Responsible Research and Innovation Revisited: Aligning Product Development Processes with the Corporate Responsibility Agenda

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Abstract

Product development is a key business activity that drives long term business success. Over time, the focus of the product development process has evolved to encompass a more diverse group of stakeholders' needs and inputs, culminating in a call for more Responsible Research and Innovation. Here we extend the debate, from its focus on science and its engagement with society, to bring the principles of Responsible Research and Innovation into the new product development process. Many of the mechanisms exist, but a holistic approach to considering social innovation in all key stages of the product development process has not yet been fully addressed. We provide an overview of the different tools at each stage of the process that can contribute towards responsible research and innovation. In the final part of the paper we establish a future research agenda and call for additional research to investigate best practice and gather empirical evidence to further the development of Responsible Research and Innovation concept within the new product development process.

Keywords

Responsible Research and Innovation (RRI), product development process, corporate social responsibility.

1 Introduction

It is well established that society faces some grand challenges ahead that have led to a call for more focus on sustainability and socially responsible business practices [European Commission, 2010, 2012; Scherer and Palazzo, 2011]. It is now widely accepted that human-induced climate change is caused by production and consumption patterns that have emerged to meet society's evolving needs [Unruh, 2000; Foxon and Pearson, 2006]. There are increasing amounts of legislation to try to encourage more sustainable practices and to reduce carbon dioxide emissions. For example, the 2008 United Kingdom (UK) Climate Change Act [UK Parliament, 2008] states that "It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline." [p. 1]. Other legislation is encouraging manufacturers to take back and recycle their products at the end of their useful lives.

However, legislation for fostering socially responsible business cases and operating more sustainable practices in industry is still in the developmental phase [Scherer, Palazzo, and Baumann, 2006]. Such regulatory gaps may be reduced when policy makers motivate industrial stakeholders to integrate social and ethical aspects into research and development (R&D) processes. In essence, industry must be encouraged to work with societal actors across the entire research and development process, particularly during product development, to better align the outcomes of R&D with the values, needs, and expectations of society. The integration of societal

values and needs into product development process is recommended from both a social and technological perspective. From the technological perspective, such integration could help to develop innovative products and services, while from a social perspective such integration provides socially desirable solutions to society [Beckwith and Huang, 2005; Patra, 2011].

Thus, the question arises of how we may align societal needs and challenges with the outcomes of product development processes, which typically occurs within R&D departments. In fact, carrying out product development processes responsibly and sustainably both benefits the company and contributes to making a better society. As such, companies need to integrate social and ethical aspects into their research and development phase. In this regard, the concept of Responsible Research and Innovation (RRI), a phrase and concept coined by EU as an inclusive approach, highlights the role of societal actors beyond the present notions of strategic corporate social responsibility (CSR) and social innovation [Iatridis and Schroeder, 2016].

The term RRI is a concept that has visibility at the highest levels within the EU policy discourse. This policy focus is predominantly focused on science, with calls for a transformation "from science *in* society to science *with* and *for* society." [Laroche, 2011, cited in Owen et al., 2012, p753] and for policy to support "the best science *for* the world rather than the best science *in* the world" [Owen et al., 2012, p753].

The European Commission [2013] defines the term as follows: "RRI is an inclusive approach to Research and Innovation (R&I), to ensure that societal actors work together during the whole research and innovation process. It aims to better align both the process and outcomes of R&I, with the values, needs and expectations of European society. In general terms, RRI implies anticipating and assessing potential implications and societal expectations with regard to research and innovation."

This government push has also been met by consumer pull for organisations to be more responsible in their behaviour and production processes. For example, the organic and Fairtrade markets have gone from being quite niche segments to more mainstream. In addition, many companies have been publically challenged over using sweatshops and child labour to produce their goods [Burke, 2000; Porter and Kramer 2006]. In response, the Corporate Social Responsibility (CSR) agenda has become quite well-established in many organisations, with these firms looking to reduce their environmental and carbon footprints, to sell ethically sourced and manufactured products and to become engaged in national or international community projects to alleviate poverty, improve education and reinvest in the natural environment. In many cases, the CSR agenda exerts pressure on firms to pursue a tripartite of economic, environmental and social performance [Sarkis, Gonzalez-Torre, and Adenso-Diaz, 2010]. This need for sustainable development is forcing companies to reconsider their business models and restructure their entire operations [Brammer and Walker, 2011; Wu and Pagell, 2011]. As such, it is very important to closely align sustainable development because of its long term perspective with the strategic product development processes of the companies. In this regard, green innovation methods could assist with developing products and services that contribute to sustainable development [Salomo et.al, 2007]. Strategic CSR plans can be applied into organizational practices to extend sustainable developments [Mcwilliams and Siegel, 2001], as social innovation strategies could meet the social and ethical needs of various elements of innovation initiatives [Taatila et. al, 2006]. Furthermore, in order to best anticipate the social and ethical impacts of new products and services, utilising an inclusive approach such as RRI along the various stages of development can assist by examining the relevant aspects of a company's business model right at the outset.

