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Perspective

Designing Responsible Innovation Ecosystems for the Mobilisation of Resources from Business and Finance to Accelerate the Implementation of Sustainability. A View from Industry

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ABSTRACT

The idea of Responsible Innovation, which deals with delivering economic profit and sustainable value to all stakeholders, is gaining wider acceptance as innovation is seen as a holistic process of delivering impacts valued by all stakeholders, i.e., society, users/consumers, and shareholders. Implementing the idea of Responsible Innovation requires an anticipation of the expectations of, and impact on, all stakeholders, the trends in regulation, and an ability to integrate continuously the latest scientific findings. Due to the financially risky nature of the innovation process, industry as the main provider of innovation must play an active and leading role that must be balanced with its fiduciary duties. Implementing Responsible Innovations is therefore a collaborative process between industry, government, academia and society, each playing a critical role in upholding the “4 gears” of an innovation ecosystem that we present here for discussion. The learnings from the failure to fight climate change and from game theory can be used to design such an ecosystem that embeds the necessary incentives to attract innovators and investors motivated to act responsibly. In this perspective paper, we present the views from innovation practitioners from industry on the different elements and typical present shortcomings of such an innovation ecosystem and we make proposals that should be addressed in order to generate innovations that truly deliver benefits to all stakeholders and train the innovation managers that will enable them.

KEYWORDS: responsible innovation; sustainable finance; innovation ecosystem; fiduciary duty; impact assessment; sustainability

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ABBREVIATIONS

CSR, Corporate Social Responsibility; EIRMA, European Industrial Research Management Association; ESG, Environment, Social and

Governance; EVA, Economic Value Added; GAAP, Generally accepted accounting practices; GRI, Global Reporting Initiative; IA, Impact Assesssment; IPCEI, Important Projects of Common European Interest; LCA, Life Cycle Analysis; PRI, Principles of Responsible Investments; RI, Responsible Innovation; RRI, Responsible Research and Innovation; SDG, Sustainable Development Goals; TRL, Technology Readiness Level; WBCSD, World Business Council for Sustainable Development

INTRODUCTION

There is a widespread view that our model of innovation must be adapted to make it more responsive to major societal challenges, to better translate the progress of science and technology and new business models into long lasting benefits for citizens and users (who can be consumers or customers) of innovations. This is what the concept of *Responsible Innovation* is all about. This paper reflects the work of a taskforce on Reponsible Innovation undertaken by members of EIRMA [1] with extensive experience of managing innovation at a senior level in industry from diverse sectors. The taskforce acts both as a think tank on how to address industry's responsibilty for long-term impacts of its activities and as an interlocutor with policy makers and reseachers seeking to do the same.

The core of the notion of Responsible Innovation is about generating sustainable value for all stakeholders, society, government, users, and shareholders, corresponding to the "*People, Planet, Prosperity*" triad. It is merging with the Sustainable Finance movement that is aiming to mobilise financial resources to generate positive societal and environmental impacts. It is also expanding the idea of CSR (Corporate Social Responsibility) that traditionally has focused on compliance to good social and environmental practices, regulations and standards. The matter of impact assessment, which relies on scientific methodology and its integrity, is central to Responsible Innovation.

If Responsible Innovation is the engine of this transition, Sustainable Finance is the fuel: both have to be mobilised to generate and capture value. Responsible Innovation cannot be implemented in isolation. To flourish, it needs to be anchored in an innovation ecosystem of stakeholders comprising government, citizens, academia and business, each playing its role and assuming its responsibility.

This paper will discuss what are the values for each stakeholder, how impact of innovation and its alignment to stakeholder values has to be measured and assessed, what are the necessary trade-offs between these stakeholders, and how they can and should partner within an innovation ecosystems to mobilise resources and accelerate the transition towards sustainability.

THE ELEMENTS OF RESPONSIBLE INNOVATION: GENERATING VALUE TO ALL STAKEHOLDERS

In this section, we discuss the process of innovation and generation of value, how it differs from research, how values differ among stakeholders and how to align this process of generating value to stakeholder expectations.

Responsible Innovation: Review of the Status of Academic Research and Why the Idea Should Be Revitalised

The idea of Responsible Innovation is rooted in an attempt by the EU and academia to design research and innovation programs that meet societal acceptance. RRI (Responsible Research and Innovation) has been a topic of research for the past decade or so. Initially, it addressed both responsible research and innovation (therefore the acronym RRI), but later has taken to addressing innovation specifically. The state of the art of the genealogy of RRI was discussed in a literature review by Lubberink et al. [2] presenting the standard framework of RRI, along the four key elements of anticipation, reflexivity, inclusion and deliberation, and responsiveness.

This framework for RRI was criticised (i.e., by V. Blok and V. Lemmens [3], with the view that research on RRI is focusing on academic R&D environments, therefore not addressing the reality of industry and business, where innovation takes place. Among the issues listed by Blok and Lemmens to be addressed we have:

- The question of addressing conflict of interest among shareholders;
- The limited transparency among stakeholders with asymmetry of information;
- The unpredictability and uncertainty of outcomes and unexpected consequences.

Such issues are obstacles to attaining a sound trajectory of innovations that are appealing to all stakeholders. They make the existing concept of Responsible Innovation “questionable, uncritical and naïve”, thus not practicable, and call for a radical transformation of its framework.

While this model of RRI ultimately failed to materialise and become a guide, either for the design of research programs, or for the design of innovation for industry, there are calls for “mainstreaming RRI” into Horizon Europe (see joint declaration [4]). There are also issues with the present RRI concept that must be addressed, if the idea has to gain traction. The aim of our publication is to contribute to a new direction for a research agenda on Responsible Innovation.

Elements for an Improved RRI Framework

A better understanding of four concepts could contribute to this redefinition of RRI:

- The value creation is viewed as an innovation process perceived differently by various stakeholders;
- The impact assessment, relying on metrics for societal value generation (or destruction!);
- The freedom of action of the innovator with limitations dictated by its fiduciary duty;
- The innovation ecosystem as a collaborative framework to generate value shared by all and to arbitrate tradeoffs.

Additionally, Responsible Innovation and Sustainable Finance—both processes that can be qualified as "work in progress" because not yet crystallized in standard practices—share common objectives, and therefore should share common methodologies and definitions.

Academic research on Responsible Innovation has so far failed to generate models that could be implemented in R&D operations, most probably because they do not align with current practices and constraints. To be more successful, such frameworks must adopt current practices in innovation management, extend to whole innovation ecosystems and integrate practices of Sustainable Finance.

At a time of transition to a new reality as a consequence of the corona virus pandemic, it would be a big mistake to give up on the idea. This would not only fail citizen expectations, but also those of shareholders.

