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Innovation portfolio management for the public non-profit research and development sector: What can we learn from the private sector?

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ABSTRACT

Innovation Portfolio Management refers to the systems, processes and mechanisms to intentionally manage innovation investments and decisions within an organization against its mission or strategy. This approach to managing and optimizing innovation and scaling investments is rarely used by public non-profit R&D organizations. This study draws lessons from innovation portfolio management in private sector organizations. Private sector invests in innovation portfolio management to: (i) enhance transparent and evidence-based decision-making, (ii) strengthen organizational agility and mission-orientedness, (iii) facilitate monitoring, risk management and prioritization and (iv) improve overall organizational performance and learning. These innovation portfolio management benefits are equally relevant for the public non-profit R&D sector, where innovation performance and outcomes are for societal impact. Public non-profit R&D can and should manage their innovation portfolios more intentionally, and can learn from private sector successes and challenges. Embracing the opportunities, whilst managing the challenges and risks requires investment in methods, mechanisms and mindsets for effective innovation portfolio management.

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Sustainable development goals; innovation systems; impact; international development; stage-gating; end-to-end innovation management

Highlights

- Private sector organizations invest in innovation portfolio management
- Few public sector organizations purposefully manage their innovation portfolios
- Public non-profit R&D sector can benefit from innovation portfolio management
- Clarity on innovation portfolio intent and resource allocation strategy is key
- Innovation portfolio management can support impact culture growth

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1. Introduction

1.1. Public non-profit research and development

Over the past years, innovation has slowly but steadily found its way into the international sustainable development discourse and practice (Silva 2021). Fuelled by an implicit belief that innovation can solve international development problems, there is increasing pressure on public non-profit research and development (R&D) organizations to demonstrate how investments in science and innovation contribute to addressing global challenges such as those formulated under the United Nation's Sustainable Development Goals (Glover, Sumberg, and Andersson 2016; Leeuwis, Klerkx, and Schut 2018; Penfield et al. 2014). On the one hand, this triggered a debate on how to better allocate, manage and monitor public non-profit R&D investments (Schut, Leeuwis, and Thiele 2020). On the other hand, it has tempted organizations to over-promise and focus on *hypes* and *quick wins* over investments in sustainable transformations along realistic impact pathways (Hall and Dijkman 2019; Kumpf and Proud 2022).

Public non-profit R&D can be defined as the research and development activities conducted by public sector organizations (governments and non-governmental) whose primary mandate is to develop and deliver innovation through public policy and market-shaping without having the objective to make profit (Chen et al. 2020; Silva 2021). Public non-profit R&D is an important driver of innovation in sectors such as agriculture, education, nutrition and health, especially in low- and middle-income countries. The sector can be further characterized in a number of ways. First, a significant portion of public non-profit R&D receives its funding from national governments, next to investments made by international financial organizations (e.g. World Bank), philanthropical organizations (e.g. Bill and Melinda Gates Foundation), companies and their foundations (e.g. MasterCard Foundation), and collectives of governments (e.g. the European Union). Second, the core business of public non-profit R&D is to design, test, validate and support uptake of innovations. In most cases, funders expect that grants and investments contribute to positive societal impact. Third, the results, outputs or innovations that are being developed are generally intended to serve the public interest rather than to generate profits. In some cases, the innovations are considered 'public goods' – available to all members of a society in an open and non-exclusive manner (Oakland 1987). In other cases, innovations are 'proprietary' – protected by intellectual property rights or commercial exclusivity agreements.

1.2. Innovation and innovation portfolio management

Innovations are generally defined as new or improved products, processes and services, or policy and institutional arrangements that intend to produce value (Nagji and Tuff 2012). Innovations can be technological or non-technological in nature (Geldes, Felzensztein, and Palacios-Fenech 2017), and can be at different stages of readiness, ranging from ideas to ready for deployment at scale (Evans and Johnson 2013; Sartas et al. 2020). The use of innovation in society depends to a large extent on the existence or absence of an enabling environment (e.g. policy, infrastructure and market conditions) that influences whether or not people are aware of, have access to, can afford,

or effectively use and benefit from the innovation. This is at the heart of recent publications that stress the importance of innovation packaging (Sartas et al. 2020; Schut, Leeuwis, and Thiele 2020) or socio-technical bundling (Barrett et al. 2022) for innovations to lead to sustainable desired impact. Not all innovations will end up changing the world. Many innovative ideas will not survive testing in uncontrolled environments where real-life political or market pressures determine whether or not innovations can contribute to impact. Decision-making on which innovations to prioritize, pause or stop is a challenging (Mathews 2013), but essential part of performance and results management in R&D organizations (Klingebiel and Rammer 2014).