This paper thus views the concept of RRI as an inclusive approach. In essence, the aim here is to define and describe how RRI can work alongside product development processes to improve and develop a company's CSR agenda.

Considering the fact that the mechanisms and activities of NPD processes support sustainable and responsible development, successful NPD requires the harmonisation of RRI agendas at each stage of the process. Scholars have only recently begun to discuss and understand how industry (and in turn companies) can productively work together with societal actors through applying RRI principles. Therefore this study is timely as it seeks ways of identifying and managing the harmonisation of the NPD and RRI agendas.

This paper will provide an overview of the history and evolution of the topic, from Concurrent Engineering to RRI and how the term RRI has been used in the literature to date. The key contribution of this paper is to extend the use of the term from science and society to the NPD process. This is achieved by outlining the Responsible Research and Innovation tools and techniques that can be used at each stage of an NPD process and by proposing a future agenda for Responsible Research and Innovation for both research and practice.

2 Baseline: Existing Theories and Research in RRI

The origins of RRI can be traced as far back as the 1990s. Here for the first time, there was a focus on the need to dispose of an increasing number of products at the end of their useful lives. This led to consideration of not only Design for Assembly, but also Design for Disassembly [Boothroyd and Alting, 1992]. This was also the key decade for the rise of Concurrent or Simultaneous Engineering [Pennel and Winner, 1989; Riedel and Pawar, 1991; Lettice, Smart and Evans, 1995]. Organisations sought to become better internally integrated to be able to produce high quality products reliably and at lower cost in ever faster product development cycles. Leading on from an increased internal integration was a shift to consider external integration. How could the supply chain be better managed and integrated? This was also enabled by new computer and IT technologies that allowed for the sharing of more data between an organization and its suppliers.

From the late 1990s and early 2000s, there was increasing recognition of the need for innovation to ensure survival and growth in an ever more competitive landscape. The attention shifted from the external integration of suppliers to a stronger customer focus. This led to tackling key issues such as how the 'voice of the customer' could be integrated into the product development process [Driva, Pawar and Menon, 2000] and understanding how organisations could listen more empathically to their customers to better discover their expressed and latent needs. [Adiano and Roth, 1994; Leonard and Rayport, 1997; Narver, Slater and MacLachlan, 2004]. Lead user and user-centred design techniques were being developed and more extensively trialled [Franke, von Hippel and Schreier, 2006].

As we move further into the 2010s, the sustainability movement has become more mainstream and there is increasing research on social entrepreneurship and social innovation in response to the need to tackle some of society's big challenges [Lettice and Parekh, 2010; Bridgstock, Lettice, Ozbilgin and Tatli, 2010]. This has been coupled with a social media revolution, opening up opportunities for different business models and approaches to business and new product development [Kenly and Poston, 2012].

2.1 The Roots of Responsible Research and Innovation

One of the first researchers to use the term 'Responsible Innovation' was Tomas Hellstrøm [2003]. His argument was that as well as producing benefits, technological innovation also comes with risks and a feeling that these risks are increasingly likely to overshadow the benefits and in many cases the problems caused may be largely irreversible. Hellstrøm [2003] uses one example of agro-food production to show the complex interplay between science, environment and society. There is for example increasing concern over food security, our ability to feed a growing world population, concerns over new technologies such as genetically modified

organisms, the effects of subsidies or their removal on farming systems and the increased unpredictability of crops caused by increasingly frequent extreme weather conditions.