Our paper will elaborate on these different points.

Responsible Innovation Is about Generating Sustainable Value

The term "innovation" has many definitions which can be a cause of confusion. It can be defined as "a new idea or method, or the use of new ideas and methods" (Cambridge Dictionary), or "a new idea, method, or device" (Merriam-Webster). The problem with these definitions is that they are not conducive to extending the concept to Responsible Innovation. They could relate just as well to invention and tend to result to a conflation of the two very distinct processes of research and innovation processes (see below).

A more applicable definition of innovation is "The process of translating an idea or invention into goods or services that create value or for which customers will pay" (see www.businessdictionary.com). An innovation is responsible when the value created benefits not only shareholders and customers, but also society, and in such a way that is long-lasting and sustainable. The question of value is therefore central to the concept of Responsible Innovation.

This value has many dimensions reflecting its impact on the various possible stakeholders: on society, on groups of citizens, on segments of consumers, on intermediaries or service providers along the whole supply chain, on shareholders, or for specific users, and in the case of health, on patients, doctors, etc. A coherent way to simplify the analysis of value creation is to cluster these dimensions along the standard methodologies

used to assess the impact of the value creation. We therefore propose a 3-dimensional approach, with: (1) *economic* value (for shareholders), (2) *societal* value (or value to society as a whole) and (3) user (i.e., *consumer or customer*) value, each being perceived and assessed differently. An innovation that destroys value to society (e.g., having negative environmental impact, destroying jobs massively, or even putting our fundamental rights or health systems at stake), to consumers (e.g., generating harmful side-effects or dubious or misleading product claims), or does not generate economic profit to shareholders, will probably not be sustainable.

We therefore define an *innovation* as *responsible* when it generates a value that is relevant and sustainable for all stakeholders: society, users and shareholders.

Innovation Is Different from Research, and Is to a Large Extent Driven by Industry

Due to misleading definitions (see above), research and innovation, that are two very different processes, are too often conflated, with the consequence that the conclusions of academic research on RRI, and later RI (Responsible Innovation) were not really applicable to the innovation process as implemented in business and industry (see also above, criticism of RI).

We propose to clarify these two concepts (Figure 1) [5]. Public funded research (basic, applied) provides the foundation on which industry draws for innovation. Research is the process of generating new knowledge, mostly driven by academics or researchers and made known through publications. Research may be driven by curiosity or commissioned by governments, policy developers or industry. Innovation on the other side is the process of creating value by using existing knowledge to create a business opportunity, or in the case of social innovation, a new way of solving a problem. Innovation is associated with financial risks and is typically driven by business [6] seeking opportunity to create shareholder value. The assessment of the value of an innovation is always related to its context and will often, but not always rely on knowledge from research to substantiate evidence-based policies and claims on benefits to users or society. To play its role, research must generate knowledge that is reliable and communicated with integrity. The widely reported crisis of reproducibility affecting science, and the mismanagement of scientific debates and controversies, such as in the cases of tobacco, sugar, and glyphosates, are major reasons for concern, and these two issues have the potential to erode the translation of achievements of research into benefits to society, shareholders and consumers [7].

Hence, the main *driver for research*, which is supportive of Responsible Innovation, *is integrity*, either in the generation of knowledge or in the communication of its results through scientific debates [8].

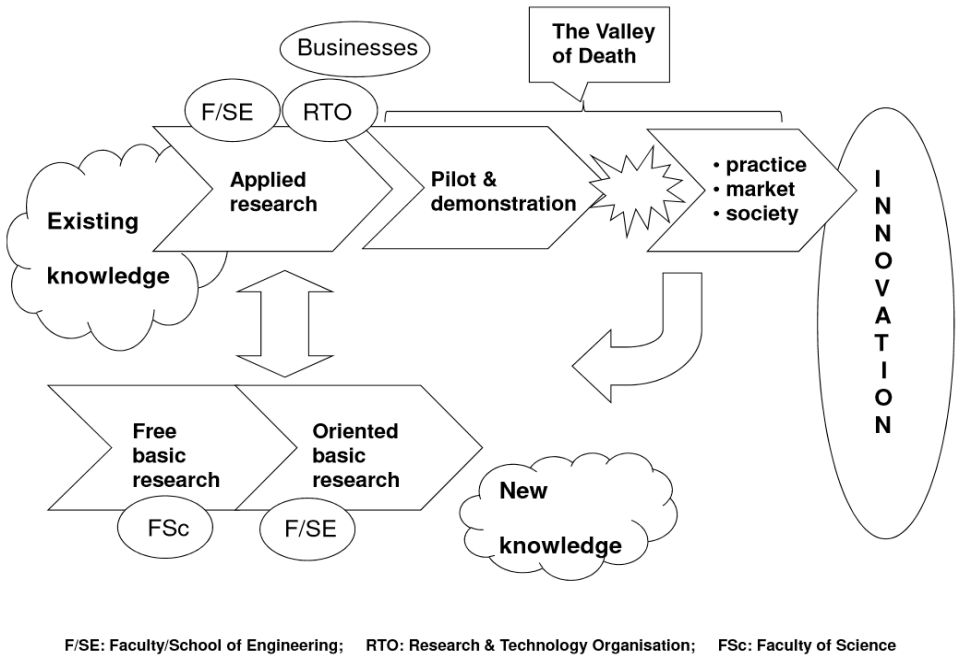

Figure 1. Innovation, the generation of value, is different from research, the generation of knowledge, and is largely driven by business and industry.

A Model of Valuing Innovation along 3-Dimensions

Assessing the value of an innovation is the delicate art of assessing its impact (that we discuss in more detail below), which is often ambiguous and difficult to quantify because it is context dependent and perceived differently by different stakeholders. Such differences of perception necessarily lead to a multi-dimensional model of valuation of innovation. While different approaches may be selected for a clustering of these dimensions, we propose a 3-dimensional model of valuation reflecting the current tools and practices that are used to measure the benefits of innovation on the 3 main actors of this innovation ecosystem: shareholders for economic value, citizens for societal value and users/customers for consumer value (Figure 2).

