation effort is aimed at generating social value, it is important to consider adding a mechanism generating business value so that the initiative has operational sustainability (i.e., rather than relying on donations/grants).

4. Discussion and Policy Implications

For science-based co-creation, as in every innovation project, objectives, resources, and implementation are the key issues. We hereby summarise the specific features emerging from the proposed framework of science-based co-creation that call for policy intervention and generate practical implications in the design of policy initiatives.

Building upon the conceptual framework presented in this paper, we aim at furthering our knowledge of science-based co-creation and our understanding of the public policy support required for sustainable success and associated practical implications. We have argued that science-based co-creation involves individuals from different organisations – ranging from universities, businesses, governments, intermediaries, and society – closely working together to increase the use of science, which simultaneously generates value for businesses and society. This clearly contains an element of significant policy interest, especially in relation to policy initiatives that target social value creation by enhancing the interaction among science, industry, and society in the broadest sense (McCann and Ortega-Argilés 2003; Mustar and Wright 2009; Andersen et al. 2011; Grillitsch and Asheim 2018).

With the increase in the influence of factors and the numerous interactions in the innovation process, the need for revising Science, Technology and Innovation (STI) policy initiatives is growing (Shove and Walker 2010), but it is essential to align the current framework conditions with co-creation thinking in a consistent and coherent way.

The traditional STI policy mix developed into common practice in many countries (Martin and Trippel 2014; Russo and Pavone 2021). Competitive intelligence and the related benchmarking exercises eventually led to stagnation in designing new instruments enhancing the current STI policy mix (Martin et al. 2011; Isaksen and Karlsen 2011; Magro and Wilson 2019). As long as the new STI policy instruments remain coupled with intelligence, it is rather unlikely that approaches like co-creation will gain significant attention within the STI policy mix design. Even more, science-based co-creation is rather complex, that is, it appears to be an interaction model that goes beyond the transfer of knowledge and technology between science and industry and can unfold in several directions with a number of unpredictable feedback loops that can either enhance or reduce the impact of policy support (Tödtling and Trippl 2011). Therefore, policies aiming at enhancing science-based co-creation will not be a substitute for other forms of innovation policies, such as those supporting internal R&D activities or knowledge transfer or exchange, but as a mechanism often used to address challenges and/or capitalise on opportunities that one is unable to achieve using other mechanisms of innovation (Nauwelaers and Wintjes 2003; Tödtling and Trippl 2005; Hodson and Marvin 2012; Shove and Walker, 2010). In addition, the evaluation criteria for related STI policies should be carefully defined with a focus upon the systemic and longer-term impact and the behaviour they are aimed at (Edurne and Wilson 2018; Morisson and Doussineau 2019).

Below we will discuss: (a) which areas of intervention need policy emphasis, (b) which policy objectives are relevant, (c) which incentive mechanisms and organisational changes should be

designed for enhancing the engagement of public research and university in science-based co-creation.

(a) Areas Needing Policy Intervention

The essence of science-based co-creation requires a systematic, multi-disciplinary, interactive approach involving both market and society interactions. Specific partnerships in the network of agents involved in a co-creation project act as catalysts, while other spillovers of industry-related partners or other research centres in the network are enhanced by the company's own innovation ecosystem. Hence, policy initiatives may be aimed at creating or encouraging the creation of specific partnerships for co-creation in order to resolve socio-economic challenges. In particular, public policy should support the building of reputation and trust between the partners along the various dimensions that might be more effective in various contexts/ecosystems.

Supporting science-based co-creation potentially becomes a target for STI policy that complements supply-driven policy instruments especially aimed at enhancing knowledge and technology transfer and developing absorptive capacities. This implies changes in organisational governance, attitude and cultural values in public research and university. Much is said about concerning labour skills and competences, mobility and career paths, but not about the implications for the needs to change the organisational context. The human dimension of innovation by means of organisational governance paired with organisational attitudes and cultural values toward innovation remain accepted as important innovation drivers but are not looked upon much in academic management and policy design and implementation debates. In practice, a departure is needed: from performance-based indicators of selected research outcomes towards a set of dimensions that we will discuss in what follows.