In recent years, cases involving firms who operate irresponsibly have been widely reported in the media and have centred on environmental and social issues [Federsel, 2006]. Quite often when safety issues are picked up by regulators, suppliers to pharmaceutical companies are held accountable, and this in turn forces companies to re-think their procurement practices. Recent incidents involving the suppliers of two global pharmaceutical companies, Pfizer and Baxter illustrate this point. In 2010 Pfizer recalled drugs made by Claris Life Sciences India from the US market after the Food and Drugs Administration (FDA) found contamination in the antibiotic and anti-nausea drug developed by the Indian supplier. Soon after, the facility in Ahmedabad was closed by the FDA. The FDA's investigation of Baxter's Heparin led them to the suppliers of the active ingredient which had been manufactured in China. At least 10 Chinese companies were involved in the supply chain for contaminated Heparin. Subsequently, the FDA tracked further companies that made or handled products contaminated with Heparin-like substances from Chinese suppliers.

When such cases occur, drugs must be recalled and destroyed, suppliers' facilities are quarantined, the risk of supply disruptions is almost certain, financial liabilities are significant and corporate image issues can be devastating. Responsibility can also be viewed as a liability in which stakeholders are perceived to have actively engaged in causing an injustice and are held responsible for any consequences (Wickert, 2014). In the disaster of the factory collapse in Bangladesh in 2013, where five clothes factories located in the Rana Plaza building were destroyed, human rights and labour standards within Bangladeshi sweatshops were heavily criticised. The U.S., Canadian and European clothing companies and retailers, the owners of sweatshops in Bangladesh, and the governmental authorities were all deemed responsible for the conditions. These actors were culpable for the poor environmental conditions and working standards in the Bangladeshi sweatshops, because they had not enforced regulations or had denies social responsibilities within their supply chains. Responsible Research and Innovation should however extend along a company's entire value chain (Porcari et.al, 2015) and all stakeholders should be liable for any of the consequences of 'irresponsible research and innovation.' These examples and incidents combine to give a "complex array of human needs, economic interests, techno-scientific uncertainties, and political responsibilities." [Hellstrøm 2003, p.375] and competing stakeholder priorities. Hellstrøm calls for the need to consider risk and unintended consequences throughout the innovation cycle, using extended peer communities to help with identifying the risks and consequences of proposed new technologies. He advocates the development of a framework for the "preventive foresight and governance of Responsible Innovation." [ibid, p.382].

Another early paper on the topic was by Guston [2006], who proposed that universities need to be responsible and attach public value to their innovations and "add societal implications components to natural science research and training proposals." [Ibid p.21]. The next wave of literature on Responsible Innovation starts in 2008 with Ishizu, Sekiya, Ishibashi, Negami and Ata's [2008] focus on the potential societal impacts of nanotechnology. Nanotechnology is widely expected to contribute to progress, future innovation and benefits to society, but it is not without its environmental, health, economic and ethical impacts. They call for responsible R&D for parties involved in nanotechnology development, which means being aware of and responding to society's needs and concerns surrounding the new technologies. They also call for collaboration around standard-setting, to help reduce any risks.

Owen, Baxter, Maynard and Depledge [2009] also recognize that we are entering an era where there is a "growing awareness of the need to innovate, but to innovate responsibly" [Ibid, p6902]. They state the importance of government-led regulation, which has been instrumental in improving air and water quality and reducing exposure to contaminants such as pesticides and heavy metals, but also identify that this process is slow and lags innovative developments. This

is a concern as once products are released, it is very hard to retract them, even when risks have been identified. The authors call for better foresight and tools including horizon scanning and risk governance mechanisms such as insurance to complement regulatory mechanisms. Their key message is for much stronger risk management around the upstream development of new technologies and innovations to promote responsible and sustainable development in a proactive way [Owen and Goldberg, 2010].

Another widely circulated definition of RRI has been presented by von Schomberg [2011a] as:

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

In other words, von Schomberg's definition suggests that key RRI actors should work together on a set of moral values to harmonize the business and RRI agendas. A recent report from a group of experts in the EC identified different indicators to evaluate the impacts of RRI initiatives and to assess their performance in relation to social responsibility goals [European Commission, 2015]. Additionally, Oftedal [2014, p2] argues that "philosophy of science [should be] a central feature of RRI, not least because openness, transparency, and a broader involvement in research and innovation will require methods, assumptions, and values in research to be explicit, understood, and discussed."