Most public non-profit R&D organizations manage not just one, but a broad variety of innovations, innovation projects and interventions aimed at delivering (positive) societal impact at scale. Innovation portfolio management refers to the systems, processes, and mechanisms to intentionally manage and optimize organizational innovation investments and decisions against its vision and strategy (Proud, Schut, and Kumpf 2023).[1] With increasing pressure from funders to show progress towards development impact (Renkow and Byerlee 2010; Woltering et al. 2019), purposefully managing innovation investments is seen as *best practice* for strengthening organizational effectiveness and performance (OPSI 2022). Several large public non-profit R&D organizations have embraced innovation portfolio management as part of their organizational vision and mission, including CGIAR – a global research partnership for agricultural research and innovation (Schut et al. 2024). Also scientifically, there is a growing body of literature that focuses on impact-oriented research and innovation in the public sector. This includes debates on mission-oriented agricultural innovation systems (Klerkx and Begemann 2020), system transformation (Leeuwis, Boogaard, and Atta-Krah 2021), responsible innovation (Stilgoe, Owen, and Macnaghten 2013), and science of innovation scaling (Schut, Leeuwis, and Thiele 2020). Research on innovation portfolio management in the public sector aligns particularly well with more action-oriented system approaches to innovation that aims at finding the right balance between understanding and analysing innovation system complexity on the one hand and informing intervention and action on the other hand.

Although the practice and scientific attention for innovation portfolio management in the public non-profit sector has recently picked up (e.g. Barrett et al. 2022; Holden et al. 2018; Megersa 2019), the vast majority of innovation portfolio management experiences come from the private sector (e.g. Mathews 2013). Innovation portfolio management has received insufficient attention in the public non-profit innovation and development literature (Behrens 2016; Holden et al. 2018; Megersa 2019). The increased interest and discussion on how to operationalize innovation portfolio management in the public non-profit sector created the starting point for this study.

1.3. Study objectives

The objective of this study is to draw lessons from innovation portfolio management in the private sector, and to explore how these can inform innovation portfolio management in the public non-profit sector. The study is guided by three questions (1) What are the main reasons why organizations invest in innovation portfolio management?

(2) What are success factors for innovation portfolio management? (3) What are challenges for innovation portfolio management?

2. Materials and methods

The academic debate on innovation portfolio management in the private sector forms the main source of analysis in this paper. We explored the databases of Google Scholar, Emerald, ScienceDirect, Springer, and Taylor and Francis for 'innovation portfolio management' in their title, abstract and other searchable fields. We then screened the publications for the following characteristics (i) whether the article was published in English language, (ii) whether the publication is published in a peer-reviewed international journal, (iii) whether innovation portfolio management is well emphasized (mentioned >5 times), and (iv) whether the study was published after 2011 to ensure its relevance. Initially, 53 publications were retrieved, of which 38 publications were excluded, remaining with 15 publications that provided our entry point for analysis (Table 1). Using a

Table 1. Overview of the 15 publications that provided the entry point for the study.

Citation (in alphabetic order)	Online access (URL)	Sector	Paper Type	Open Access (Y/N)
Behrens (2016)	https://onlinelibrary.wiley.com/doi/abs/10.1111/caim.12157	Cross-industry	Empirical	N
Brook and Pagnanelli (2014)	https://www.sciencedirect.com/science/article/pii/S0923474813000830	Automation industry	Empirical	N
Holtzman (2014)	https://www.emerald.com/insight/content/doi/10.1108/JMD-11-2013-0138/full/html	Innovation, new product development, and research & development industries	Empirical	N
Huvaj and Johnson (2019)	https://www.sciencedirect.com/science/article/abs/pii/S0148296318306660	Medical device industry	Empirical	N
Klingebiel and Rammer (2014)	https://onlinelibrary.wiley.com/doi/abs/10.1002/smj.2107	Cross-industry	Empirical	N
Kock and Gemünden (2016a)	https://onlinelibrary.wiley.com/doi/abs/10.1111/jpim.12336	Cross-industry	Empirical	N
Kock and Gemünden (2016b)	Retrieved from the authors' private ResearchGate repository	Cross-industry	Empirical	Y
Martinsuo and Vuorinen (2019)	https://trepo.tuni.fi/handle/10024/135967	Construction and software industries	Empirical	Y
Pashley et al. (2020)	https://link.springer.com/article/10.1007/s11518-020-5467-z	Software development industry	Empirical	N
Röth, Spieth, and Lange (2019)	https://onlinelibrary.wiley.com/doi/abs/10.1111/jpim.12501	Automation industry	Empirical	N
Sicotte, Drouin, and Delerue (2014)	https://journals.sagepub.com/doi/abs/10.1002/pmj.21456	Research and development industry	Empirical	N
Spieth and Lerch (2014)	https://onlinelibrary.wiley.com/doi/abs/10.1111/radm.12092	Cross-industry	Empirical	N
Toh and Ahuja (2022)	https://onlinelibrary.wiley.com/doi/abs/10.1002/smj.3351	Cross-industry	Empirical	N
Urhahn and Spieth (2014)	https://ieeexplore.ieee.org/abstract/document/6849434/	Cross-industry	Empirical	N
Üçler (2018)	https://www.betadergi.com/jeim/yonetim/icerik/makaleler/93-published.pdf	Innovation industry	Empirical	Y