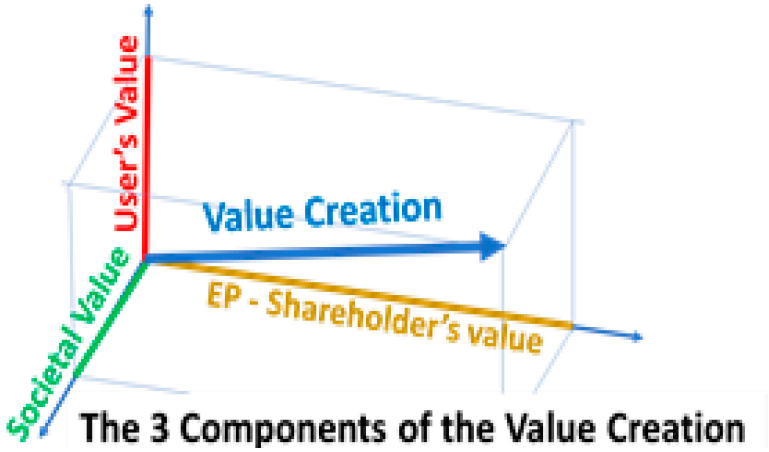

Figure 2. The 3-dimensions of value creation: Societal, Shareholders, and Users/Consumers.

- E*conomic value* of an innovation is best assessed through the Economic Value Added, EVA, i.e., the benefit to shareholders from investing in an innovation. Calculating this EVA requires assumptions about the expected revenue stream. An innovation that is expected not to generate lasting revenues for a company will not be launched,
- S*ocietal values* are best captured by the now widely quoted UN sustainable development goals (SDGs), a framework of 17 goals agreed by all UN member nations as underpinning the 2030 Agenda for Sustainable Development [9] that can be clustered along People, Planet and Prosperity, or Society, Biosphere and Economy (Figure 3) [10]. They address relevant societal issues such as education, health, poverty, biodiversity, water, land use, climate and institutions, including here tax behaviour, compliance to local laws, payment of bribes or fair labour practice. SDG's have been criticised for being too broad, with contradictory trade-offs, and difficult to measure [11], but presently, they do represent the most widely accepted framework so far. Innovations that go deliberately against these goals are likely to be rejected on the long term and are probably not going to generate value sustainably, even for the shareholders. While they might be launched, they are likely not to last, and will ultimately backfire.

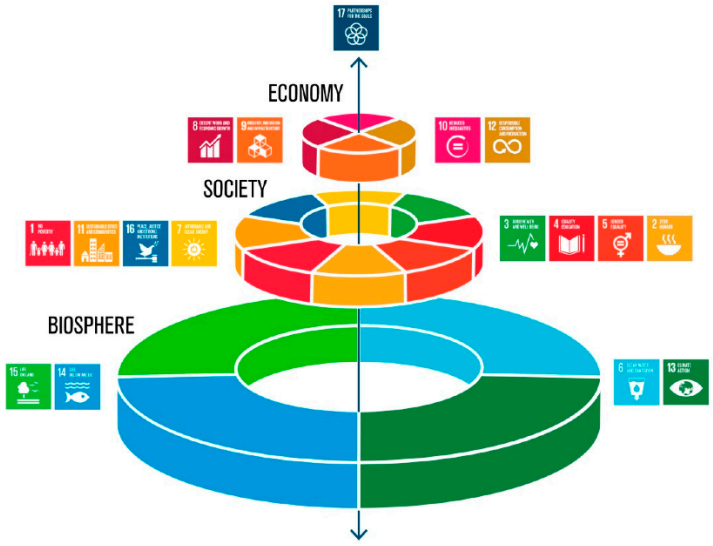

Figure 3. The UN SDG's clustered along Societal, Environmental and Economic Values.

A*ssessment of social and environmental impacts* is as much an art as a science and will require judgment calls based on a sound understanding of the methodology tools and best practices that we discuss below.

Disconnecting economic growth from negative environmental impacts will require trade-offs and policies that foster a *circular economy* and enable a *change of behaviour* in society and consumers.

Additionally, a clear understanding of *what citizens want and value* is a necessary condition to design innovations that translate into societal impacts that fulfil desired values, which are not universal. Several studies,

e.g., the "Moral Machine Experiment" by MIT [12] have concluded that what citizens want and value may differ widely, with clusters of preferences and priorities depending on geography, generations, cultures or stages of economic development [13].

The *value to users* of an innovation (we define *users* as those *benefitting from the functionality of the innovation against any form of payment*, such as consumers for products, customers, or patients in the case of health) is best described by the ratio of the perceived benefit over the money users of the innovation will pay for it. The optimisation of this trade-off is addressed by the methodology of *design thinking* [14], the process of identifying and quantifying these benefits and the price that is acceptable to users. In many cases, the claims of benefits will rely on the knowledge gained from scientific research, which can be biased when the research is not conducted properly and with integrity. Here as well, innovation users will differ widely on what they value and this is why products are targeted at clusters of preferences. In any case, Responsible Innovation to users concurs with the marketing saying that one can fool some consumers all of the time, all consumers some of the time, but not all consumers all of the time.

An innovation that does not deliver positive value on the three dimensions is unlikely to be sustainable. Designing Responsible Innovations is therefore going much further than compliance to rules and regulations. It has to deliver EVA to shareholders, and also contribute positively to the other two dimensions of user benefits and SDG's. It needs not only to anticipate as much as possible the impacts and values it will generate by analysing trends and building scenarios, but also to adapt to new evidence coming from advances in science. Emerging issues visible sometimes only in a late stage of the scale-up phase are best managed through an on-going monitoring supported by "ex-ante" regulations, i.e., addressing critical issues upfront, such as in the development of drugs or the regulations on toxicology.

"Values" Are Not Universal and Impact Assessment Is Context Dependent

There are several issues with the concept of values:

- Quantifying them is often ambiguous. Even EVA assessments, which are based on clear guidelines of GAAP (rely on assumptions such as future environmental regulations or the shifts of public opinion over the whole life-cycle of the proposed innovation that may, or may not materialise;
- Values are not stable and will evolve over time, as a result of changes of perceptions related to new scientific evidences or cultural shifts;
- Additionally, quantifying impacts is a process that requires realistic assumptions along the whole supply chain and over the whole life-cycle, from "cradle to cradle", addressing the source of resources, the

transformation processes, emissions and waste management, and labour practices;
- Finally, as discussed above, what citizens value, and what users value can differ widely along clusters of preferences, without universal norms applicable.

In any case, the impact and the value of an innovation must be considered within the context of the underlying *business model*, the innovation proposition that will address sourcing, financing, manufacturing, distribution, target groups and communication, each step with a clear potential impact on the sustainability of the value creation. Its design is an essential part of the innovation process [15] and will influence the delivery of perceived benefits according to the communication plan of claims or benefits, or the societal and economic impacts which are dependent from, and related to, the type of supply chain.