To summarise, while the extant RRI literature generally tends to focus on the development of practices associated with science and its engagement with society, there are some emergent studies that seek to align this RRI agenda with business initiatives [Lettice et al, 2013; Flipse et al., 2013; Yaghmaei, 2015]. In line with this, we take the broad guidelines developed by those researching and writing about RRI, but rather than continue to focus on the development of theory, we instead shift the focus onto product development processes within organisations, where we believe RRI practices are equally important.

3 Research Approach

For this research, we have carried out an extensive literature review on RRI to trace the development of the concept and its meaning. From this, we concluded that the term has been used mainly for science and for those scientists involved in emerging technologies and discoveries such as nanotechnologies, pharmaceutical drug discovery and development, geoengineering, information and communication technologies and security technologies [Von Schomberg, 2011b]. We have then used this as a basis to argue for the concept to be extended into the product development process across multiple sectors and organisations, not just universities and high technology R&D laboratories. What follow is the presentation of a framework to apply the principles of RRI to the new product development process. This conceptual work requires empirical testing, which we acknowledge in the conclusions and agenda for future research on this emergent topic.

4 Responsible Research and Innovation in the New Product Development Process: Initial Findings –

There are many different ways of conceptualising the product development process. For the purposes of this paper, we will use Cooper's [1990] widely adopted, stage gate process. He identifies that after an initial (0) discovery stage, there is (1) a scoping stage, (2) a build the business case stage, (3) a development stage, (4) a testing and validation stage and then (5) a launch stage. For an organization to be more responsible, we consider some of the mechanisms

that can be used or activities that can be completed to ensure that a more responsible approach is taken. Checklists to ensure that these happen can be built into the stage gate process.

4.1 Discovery Stage

The discovery stage is where activities are focused on identifying opportunities and generating new product ideas. This stage is the best opportunity for organisations to consider how they can develop responsible innovations. Just as within the scientific domain, this stage is ideal for engaging the public, customers, suppliers and a broad range of external stakeholders. This can be achieved by using traditional market research techniques, such as surveys and focus groups. However, more organisations are starting to experiment with new technology-enabled methods such as "Enterprise 2.0" or "Crowdsourcing" [Howe 2006] and also sometimes referred as, "interactive value creation" [Reichwald and Piller 2009]. An example of such an approach can be found in the pharmaceutical industry, where an independent web platform links large pharmaceutical MNEs with external individuals who offer corresponding problem solutions for a fee. The business scenario is quite simple: The enterprise is looking for a solution to a problem which cannot be solved by the internal R&D department. It presents the problem with a description an independent organisation's web platform and offers a reward (remuneration) to the person solving the problem best within a specified time span.

Some organisations are using formal strategies to promote more external engagement, and this has been termed open innovation [Chesborough, 2006; West et al., 2014]. A famous example is Proctor and Gamble's Connect and Develop programme (www.pg.com/connect_develop) where they have increased the number of innovations sourced from outside their organization to over fifty percent. There has also been a growth in the number of websites that connect organisations with inventors, such as Innocentive (www.innocentive.com) and Ninesigma (www.ninesigma.com).

There has been some debate over whether or not such crowdsourcing techniques work and whether users or non-experts can develop better new product ideas than experts or professionals. Nonetheless many companies have been experimenting with these approaches, including Dell, Threadless (t-shirts), Apache/Linux, Muji and 3M. In a study on baby products, Poetz and Shreier [2012] found that users generally came up with better solutions that met customer needs, although these proposed solutions may be slightly less feasible. They conclude that depending on the complexity of knowledge needed, which will depend on the industry sector or product category, users can be a good source of new ideas for the NPD pipeline. However, it is important that organisations using this approach frame the problem well, provide appropriate incentives, have the means and the right people to filter and select a wide range of ideas and carefully manage any intellectual property issues. User centred approaches such as human-centred design, human-driven design, and participatory design [Niemelä, et al. 2014] help to activate stakeholder engagement in research and innovation activities [Porcari et.al, 2015].

Sets of tools that can help to frame the problem are now emerging [Lettice and Parekh, 2010]. These include aspects such as changing the lens, scenario planning and scanning the periphery. Additionally, informal social media tools are being adopted at this stage of the process. Kenly and Poston [2012] found that companies are using social media and Web 2.0 tools to generate new product ideas and requirements at lower cost. They are also using the tools to monitor social networks for customer needs and to gauge the market's perception of brand. But a significant proportion of companies surveyed reported that they lack the internal expertise or best practices required to use these techniques.