In the conceptual framework outlined in this paper, it is clear that international STI collaboration may play a key role in science-based co-creation for addressing the global challenges identified in the SDGs. However, this implies that national and regional policies should be designed in order to make co-creation possible and, accordingly, that appropriate performance schemes should be defined, which we discuss below.

To conclude, in a policy framework supporting science-based co-creation, three other critical dimensions must be considered to reduce/avoid the mismatch between policy effort and its impact. First of all, with regard to the impact of science-based co-creation, there is significant potential for the timely transfer of research results into commercial applications as well as the vitalisation of regional networks with national and international reach. Therefore, it is important to better understand how, under what circumstances, and with which support, co-creation should be used for commercialisation and for system transformation. For instance, co-creation for commercialisation could be led by companies, whereas those for systemic transformation could be led by governments. Secondly, a significant shift from a short to a long-term focus must be considered. It emerges that there is a significant barrier to establishing co-creation because of both the high transaction costs occurring in their early stages and the rather short-term focus of companies. This might hamper the potential for synergies that would not be fully developed and be exploited due to the tendency of companies to employ a controlling mechanism in co-creation, which to some extent is counterproductive to the long-term nature of building and using synergies. Thirdly, the increased emphasis upon co-creation initiatives in recent years as well as its uniqueness in dual value creation, compared to other forms of interactions, have intensified the need for new STI policies in taking an ecosystem perspective to support joint activities as a strategy to generate social and business values.

(b) Policy objectives

In line with the policy framework outlined above, policy initiatives that are specifically needed for science-based co-creation should enhance a variety of styles of initiatives targeting specific objectives. While public policy actions introduced in recent years have encouraged and supported collaboration (e.g., through the configuration of a partnership, by companies' size, sector, or location), more needs to be done to facilitate different forms of science-based co-creation style initiatives.

First of all, STI policies should offer opportunities to develop and use certain dynamic capabilities, including relational capabilities, communication capabilities, and operational capabilities, the use of which may change over the life cycle of the co-creation project (i.e., capabilities required at the initial stages may vary from those required at later stages).

Secondly, STI policy initiatives need to promote the longer-lasting cooperation of various subsystems and all eligible players, namely research institutes, universities, small and large businesses, innovation intermediaries, local and regional communities, and associations. This style of cooperation would enable the generation of more value from ecosystem-based co-creation.

Thirdly, STI policies need to provide conditions allowing public organisations and public sector employees to engage in co-creation, by defining all related rules and norms to be set for the effective involvement of all the agents taking part in the project.

Fourthly, in science-based co-creation, partners decide the level of openness required to achieve the objectives of co-creation. Although they do not require that all partners be fully open with each other, the bundling of resources and institutional cooperation allow for the targeted exchange of knowledge and inspiration between basic and applied R&D and the resulting synergies. In such a framework, the reputation of the institutions involved is essential for trust building and open exchange between the partners. In order to support the building of reputation and trust between the partners that have no previous experience, allowing them to seize those dimensions in their collaboration, policy instruments have to be tailored to reduce uncertainty, for example by pooling a minimum amount of resources to be used as a guarantee of sharing risk in the medium term. In addition, policy instruments can target specific free rider behaviour and allow the sustainable use of competences to be mutually developed.

(c) Incentive mechanisms in research and university

The incentives mechanisms for individual researchers in the public research system are complementary to the policy objectives recalled above. The institutional framework for managing universities and research institutes needs to be rethought with the aim of empowering people working at public organisations to be engaged in science-based co-creation projects. The present indicators and measurements of researchers' engagement target only research outputs that can be measured (in the short term). Performance-based management uses indicators targeting the measurable research outputs of individual researchers and the organisation they belong to. The current predominant use of indicators for the science and research base (number of scientific articles, citations, patents, etc.) clearly misleads institutional management and hardly creates incentives at the individual level for researchers to contribute co-creative activities.

In addition, the current measurable indicators do not reflect the eventual spillovers for the economy and society. In order to design effective and impactful co-creation initiatives and generate significant spillovers, accompanying policy measures need to take these into account. Therefore, an urgent need arises to develop metrics for the intangible dimensions in the research and

science community. This is much in line with the demand to understand research and innovation culture. The latter is frequently considered as a black box that is somewhat in place but never fully understood.