snowball approach, this initial set of publications allowed us to identify other publications on innovation portfolio management in the private sector, as well as a special issue in the Journal of Research-Technology Management on the topic (Mathews 2013).

The analysis of the literature was guided by the three questions elaborated in Section 1.3. After initial familiarization, we used a matrix approach to identify, structure and group key (sub-)themes related to the three guiding questions. In many cases, reading the individual publications supported us in identifying additional literature on the topic. We applied the 'principle of saturation' to decide whether or not to identify and analyse additional literature on the (sub-)themes (Saunders et al. 2018). Further analysis focussed on identifying patterns across themes or publications, for example by identifying multiple publications referring to similar phenomena or reaching similar/ contradicting conclusions. When writing up the key results, we often went back to the publications to ensure we properly interpreted concepts and looked for examples to underpin our main conclusions.

3. Results

Innovation portfolio management is generally defined as a systematic approach to optimizing or aligning internal processes, resources, partnerships and performance to achieve organizational mission, vision and goals. There is a strong consensus that innovation portfolio management improves decision-making in organizations and overall organizational performance.

From our initial scoping of the literature, several studies are cross-sectoral and focused on innovation portfolio management in manufacturing companies, high-tech companies, metal/steel companies, electrical companies, automotive, and the chemical/pharmaceutical industry (Behrens 2016; Kock and Gemünden 2016a; Kock and Gemünden 2016b; Spieth and Lerch 2014; Urhahn and Spieth 2014). Five papers assess innovation portfolio management in German companies (Klingebiel and Rammer 2014; Kock and Gemünden 2016; Röth, Spieth, and Lange 2019; Urhahn and Spieth 2014). Whilst most studies focus on innovation portfolio management in larger commercial companies, Pashley et al. (2020) explored innovation structure framework in small and medium enterprises. Martinsuo and Vuorinen (2019) compared innovation portfolio management in project-based construction and software companies. Studies that were identified through snowball sampling focused on decision-making or stage-gating for portfolio diversity and health and drew from a broader variety of private sector experiences.

3.1. Main reasons why organizations invest in innovation portfolio management

3.1.1. Enhance transparent and quality decision-making

Adopting a systematized process for innovation management will lead to repeatable and trustworthy decision-making process (Kock and Gemünden 2016; Pashley et al. 2020; Röth, Spieth, and Lange 2019; Spieth and Lerch 2014). Szutowski, Szulczewska-Remi, and Ratajczak (2019) found that traceability, reproducibility and formalized procedures are critical factors for improved innovation performance and to distinguish innovations

that continuously show positive results and thus impact potential from those that do not. This is also referred to as stage-gating (Cooper 2008), where an organization defines stages, gates, and gate assessment criteria to manage innovation development and deployment progress. Innovation portfolio management should be integrated in reporting mechanisms and aligned with the strategic management and decision-making agendas of senior managers or executive leaders of the organization (Holtzman 2014; Spieth and Lerch 2014).

3.1.2. Strengthen organizational agility and mission-orientedness

Improved agility is the second theme that emerged. Several studies mentioned that formal monitoring of innovation portfolios increases the agility of the organization in making strategic decisions (Brook and Pagnanelli 2014; Kock and Gemünden 2016; Martinsuo and Vuorinen 2019). Agility is being described as the adaptive nature of an organization and how they can respond to a changing, turbulent market or funding environment (Karvonen, Sharp, and Barroca 2018). Agility allows organizations to respond to emerging opportunities, whilst using the organizational mission as its compass (Attar and Abdul-Kareem 2020). In addition, it was shown that innovation portfolio management is used to align employees' capabilities and innovation activities with the overall organizational mission (Martinsuo and Vuorinen 2019; Röth, Spieth, and Lange 2019; Spieth and Lerch 2014; Urhahn and Spieth 2014).