At this stage, ideas can be sought from a wide range of stakeholders and tested to see if they are responsible or whether there are too many risks to pursue. By framing good problems that are focused around social responsibility, the pursuit of more Responsible Innovation can be realised. Although social media and Web 2.0 tools are being used, there is a need for more research to see

how these tools can be better designed to gather and process product ideas and to identify and share best practice as it emerges.

4.2 Scoping Stage

The scoping stage is an assessment of the technical merits of a product and its potential market. Increasingly, as companies put CSR policies into practice, an ethical assessment of the product is also required at this stage. This typically entails a detailed risk assessment of the societal and environmental impacts and corresponding risks of the product under development. Although there will be many uncertainties, making risks difficult to quantify, by paying attention to these aspects, Responsible Innovation will be easier to achieve. It is especially helpful if focus group opinion can be obtained at this early stage. However these additional requirements will add costs.

4.3 Build the Business Case Stage

This is the feasibility stage to ensure that the project has a good product definition, a strong justification and a plan for delivery. Here, the focus is typically on the technical, market and financial feasibility of the product. For Responsible Innovation, the ethical and environmental feasibility of the product and associated manufacturing and consumption processes should also be considered. Increasingly more organizations are relying on sourcing raw materials and components from external sources, often from obscure locations. As argued earlier, sometimes the inappropriate and unethical actions of suppliers can seriously damage the image and reputation of large multinational enterprises. Therefore organizations have to move beyond their legal, environmental and social obligations, as stipulated by CSR directives and guidelines. There are many examples where suppliers, in their desire to increase profit margins, exhibit socially irresponsible behaviours, such as employing child labour, exploiting employees, putting consumers at risk, poisoning the environment, and violating regulatory laws.

At this stage, different business models can be considered. For example, there are increasing trends towards product service systems [Baines et al., 2007]. For example, Du Pont have shifted from selling floor coverings to providing total servicing to customers including installation, tailored maintenance, take back and recycling. This is coupled with another similar concept: collaborative consumption. New technology enables consumers to form peer communities to share, barter, lend, trade, rent and swap products to enable more sustainable and responsible consumption patterns.

4.4 Development Stage

The development stage is when the actual design and development of the product occurs. Raw materials should be sourced appropriately. They should be created in safe facilities by workers who are well-treated and paid suitable wages to work legal hours. Care needs to be taken not to use child labour and prison workers. Cases such as IKEA in Eastern Europe and Apple in China have shown that it is not always straightforward for organisations to achieve these standards throughout their supply chains. The suppliers also need to respect the environment in the manufacture of the products, using materials from sustainable sources and implementing effective pollution and emissions measures and controls.

4.5 Testing and Validation Stage

Here the entire project is examined, including the product itself, the manufacturing processes, customer acceptance and the economics of the project. Care should be taken to incorporate the holistic issues covered in the earlier stages of the NPD process.

Moreover, this stage requires ensuring that the product lives up to the claims being made. The product needs to be reliable, maintainable and safe to ensure that customers will not be injured by defective products. High profile examples of using lead paint for toys from third party suppliers e.g. Mattel (www.nytimes.com/2007/08/02/business/02toy.html) and others

(http://www.telegraph.co.uk/news/worldnews/asia/china/8944028/One-third-of-Chinese-toys-contain-heavy-metals.html) have shown that this is not always achieved throughout the supply chain. In addition, organisations need to ensure that they are not violating patent, trademark or copyright laws. For some industrial sectors, ensuring that there is no animal testing or experimentation might also be important.

As well as the typical technical and marketing requirements, there need to be processes to ensure ethical and environmental standards are met. Waste reduction, recycling and reuse options need to be monitored and improved and detailed life cycle analyses performed to ensure that the products meet standard at all stages of the lifecycle.

4.6 Launch Stage

This stage is the full commercialization of the product, the beginning of full production and commercial launch. Global consumers are increasingly expressing that they want brands to do well while doing good and prefer to buy from organisations that are supporting good causes than those that are not [Edelman, 2012]. In the fashion sector, Marks and Spencer, H&M and Uniqlo provide opportunities for their customers to recycle and donate old clothes to charity, which promotes environmental sustainability and supports people living in poverty. Innocent drinks have launched the Big Knit to support older people during the colder winter months. Supporters of the brand and the cause knit woolly hats for the smoothie bottles and 25p from every hatted bottle sold goes to Age UK, which raised over £1m in 2012 (www.innocentdrinks.co.uk/bigknit). These are examples of encouraging responsible consumerism.