The long-lasting implementation of evaluating public researchers' and scientists' performance has caused a mindset change that allows the individual focus upon meeting performance indicators, thereby targeting resources towards related activities. This behaviour is juxtaposed to the nature of science, at least partially, as this is not quantifiable *ex ante* in terms of impact. Furthermore, STI policy measures have to consider objectives, resources, capabilities, business models and multiple values as central elements for co-creation projects. Such a policy framework has to carefully integrate specific measures to promote academia towards co-creation. Accordingly, it is necessary to design a coherent innovation policy framework for performance evaluation and to define appropriate incentive mechanisms within public research system.

Moving on to international collaboration, incentive mechanisms become an even more critical issue. Although largely advocated by national policies, there still remains a clear weakness in the globally agreed agenda upon policy initiatives which expect each country's individual contribution to addressing SDGs. Performance measurement schemes are still mainly aimed at detecting impact on local, regional, and national ecosystems, with no consideration for the need of international level co-creation to address global challenges. If the scope of co-creation involves global challenges, national selfishness needs to step back, and strong support throughout the activity by political means is needed. This involves an agenda agreed upon among different national and regional policymakers at different levels: experience from responses to SDGs shows that global political commitment is supportive of science-based co-creation, but more needs to be done to implement related activities.

The reasons why there is little progress on the SDG-related policies are manifold, including the strong competition of national research systems around the world, which should rather attempt at co-creating globally meaningful dual value. The current joint international effort toward STI amid the COVID-19 pandemic might pave the way for a new strand of international co-creation initiatives addressing global challenges. Hence, it is important that these aspects are considered, when designing performance evaluation and incentives of policy initiatives supporting science-based co-creation.

Evaluation practices/regimes of the impact of STI policies built on classical evaluation approaches using input-output assessments hardly open the black box of the underlying business models and operational approaches. This becomes essential when co-creation must be addressed by STI policies. More importantly, it is likely that social and business values will be generated at different times. For instance, an initiative with predominant business value creation is likely to generate significant social value in the long run. Therefore, having a short-term focus might hamper the willingness of companies to engage in more strategic, long-term co-creation initiatives. Hence, the evaluation criteria for such policies should be carefully defined with a focus upon the systemic and longer-term impact and behaviour they are aimed at, and any other significant practice should be explored, thereby supporting innovation in policy initiatives.

5. Conclusion and Further Developments

For many years, the transfer and exchange of knowledge and technology between academia and industry have been discussed as an important means for generating commercial value. The underlying rationale for such collaboration is that knowledge and technology from academia

lead to firms' competitive advantages. While these past studies have made good progress in terms of highlighting business impacts and their determinants, we lack knowledge on how a science-based collaborative approach simultaneously generates social and business values; our paper sheds some light on this subject.

This paper focuses on a specific form of collaboration known as co-creation. We make an original contribution by highlighting the unique features of science-based co-creation in comparison with other related domains of literature, which provides an opportunity to enhance our knowledge on interactions between individuals associated with different organisations, who devote and integrate complementary assets to simultaneously generate social and business values across science, technology, and society, which a single party is unable to deliver independently. It is apparent in our paper that past research on industrial districts, clusters, innovation systems, Triple Helix/Knowledge Triangle/Quadruple Helix, open innovation, university-industry relationships, R&D collaboration and civic universities or *sustainable/social co-creation* have not placed enough emphasis upon science-based co-creation and its determinants. Against this backdrop, our paper provides a foundation for future empirical work and for the design and implementation of policy measures needed to support science-based co-creation. Examples of diverse co-creation activities, in their many different forms, can be found in various areas of economic, societal, and environmental challenges.