Managing Stakeholders for Responsible Innovation

Responsible Innovation being about delivering value to all stakeholders, the question of managing these stakeholders with integrity must be handled carefully. The standard methodology for stakeholder's management that was developed by PMI (Project Management Institute) for projects, and which is based on the *stakeholder theory* originally developed by Freeman and co. [16], is fully applicable here, with some adjustments.

Extensive details on the best practices of stakeholder management are captured in the PMIBOK (Project Management Body of Knowledge) (chapter 13th, [17]). In these standards, stakeholders are defined as any people, organisation or groups that can be influenced or impacted by the project. Stakeholders represent a risk if the innovation project is delivering outputs that impact them adversely. Managing stakeholders is therefore a process related to managing risks. These stakeholders must be first identified and mapped, then rated and prioritised (clustering those with a high risk and probability of impact, or vice versa) to get a differentiated attention, and their engagement must be monitored on the basis of a communication plan.

The selection of stakeholder spokespersons (paid or not) is either made by the groups, or by the project management, ensuring that there is no conflict of interest and that they will represent these groups with integrity and authority, something that is rather straightforward for governmental organisations, but less obvious for NGO's or communities.

Several methodologies have been developed to identify and address the needs of stakeholders, but two have become standard practices, albeit in different circles:

1. *Design Thinking* (see also below), a standard practice in industry and business for innovation management focused on identifying and addressing consumers needs along a 5 steps process of (re)defining the

problem, need-finding and benchmarking, ideating, building, and testing. Several guides or handbook are detailing these steps, e.g., at [18].

2. The *quadruple helix model*, a collaborative innovation design model widely applied in regional innovation ecosystem design (described in [19]) involving representatives from all members of society: public authorities, industry, academia and citizens and NGOs, with methodologies such as living labs, service design, and tools such as hackathons, focus groups, etc. It can be considered as a variation of the Design Thinking process which is often regarded as being a good approach in social innovation.

Principles of Sustainable Design Thinking: Anticipating Impacts

Design is an essential part of the innovation process. The standard methodology for the design of products delivering value both to users and the company is *Design Thinking*, which can be extended to *include sustainability*. While the practical application of Sustainable Design Thinking varies among design disciplines (product design, architecture, etc.), they share some common principles [20] and [21], addressing especially environmental impacts through design for circularity, with:

- Use of non-toxic, sustainably produced or recycled materials from nearby, sustainably managed renewable sources;
- Use of manufacturing processes which are energy efficient;
- Design of longer-lasting, better-functioning, repairable products reducing the impact of producing replacements;
- Design of products for reuse and recycling, easy to disassemble so that the parts can be reused to make new products;
- Using life cycle analysis to design more sustainable products along the whole value chain;
- Shifting the consumption mode to the sharing economy, from personal ownership of products to provision of services which provide similar functions.

Social impacts on human rights, labour standards in the supply chain, non-exposure to illegal child labour, and more routine issues such as adherence to workplace health and safety must be considered and anticipated as well.

In the case of innovation, sustainable design must extend beyond compliance, and anticipate expectations from society. *Frugal innovation* is another type of design of products or services that also embeds elements of Sustainable Design Thinking, and is particularly adequate for emerging markets [22].

RESPONSIBLE INNOVATION (RI) AND IMPACT ASSESSMENT (IA)

Responsible Innovation requires the involvement and collaboration of all stakeholders. Therefore, it necessarily deals with *trade-offs*. This can

only be done constructively when the impacts of the innovation on each of the various stakeholders can be quantified, and measured, at least to a large extent. We discuss in this section the delicate and complex art of impact assessment, which can be compared to the "trolley dilemma", that is about a wild running-away trolley that can be directed to kill either one or five persons, a dilemma used to model the decision process facing ambiguities (more on the trolley dilemma in [23]).

Impact Assessment Is at the Core of Responsible Innovation and Sustainable Finance

Impact Assessment (IA) is the process of predicting the future consequences of a current or proposed action or decision [24]. IA, based on natural and social sciences, is at the core of Responsible Innovation, and is always contextual: a product can be sourced from raw materials produced according to best environmental practices, by abiding to labour laws, and with benefits communicated ethically, or it can be produced just the opposite way. At the end, it will be the same product, but the impacts will be vastly different. Because *Impact Assessment is always contextual*, this is also what makes innovation a process fundamentally different from research, which must be assessed in relation to a business model. IA originated from the environmental impact assessment of development projects, but its scope includes now general social and environment impacts. The principles and best practices of IA are captured by the International Association for Impact Assessment (IAIA) [25], but other organisations are also contributing methodologies, such as *Ecosense* [26], ESIA (Environment and Social Impact Assessment), a well-established procedure, or with guidelines for implementation such as those from WBCSD [27], with other examples of best practices from industrial projects [28], or the World Bank [29].

IA typically addresses two items, (1) compliance to national or international regulations and standards, and (2) due diligence in mitigating risks and negative impacts based on state-of-the-art technologies and best practices.

Due to the fact that innovation is an iterative process most often facing ambiguities and uncertainties, a comprehensive and quantitative IA can be a very demanding task. In line with the guidelines of IRIS [30], the selection of the right metrics is essential. These metrics will be refined throughout the development and risk mitigation processes.

It is also necessary to mention that the present trend is to align the format of the IA methodologies to the format of the SDG's.

Issues with Measuring Impacts: Methodologies and Metrics

Measuring impact, especially within the framework of innovation, is as much an art as a science, for several reasons: there is no standardised methodology, databases for manufacturing and distribution processes are generally not comprehensive enough, and the state of scientific knowledge

will change. Several endeavours are in progress to clarify and harmonise the methodologies. Several organisations that are centres of expertise in this area, are aiming at addressing these shortcomings, such as:

- The *IAIA* (International Association for Impact Assessment) [31], mentioned above, with a repository of methods, checklists and references;
- More particularly, the *Impact Management Project* [32], that has pooled a few thousand experts to propose a methodology on impact assessment;
- *IMPAAKT* [33], a kind of WIKI platform collecting focused and factual impact assessments by certified volunteers, and also proposing on-line training on IA.

The *methodology* of IA is based on the chain of events of the Theory of Change [34]: a change is measured by its *impacts* with long lasting effects, resulting from *outcomes*, resulting from *outputs*, resulting from *activities*, triggered by *inputs*. The Theory of Change, originally used in development policies, is a methodology about defining goals, specifying the means needed to reach them, and articulating the necessary resources to reach them. It is clearly separating actions from achievements. Outcomes must be defined in measurable terms, using metrics, and supported by interventions (Who will do what, how, and when). The way outcomes will influence stakeholders, the impacts, is the ultimate goal of change, or here, responsible innovation. Therefore, the assessment has to measure impacts, the last event of the chain, and not, as is often done in reporting, inputs, the first one, that is often just stating good intentions, a euphemism for green washing.