In addition, organisations should ensure that when their products are launched, sufficient information is available to consumers to allow them to make informed decisions and hence purchases. Much eco-labelling is voluntary, but some global and local standards have emerged, such as the Fairtrade label, the Forest Stewardship Council (FSC) for wood-based products from sustainably managed forests and the Marine Stewardship Council (MSC) for sustainable fishing. The European Commission introduced the EU Eco Label in 1992 to ensure that organisations adhere to high standards of environmental performance and quality. The take up of the labelling is mixed, and the proliferation of labels can be confusing, but with time they should help with the move towards more sustainable and responsible consumption of RRI.

Collectively, we find that a common feature of successful NPD while the company progresses through its stages is the fulfillment of mechanisms and activities of each stage. Effective NPD enables more robust product development processes, which in turn results in to better end products and services. The various mechanisms and activities for each developmental stage are summarised in Table 1.

Stage	Mechanisms and Activities
0 Discovery	• Engage a broad range of stakeholders including: surveys, focus groups, crowdsourcing, open innovation, social media, Web 2.0, online forums, etc. • Monitor trends, gather and process product ideas, identify and share best practice
1 Scoping	• Carry out risk assessment in terms of all major aspects such as market, technical (inc. cyber risk), ethical, societal and environmental impacts and risks of product ideas
2 Build the Business Case	• Ethical and environmental feasibility: extend beyond CSR and into supply chain and supply networks, taking into account supply chain complexity • Product service systems and collaborative consumption

3 Development	• Raw materials from safe facilities and not using child and/or prison labourers • Sustainability factors: sustainable sources, effective pollution and emissions measures and controls throughout the supply chain
4 Testing and Validation	• Product/service needs to be reliable, maintainable and safe • Legal factors: not violating patent, trademark or copyright laws • Life cycle factors: detailed life cycle analyses and ensuring waste reduction, recycling and reuse options monitored and improved
5 Launch	• Finishing touches – explore and encourage key aspects to build an ongoing customer relationship e.g. through information on responsible consumerism, eco-labelling, country of origin, etc.

Table 1: Mechanisms and Activities for Each Stage of the NPD Process

The biggest opportunities to influence RRI lie in the earlier stages of the innovation cycle, which is illustrated graphically in Figure 1. In the later stages, assessments can be made to check that the highest standards are being met. Labelling can also help consumers to identify and then purchase the products of RRI processes. Well-known examples of this are dolphin-friendly labels on tuna cans, Fairtrade coffee, water usage levels during manufacturing, eco textile labelling and associated country of origin information.