In this paper, we argue that in order to fully outline a conceptual framework that would facilitate the analysis of science-based co-creation, it is necessary to make explicit the heterogeneity of its underlying mechanisms and to single out how to enhance its effectiveness in achieving specific organisational/individual objectives, which would in turn improve our understanding of the government and policy support required for the co-creation success. We discuss that while co-creation initiatives simultaneously generate social and business values, these are multidimensional in terms of the scope of innovation (i.e., different types of innovation ranging from technologies to capabilities), reach (i.e., whether the value reaches a broader or focused group of recipients), and prominence (i.e., the balance between social and business values). Therefore, co-creation initiatives are heterogeneous depending on the type of social and business values co-created. We then discuss three types of determinants of value generated, namely, the decision to engage in co-creation, inputs for co-creation offered by actors, and the management of co-creation. It was evident, first of all, that the criteria used by individuals and the organisations with which they are associated influence the decision to engage in co-creation (as opposed to other forms of innovation/value creation such as internal R&D, knowledge transfer, and knowledge exchange) and further influence the types of actors involved in a specific initiative, resources offered by them for the initiative, and the objectives of the initiative, which in turn impacts the types of value co-created. Second, on the basis of the actors involved in a co-creation initiative and their goals, the types of resources offered would vary, which will influence the types of created value. Third, we also discuss key factors that would affect the co-creation process and its success. For the successful implementation of co-creation cooperation, common interests and complementary skills are a key prerequisite.

While our conceptual framework allowed to identify the key determinants of co-creation, it is apparent that significant knowledge gaps remain regarding how these determinants influence the dual nature of value co-created and which specific policy instruments should support science-based co-creation and what metrics should be adopted in comparing policy measures.

Building on our conceptual framework, we discuss the rationale for public interventions and the critical dimensions of policy implementation and assessment. Policy design aiming at sup-

porting societal challenges through science-based co-creation should address incentive mechanisms and organisational changes for enhancing the engagement of individuals in the public research system.

In what follows, we will briefly discuss some future research issues.

First, with regard to the objectives to be addressed through co-creation, a critical issue is how the involved parties (i.e., businesses, universities, governments, intermediaries and citizens) decide which objectives should be achieved through co-creation and which objectives should be achieved through other forms of innovation (e.g., knowledge transfer and internal R&D) and how their decisions influence the dual nature of co-created value. For instance, if we consider a business, under which circumstances does a business decide to co-create as opposed to using another form of innovation? How would this impact the co-creation process and the resulting types of social and business values? If value creation is at the core of the process, how collaborators combine the different competing goals (e.g., social and business goals) of individuals and organisations involved in co-creation matters, so that all parties would be better-off. In addition, as co-creation evolves, parties and their objectives evolve as well. How they manage such evolutions during the lifecycle of co-creation is a specific dimension of the process that should be studied in the future. It should also be noted that the time taken to generate social and business values may vary. While some initiatives (e.g., co-creation of COVID-19 vaccines) is likely to generate both values at the same time, there are other initiatives in which the generation of measurable social value may take time. Future research should also consider this time dimension, especially when considering the individual and organisational objectives to engage in co-creation.

Second, mobilised resources must take into account both tangible and intangible inputs: how would parties involved in a co-creation process decide upon the best mechanisms to integrate those resources? Each party would bring different types of tangible and intangible resources and it would be interesting to investigate how they make decisions on ways to integrate different resources and how this would impact the types of social and business values co-created.

Third, operational models, capabilities, and practices shape the actual unfolding of any collaboration process, but it is possible that general training toward the attainment of capabilities and skills most required for co-creation projects would be desirable. The strategies they adopt in enhancing the pace and direction of such processes might impact the outcome of co-creation. Firms might be able to use co-creation as an opportunity to train staff with the relevant skills and capabilities that hold value for a firm's future. How can one do that, and who could train people for co-creation? How would these capabilities evolve during the lifetime of co-creation? Deepening the knowledge about the operation models of co-creation appears important in all respects. Studies undertaken so far follow more or less classical evaluation approaches with input-output assessments but hardly open the black box of the underlying business model and operational approaches.

Last, but not least, in order to design effective and impactful science-based co-creation initiatives and to generate significant spillovers, accompanying policy measures must be taken into account. This in turns requires an effort for reshaping not only the conceptual framework for designing policy measures but also for creating the information base related to innovation policies supporting science-based co-creation: new indicators, metrics and measurements are needed for designing, implementing and evaluating more effective innovation policies which also should target organisational changes.

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