IA must be clear on the real contribution of the chain of events. This means that an IA must identify the true contribution of an innovation and also clarify what would have happened without it. For this, an IA has to be specific as well, along the 5 dimensions of impacts: *what* is delivered, *who* is generating it, *how* much was produced, what is the exact *contribution*, and what is the *risk* that it does not hold in the long term (sustainability of impact).

Quantitative measurement of impacts is critical to handling trade-offs for the transition towards a sustainable economy, but no framework similar to the GAAP is yet accepted. Therefore several initiatives are presently in progress, such as the WEF, proposing metrics based on the SDG's clustered along 4 pillars, i.e., Governance, People, Planet and Prosperity, and relying on the GRI (Global Reporting Initiative) that has just recently issues new standards [35].

Scientific Integrity, the Foundation of Impact Assessment for Responsible Innovation

The assessment of impacts on consumers and users, especially for breakthrough innovation, will rely to a large extent on advances in

science, and specifically life science for health or pollution, or social sciences for evidence-bases policies such as fighting abuse of drugs or alcohol or obesity. Additionally, to a large extent, the scientific methodology is the foundation of the major outstanding achievements of the last two centuries such as improvements in health, life expectancy, communications, mobility, etc. However, the pressure to accelerate the R&D system has triggered several challenges [36], two of them requiring a special attention.

- The well documented *reproducibility crisis* [37] is affecting trustworthiness of life and social sciences publications particularly. This crisis has very serious consequences, as it may erode the credibility of the assessment of the benefits on users and the impacts on society, creating doubts on the usefulness of innovation and of policy developments;
- Furthermore, this crisis is fuelling a *crisis of trust in experts*, and in the consistency of the debates and the *controversies* [38] that are necessary at the birth of any innovating streams of ideas. This creates the risk that achievements stemming from the scientific methodology could get stuck in the quicksand of doubts, hampering their translation into beneficial innovations and policies.

Some Issues with Responsible Innovation

Beyond the reproducibility crisis and the lack of consistency of IA, the concept of Responsible Innovation is also facing the following issues:

- *Future vs. near term value generation*, or the dilemma of investing for immediate benefits or future generations. Theoretically, the present low interest rates should favour long term options.
- The *prisoner's dilemma* (see below) and personal responsibility: ideally, we would expect that individuals (or corporations) would act responsibly and adopt adequate behaviour to ensure that future societal interests are protected, but this is not what is observed. Consequently, an adequate regulation framework is necessary. When this framework is too stifling, it will throttle innovations that could benefit to the society and the users.
- The *ethical stance of the leadership team* is also fundamental. Examples abound that in difficult times, but not only, flawed management may be tempted to cut corners to maximise benefits in the short term, even at the cost of not-compliance or jeopardising long-term shareholders interests.

RISK MANAGEMENT, LONG TERM IMPACTS AND THE FIDUCIARY DUTY FOR THE XXI CENTURY

Innovation is by its nature a risky business that must be managed and rewarded adequately if we want it to strive and address our societal issues as well as the pursuit of profit. In this section, we discuss the types of risks

in innovation, how it can impact the valuation of corporations, and what it means in terms of corporate responsibilities or fiduciary duties.

Risk Management, Central to Innovation, and the Role of Business

Innovation is about charting new territories in which not all latent risks can be either anticipated or prevented. The biggest risk society can take is to not innovate at all. Statistics differ on the failure rate of start-ups or new products or services, with 60% to 90% reported to disappear after 5 years. Among the many reasons behind this situation, beyond unrealistic initial expectations are: regulations or citizens' priorities may change, science may trigger better, more competitive propositions, the expectations and needs of society or users may have been misunderstood, or may have change in the meantime. Additionally, the costs for launching a new product have increased substantially in the last 20 years, reflecting the ever-increasing requirements of compliance and market complexities, and necessary investments for product launch. Typically, the cost for launching a product can be 100 to 1000 times the cost of the initial applied research, with many pitfalls on the way that may kill the project. This long journey from product ideation to a product being taken up by the market is often referred to as *the valley of death* (Figure 4) [39]. Crossing this valley requires sound competencies in risk management, in understanding the business environment, in agility to react to unforeseen events and in putting up with long-term return on investment.

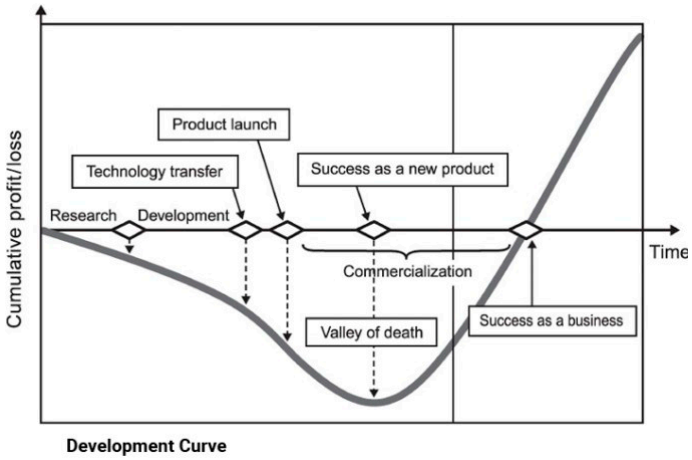

Figure 4. The valley of death- the financing gap before returns are made

Operating in this risky business environment requires continuous adjustments of the assumptions underpinning business plans. Effectively implementing innovation means carefully monitoring emerging risks and responding swiftly with appropriate action. This is labelled *Agile Innovation Management*, now considered to be a core competence in innovation management. The necessary governance structure required for successfully managing risks and generating value from innovation

seems to indicate that historically, business has been the most successful among all players driving the innovation process.

Responsible Innovation for Business: Fiduciary Principles and Beyond

Fiduciary duty is about ensuring that those managing money do so in the interest of the owners. This duty is often, but wrongly, used to justify that decisions must solely focus on maximisation of profits, leaving aside other criteria. However, more recent research (see also below [40]) has demonstrated that corporations that integrate a long-term focus in their strategy perform better, as they incorporate broader elements, such as societal impacts, in their risk management. On the other side, fiduciary duty will also set the *limits to the trade-off* that a company can afford between maximising EVA and remaining competitive and going beyond sheer compliance with existing regulations (see Fiduciary duty and prisoner's dilemma, below).