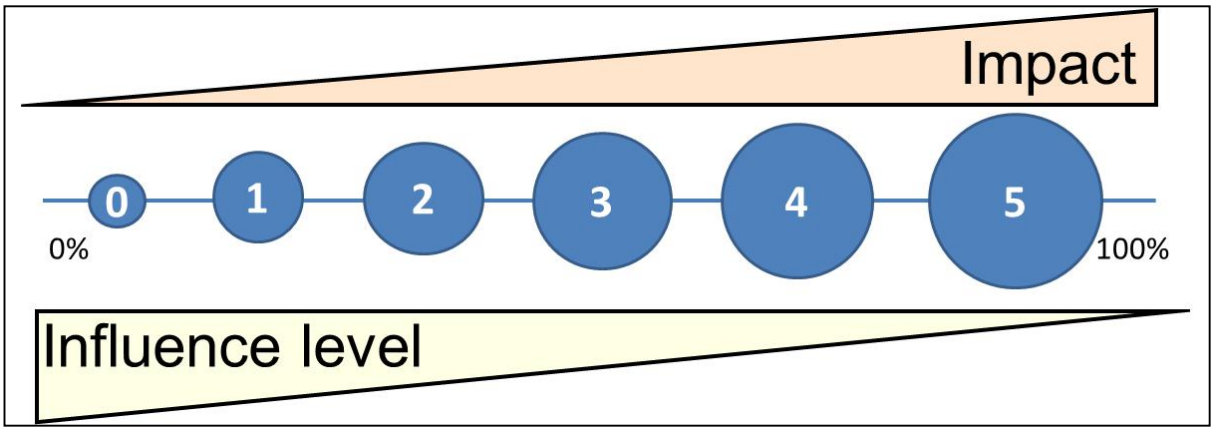

Figure 1: The Relative Impact and Influence by Stage of NPD Process

5 Conclusion and Revised Agenda for Future Research and Practice

The focus thus far has been on RRI for science and particularly around the development of genomics, nanotechnologies, geo-engineering, synthetic biology and ICTs [Owen et al., 2012]. There has been a call for more public or civic engagement in the upstream science phases, to help foresee unintended consequences or risks and to reduce public misunderstanding of these new technologies. There has also been a call for more risk management techniques and mechanisms to identify and better mitigate these risks. This does not aim to replace government-led regulation, but instead helps to shorten the lag between the ever-faster development of new technologies and the slower speed at which government regulation can be enacted.

In this paper, we identified some ways in which mechanisms and activities can be introduced at key stages in the new product development process to move towards more Responsible Research and Innovation.

At each stage of the product development process, there are opportunities for companies to consider aspects of Responsible Research and Innovation. As well as focusing internally, the company needs to take into consideration consumers and the corresponding supply chain activities needed to transform traditional innovation practices to RRI practices. Companies need to manage RRI activities at each stage along the new product development process by addressing the main dimensions of RRI, including: RRI awareness, RRI implementation, and RRI assessment [Yaghmaei, 2015].

New technologies will inevitably enable more solutions towards Responsible Research and Innovation. But with all new innovation, a risk assessment is required with wide stakeholder involvement to ensure that risks and unintended consequences are identified and mitigated. Reflecting RRI into NPD processes still needs to be enriched in many ways. There has been some progress in applying RRI instruments within the nanotechnology industry (e.g. Malsch et al., 2012), but these are so far limited. For future NPD research and innovation projects, as highlighted throughout this paper, responsible research and innovation practices play a vital role. In fact, it is important to emphasise that inclusion of an RRI agenda into NPD processes is in many ways inevitable and companies need to try to embed responsible practices as a matter of routine. Many of the tools, techniques and approaches outlined in this paper are not new. However their use in an integrated way across the product development process is to be encouraged. Organisations are experimenting with different techniques and some will be more or less suitable depending on the specific product and sector of application. A better understanding of which tools to use and when is therefore needed as a matter of some urgency.

In line with our findings and reflections on RRI and NPD, we propose the following research agenda:

1. Undertake an ongoing literature review of developments in RRI during NPD
    - » reflect on lessons learnt from CSR – bring in RRI principles to organizational processes
    - » broaden the scope to encompass relevant elements of associated areas such as green innovation, bottom of the pyramid approaches, the circular economy, social entrepreneurship and the role of open innovation in addressing societal challenges
    - » develop a structured and thorough classification, highlighting current state of the art themes and dominant research streams
    - » ensure that the potential influence of public policy changes and developments is taken into account (e.g. EU directives)
    - » this could form a data repository that could be made available via a wiki style website that will then be able to grow outside of a specific project

2. Gain practical insights through primary research
    - » identify and target experts from both industry and academia to gauge RRI readiness for NPD
    - » both survey (via a large scale online questionnaires) and in-depth interviews with a global reach should be undertaken
    - » questions should be based on eliciting information on key activities for each stage of the NPD process (as listed in Table 1)
    - » analyse from the perspective of empirically based comparative studies on an international basis

» identify what are the key activities and performance measures for RRI and NPD

3. Develop an RRI for NPD maturity assessment tool
   » incorporate technology risk assessment and ethical reflexivity and harmonize both the RRI and business agendas
   » in this way - provided multiple industry sectors have participated – a rich picture of the differing requirements by sector would emerge
   » this tool would provide the foundations for more informed decision making, given multiple stakeholder perspectives obtained from step 1 and 2

4. Develop strategies for future planning and implementation
   » determine how this assessment tool could be further developed and implemented in a variety of contexts (depending on company size, experience, stakeholder reach, etc.)
   » will this lead to the need to develop new tools or add functionality to existing tools and techniques?
   » consider how such an assessment tool could incorporate self-learning, using inputs from the data repository/wiki site proposed in step 1.

In summary, we call for extending Responsible Research and Innovation thinking and practices beyond universities and high technology industries to all sectors that are innovating and are involved in developing new products and services (for both public and private sector organisations). This is an extension of the corporate social responsibility agenda with the aim of more fully embracing RRI concepts at all stages of the new product development process.

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