Companies Market Valuation and Intangible Assets: Redefining Fiduciary Duties

The structure of the market value of an enterprise has dramatically shifted in the last 50 years. While in the 1970s, 85% of the market value of a company was based on tangible assets at booking value, such as equipment, real estate, etc. this is now down to 20%, with the rest based on intangible assets such as patents, brand value, goodwill, etc. that are far more difficult to quantify and also more volatile [41]. This means that risk management has now to extend much beyond the financial risk. In this context, most companies are aware that responding to citizens' concerns is a necessity, if they are to keep their license from society to operate. For that purpose, more and more companies are issuing social and environmental impact reports. Their main driver, beyond responding to investors' expectations, is also to protect their image in the eye of customers/consumers, employees and citizens.

This has resulted in redefining the *fiduciary duties*, by which corporations should not only address the maximisation of profits, but have to accept broader social responsibilities [42]. Fiduciary duties should also include due diligence in risks' mitigation and compliance with future policies and regulations, or citizen and user expectations. Today, the view is that "failing to consider long-term value drivers in investment, which include environmental, social and governance issues, is a failure of fiduciary duty" [43].

This is supported by research confirming that companies which embed long-term views in their strategies perform better on several parameters such as growth of earnings, economic profit and market capitalisation, an incentive to shift perspective on the short-term/long-term dilemma [44]. This is reinforcing the idea of the stakeholder capitalism, promoted i.e., by the WEF (World Economic Forum), with several reasons to embrace it [45], such as improved risk management by anticipating expected

accountability on societal issues, enhancing competitiveness on the job market and on product and a better brand appeal by improved corporation image. This aspect was reflected by the USA Business Roundtable, with the statement of 181 CEO's of major corporations in 2019 [46] that "the Purpose of a Corporation is to Promote 'An Economy That Serves All Americans'".

RESPONSIBLE INNOVATION AND SUSTAINABLE FINANCE: ON IMPACT, COMPANIES RATING AND SUSTAINABILITY

While the engine for the transition to this new reality is *Responsible Innovation*, its fuel is Sustainable Finance. In order to gain momentum and address effectively the societal challenges, both resources from corporations on innovation, and resources from the financial community must be pooled. In this section, we discuss the commonalities and complementarities of the ideas of Responsible Innovation and Sustainable Finance, and the issue of trade-offs, described with the Game Theory's prisoner's dilemma.

Responsible Innovation and Sustainable Finance

An expected result of implementing Responsible Innovation effectively should be an improvement of the ESG rating and ranking of a company by designing innovations that generate genuine value to all stakeholders, i.e., users, society and shareholders. This is achieved with innovations contributing to SDG's while minimising negative social and environmental impacts through "Sustainable Design Thinking", e.g., promoting a *circular* [47] and *collaborative* economy [48] to disconnect economic growth from incremental environment impact. In the finance community, these attributes are named ESG (Environment, Social and Governance).

Sustainable Finance and ESG

While many investors are not necessarily interested in investments targeting specifically ESG [49], due to the kind of militant image of those investments, most also don't want to be trapped in investing in illegal activities, such as child-labour or chemical weapons. They would rather favour companies with a good ESG rating and demonstrated due diligence at mitigating risks and negative impacts of their activities on society and the environment. Sustainable Finance in action can take three levels, with *level 1*: about exclusion criteria, *level 2*: about rating a company on its ESG practices, and *level 3*: about generating positive impact to society as well (also labelled Impact Investing). Sustainable Finance and Responsible Innovation meet at the level 3, i.e., at generating positive impact.

Corporate Social Responsibility (CSR) and Responsible Innovation

Corporate Social Responsibility is about compliance to practices in governance, human rights, labour practices, environment, consumer

issues and community involvement as described typically in the ISO 26000 [50]. It is therefore a necessary, but not a sufficient element for Responsible Innovation, where the element of anticipation of future impact is key (see above).

Rating and Ranking ESG of a Company

The foundation for the implementation of the Sustainable Finance idea is the rating and ranking of corporations on their ESG components. These components are based on a multi-criteria approach and historical company data, focusing on *Environment* (CO_2 emissions, water consumption, etc.), *Social* (accidents at work, forced labour in the supply chain, etc.) or *Governance* (independence and integrity of the management boards) to ensure alignment with the values of investors. While there is a multitude of methodologies addressing the ESG rating [51], such as Robeco, SAM, MSCI, CDP, Thomson-Reuters, Sustainalytics, they may differ tangibly in their outcome [52]. The quality of the ratings is strongly affected by the credibility of the data source, and it is accepted that further improvements of the methodology are needed to enhance the transparency, accuracy and comparability of such ratings [53].

A major issue is that rating agencies do not necessarily agree on what are good or bad companies, providing vastly uncorrelated ratings [54]. This is related to issues with common databases, transparency of data or lack of standardised assessment methodologies, and this is of course related to the question of measuring impacts, discussed above.

Many investors, if not most, are open to the idea of ESG criteria, but claim that most companies do not provide sufficient data and lack transparency. This prevailing ambiguity is exposing ESG to the risk of "green-washing", i.e., twisting facts and figures for the purpose of selected reporting, at the cost of discrediting the idea.

Recommendations on improving *ESG reporting* are emerging, such as the ESG Disclosure Handbook from the WBCSD [55] or the GRI standards [56]. *Integrated reporting* is another format of reporting beyond financial data. While far less focused on environmental and societal impacts, integrated reporting seeks to explain how an organisation interacts with the external environment and the capital to create value over the short, medium and long term [57].

The SDGs, the framework of *Sustainable Development Goals* adopted by the UN in 2015, are more comprehensive than the ESGs. These are increasingly taken as the reference format for assessing societal impacts.

ESG ratings are therefore used by investors, according to their strategy, either for exclusion (e.g., no weapons, coal), or for thematic investments, i.e., selecting companies that contribute positively to some SDGs, or to focus on companies with good ESG ratings, but with the limitations of the consistency of the ESG ratings discussed before.

RESPONSIBLE INNOVATION ECOSYSTEMS AS COLLABORATIVE FRAMEWORKS

A major criticism of the idea of Responsible Innovation discussed above is that it is naïve and not anchored in reality. Innovation is not taking place in isolation, and Responsible Innovation can only take place within a collaborative ecosystem conducive to the generation of value shared by all stakeholders. We discuss here the components of such an ecosystem.

The Responsible Innovation Ecosystem and the Prisoners' Dilemma

The slow implementation of the necessary measures to fight climate change, a concern that also applies to pollution, plastics, food security, etc. was the topic of several articles [58], and they mostly point at the so-called repeated prisoners' dilemma [59] developed in the context of game theory in the 1950s (more explanations here: [60]), and also known earlier in a narrower scope under the Tragedy of the Commons.

The *answer* to the repetitive prisoners' dilemma is "a collective action that enforces a cooperative behaviour through reputation, rules of laws and explicit social punishment to transform the dilemma towards a collective cooperative outcome" [61] and beneficial impact. It can be a kind of club approach, where members of the club (or of the RI ecosystem) agree on rules, and share also benefits related to taxes, subsidies, access to national or state markets. Without such rules and conditional benefits attached, the end result will necessary be that free riders will join the party. This club-approach can be used to define the conditions for a Responsible Innovation ecosystem to work that we define in the next paragraph, and that will require:

- Robust science that is enabling the assessment of impacts based on the scientific methodology that is also properly communicated. Integrity is the leading word here;
- A society that will provide guidance on what is acceptable or not and will turn this into a political action. This requires Involvement.
- A government that is responding to social expectations;
- And a business that is anticipating these expectations and integrating them into a long-term strategy.

This is the foundation of a *4 Gears Model for a Responsible Innovation Ecosystems* that we present in the next section.

Systems of Innovation: An Overview of the Research

Our *4 Gears Model* of Responsible Innovation, detailed further below, relates also to a very rich research on systems of innovation. The concept of systems of innovation, at a national level, originated in the late 1980s by C. Freeman, highlighting the importance of building strong technological infrastructures at the national level, and by B. Lundvall, analysing the interactions at market level between users and producers of new products

[62]. A major contribution was also made by M. Porter a.o. with his analysis “On the competitive advantage of nations” [63].

A wealth of contributions followed, reviewed by B. Schrempf, D. Kaplan and D. Schroeder [64], that were the foundations of the approach of designing systems of innovation at national, regional or sectoral level to foster RRI for the EU-FP7 program. Such innovation systems are proposed as instruments to shape policy opportunities and legal rules and norms, to foster collaboration between industry and universities, and to foster public-private partnership for innovations that address value creation on the 3 dimensions we proposed above. There are many examples of such systems generating competitive advantages through innovation, such as in Japan at the national level or in Silicon Valley at the regional level.

Our 4 Gears Model is aiming at better connecting innovation systems to the impact assessment of innovation, at converging with the objectives of Sustainable Finance and at reflecting constraints of companies such as fiduciary duty.

The 4 Gears Model for a Responsible Innovation Ecosystem Generating Value to Stakeholders

Responsible Innovation, or the process of generating value that benefits society, shareholders and consumers is a holistic process requiring that all stakeholders play their role within the innovation eco-system, each fulfilling conditions and accepting rules so that the whole system is working. Because the impacts of innovation are not always easy to anticipate and quantify and can be also unexpected, trade-offs and adjustments will be necessary, in a spirit of agile governance which makes a partnership with all stakeholders necessary. Each has to identify and assume its role and responsibility in such a way that the whole ecosystem can mobilise and capture the necessary resources to deliver innovation to the common benefits. We discuss the role and responsibilities of these four stakeholders, with*:*

- *Government that* must be equipped to fight frauds, corruption, unfair competition or abuse of gaps in legislation, ensure a transparent and open debate about what citizens need and want, anticipate emerging societal needs, and translate these into “*smart policies*” based on the *sandbox* approach that are focused, based on evidence, and will require the minimal resources necessary to achieve their goals. These policies are monitored by an *agile governance*, which assumes that innovation is a learning process and is, therefore, adaptive and flexible. Furthermore, they are supported by smart regulation, which are geared on outcomes and less on processes, leaving space for self-regulation when the necessary trust and commitment are demonstrated. It is also responsible for providing the necessary resources and independence to the research community, so that they, as well, can assume their responsibilities.

- *Academia and others in the scientific research community* that are driving fundamental and applied research must deliver robust science for reliable impact assessments. They have to generate knowledge that is not partisan or affected by cognitive bias. They must ensure that the necessary debates and controversies are conducted ethically and are relying on scientific methodology. The results of these activities need to be peer-reviewed and published and debated in an open and scientifically sound manner.
- *Business and the corporate sector* are responsible for developing and introducing innovations that generate *true positive values* to shareholders, innovation users and society, and to anticipate related issues as far as possible. It has to extend its fiduciary duty in order to include risks of future non-compliance or liabilities for externalities and discuss this with public authorities in the relevant spaces (sandboxes). Business enjoys the benefit of asymmetry of information, therefore it is expected to report with integrity and transparency on any undesired or unexpected impacts, and to apply integrity and due diligence in mitigation plans. Shareholders, or their representatives, are also responsible for the ethics and integrity of their management.
- *Society*/*citizens* have the high responsibility of choosing their representatives, holding them to account, and supporting civil organisations that will foster their values in society. As customers/consumers, they have a critical role to play by making responsible purchasing decisions and acting responsibly.

Innovating efficiently requires *operating in a "sandbox"* of lean and smart regulations and agile governance, and necessitates a high level of *transparency*, responsibility, commitment, and *trust* from the different stakeholders, with a delicate balance between the precautionary principle and the innovation process. Consequently, neither innovation that destroys consumers' or societal values, nor science that would be wrongly applied due to poor reproducibility or mismanagement of controversies, will enable Responsible Innovation in the long term. Only partners with a high level of trust and recognised ethical leadership should therefore be accepted to join the ecosystem (or "Club").

This 4 Gears Model of industry & business, universities/academia, societal actors and government for Responsible Innovation (Figure 5) complements the concept of Systems of Innovation described above, by focusing more on generating value and impact. It addresses the issue of adjusting constraints and boundaries of the ecosystem, especially the limits of the fiduciary duty, to generate a competitive environment fostering prosperity. It differs from the *triple* (or rather quadruple) *helix* concept [65] that includes the co-creation and knowledge generation process industry, government and academia and that is used extensively in smart specialisation projects.

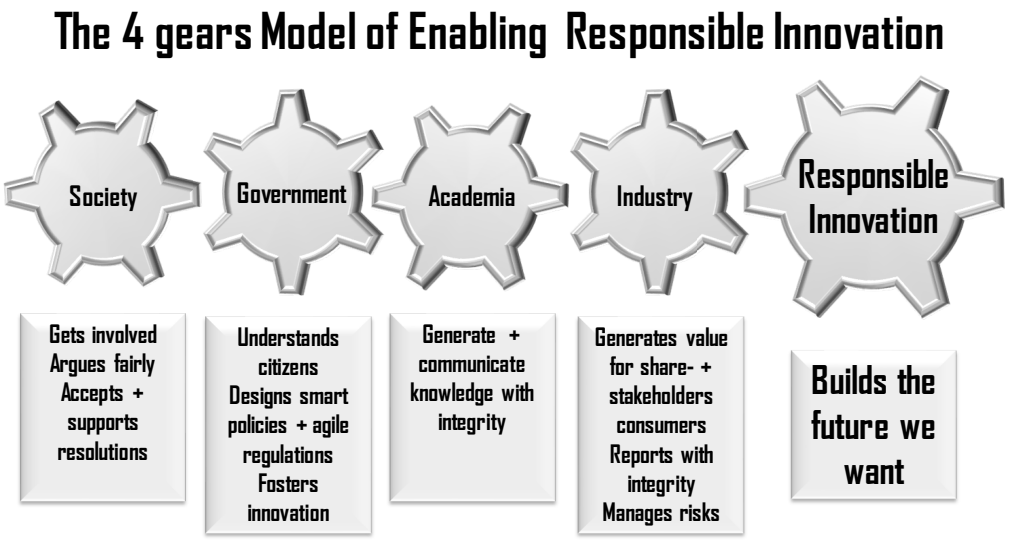

Figure 5. The 4 Gears Model for the design of an ecosystem for Responsible Innovation. Responsible Innovation cannot take place in isolation, but in an ecosystem where all stakeholders have a role to play and a responsibility to make it happen. Foundations of the 4G: trust and ethical leadership.

Defining and Rating a Maturity Level for a Responsible Innovation Ecosystem

Responsible Innovation is unlikely to be achieved in isolation and has to be anchored in an ecosystem that must fulfil the necessary conditions of maturity by each stakeholder with a high level of trust and ethical leadership in order to provide incentives to motivate collaborative behaviour. Such conditions relate to, among others, adequate regulation, smart and agile governance, alignment of the expected impact of the innovation to the values of the users and society, a level playing field providing fair competition, a taxation system that is conducive to responsible innovation, science that is not controversial and that is providing evidence of benefits. These conditions must be fulfilled to a reasonably high level of maturity to be able to attract investors and innovators. There is presently no agreement on a normative definition of such a maturity level framework for a Responsible Innovation ecosystem, and this is hampering the idea of both Responsible Innovation and Sustainable Finance. Progress must be achieved in the description and the rating of the maturity of each element (or gear, in our model), that will require norms and standards for qualitative impact assessments and metrics to guide the necessary trade-offs required in the design of responsible innovations. The proposed 4 Gears Model could be used to *develop a maturity level of a Responsible Innovation Ecosystem*, similar to the Technology Readiness Levels (TRL) or Social Readiness Levels (SRL) that are used in guiding investments in new technologies, and therefore address the possible gaps that are slowing-down the implementation of Responsible Innovation by failing to motivate entrepreneurs or investors.

Proposal of a Skill-Set for Responsible Innovation Managers

What we have discussed so far should highlight the fact that innovating responsibly is about venturing into uncharted territories of trade-offs, ambiguities, and contextual assessments. Additionally, many methodologies for impact assessments are work-in-progress and might probably always be so. In such a situation, the development of highly skilled RI managers capable of connecting to situations will make the difference. No skill set for these RI managers has been defined yet, and what we make here is a proposal for further discussion.

In order to be able to operate in this environment of ambiguities, RI managers should have training and practice on:

Innovation management and more specifically
- Innovation management best practices according to ISO-56002:2019
- Agile project management
- Sustainable Design thinking
- Quadruple Innovation Helix
- Research ethics

Sustainable Economy, and more specifically
- Life cycle thinking
- SDGs
- Circular economy and social + environmental LCA
- Principles of Sustainable Finance
- Systems of Innovation (e.g., the 4 Gears Model)

Impact Analysis, and more specifically
- Theory of Change
- Standards for impact assessment and non-financial reporting along WBCSD or GRI
- Impact assessment certification (e.g., by Impaakt.com)

These concepts that were discussed in this article should be part of the tools of a manager striving to develop responsible innovations and should be largely disseminated if we want the RI idea to get traction.

CONCLUSION

Starting with our definition of what responsible innovation means, we have:

- critically reviewed the research on Responsible Innovation and its shortcomings;
- explored the concept of value creation to stakeholders as foundation of the Responsible Innovation process, with its links to SDGs, shareholders value and consumers benefits;
- selected a model for research and innovation, also highlighting the differences and complementarity of both research and innovation;

- explored the state-of-the-art of impact assessment for innovation, with the current shortcomings and "work-in-progress" for the standardisation of the metrics and the reporting;
- identified the limitations of innovators from business and industry, using the prisoner's dilemma from game theory, and relating the benefits of a corporate strategy embedding sustainability to the shareholder's value, to revisit the fiduciary duty;
- highlighted the links between Responsible Innovation and Sustainable Finance, as engines and fuel for the transition to a sustainable economy.

We have used these elements to propose a Responsible Innovation Ecosystem (our 4 Gears Model) conducive to the development of Responsible Innovations that in our view cannot take place in isolation, but only within a collaborative ecosystem, in which all stakeholders assume vital roles and responsibilities, with:

- *Citizens*, as main beneficiaries and actors, either as users, or as referees
- *Academia*, as independent providers of knowledge, either for the assessment of impacts or for the generation of breakthrough innovations
- *Government*, as enabler of innovation to the benefit to society through agile governance and smart policies
- *Industry*, as provider of innovations that generate value to all stakeholders.

This is our proposal of a 4 Gears Model of a Responsible Innovation Ecosystem that could be expanded and improved, and could be a basis for two further directions of research:

- developing a model for rating the maturity level of a Responsible Innovation Ecosystem that could guide the four stakeholders in their collaborative effort;
- developing and expanding our proposed model for a competency skill set for responsible innovation managers that could support and guide them on their journey to developing Responsible Innovations as an engine for the transition to a sustainable economy.

As of July 2020, we are emerging from the coronavirus pandemic lockdown, one of the worst crisis in recent history, with consequences that are by far not yet fully grasped. Beyond the necessity for immediate recovery actions, it appears there is a strong consensus among citizens that the huge support packages from governments worldwide to relaunch our economies have to be used to foster the transition to a more sustainable economy, and address our grand challenges such as climate change, plastics waste, circular economy, obesity, water stress management, food security, green mobility, air quality, data privacy, ethical artificial intelligence, just to name a few. The engine of this

transition will be an innovation that is responsible, and that will be steered by responsible innovation managers.

AUTHOR CONTRIBUTIONS

MD is the lead writer of this article. JvH is a co-writer and has provided numerous reviews and comments. AG has provided advice, comments and reviews. MS has provided expertise with the EU innovation framework, comments and reviews.

CONFLICTS OF INTEREST

The authors report no conflict of interest for the content of this article that was written in full independence and that is not necessarily representing the views of EIRMA.

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