3.1.3. Facilitate monitoring, risk management and prioritization

Innovation portfolio management supports the tracking of innovation processes and products in an organization (Pashley et al. 2020). Several studies conclude that innovation portfolio management is essential for monitoring and prioritizing innovations in order to understand which projects should be assigned resources, put on hold, or be stopped (Holtzman 2014; Röth, Spieth, and Lange 2019; Urhahn and Spieth 2014). Risk management that defines and assesses different types of risks for each portfolio item plays a very important part in this prioritization, and a balanced approach to risk should be taken (Holtzman 2014). Risk-Reward monitoring is mentioned in several studies as a key metric of innovation portfolio management (Cooper and Sommer 2023; Holden et al. 2018).

3.1.4. Improve organizational performance

There seems to be consensus that innovation portfolio management increases organizational performance, value maximization and profitability, and competitive advantage (Behrens 2016; Holtzman 2014; Klingebiel and Rammer 2014; Sicotte, Drouin, and Delerue 2014; Spieth and Lerch 2014; Toh and Ahuja 2022; Üçler 2018). This is a result of improved organizational agility, learning and preparedness to align organizations to their everchanging environment (Cooper and Sommer 2023). In addition, innovation portfolio management provides benefits with regard to planning investments against short, medium and long-term time horizons (Behrens 2016; Toh and Ahuja 2022). Although the performance benefits seem obvious, Mathews (2013) emphasizes that tracking and improving (often chaotic) innovation development processes is far from easy.

3.2. Success factors for innovation portfolio management

3.2.1. Fit-for-purpose systems to ensure timely access to quality information and metrics

Access to quality information, data and metrics is a key success factor for innovation portfolio management. Huvaj and Johnson (2019) state that innovation development processes should be measurable, both quantitatively and qualitatively. Innovation data can focus on tracking internal R&D, manufacturing, distributing processes, and costs , as well as help understand the broader external innovation environment in a holistic way (Holtzman 2014). This implies considering data about other competing or coopting organization, supply chains, customer needs and uptake. Beyond primary innovation data also other metrics should considered by organizations, including advanced pattern recognition (e.g. on client needs), mathematical computer modelling (e.g. foresight of use potential or competition), and identifying and interpreting weak signals in the enabling environment (e.g. policy and regulatory changes).

To ensure that the information and metrics are of sufficient quality, timely and relevant, data collection structures and systems are essential (Urhahn and Spieth 2014; Üçler 2018). Such structures and systems are often referred to as innovation management systems (Üçler 2018). An innovation management system is a specific type of information system that includes procedures and governance mechanisms designed towards achieving a particular organizational mission (Dzwigol et al. 2019). Such systems define the roles and responsibilities of the various actors involved in innovation portfolio management, as well as the processes and governance mechanisms for decision-making (Röth, Spieth, and Lange 2019). Studies by Röth, Spieth, and Lange (2019) and Urhahn and Spieth (2014) show that formalized innovation portfolio management systems lead to better organizational performance and innovation outcomes. As part of strategic decision-making, innovation data collected through formal systems and procedures needs to be complemented by political sense-making and vision (Röth, Spieth, and Lange 2019).

3.2.2. Clarity on innovation portfolio intent and related decision-making criteria

Innovation portfolio management requires making strategic decisions before innovation potential and outcomes can be fully validated. A key prerequisite for making such strategic decisions is having clarity on an organization's innovation portfolio intent (Klingebiel and Rammer 2014), which refers to the overall organizational vision, mission and goals associated with the portfolio of innovations (Proud, Schut, and Kumpf 2023). Clarity on the specific portfolio objectives and outcomes (what to achieve) needs to go hand in hand with clarity on the path to reach those objectives and outcomes (how to achieve). This may include an organizational vision on risk-reward and related investment in incremental innovations (lower risk), and investment in radical or disruptive innovations (higher risk) (Cooper 2013; Pashley et al. 2020). Another example is to have clarity on key client groups and markets, which may influence which type of innovations are prioritized.

Simply setting the goal is not enough; goals must be supported by clear criteria for decision-making and transparent resource allocation strategies (Cooper 2013). Decision-making criteria need to be aligned with the organizational mission and

innovation portfolio intent. For example, if an organization values sustainable development, then sustainability criteria should be able to guide decision-making on the portfolio, ie. which innovations have a higher/lower likelihood to contribute to ecological, social and or economic sustainability (Brook and Pagnanelli 2014). Criteria support innovation portfolio managers in making strategic decisions about financial and human resource allocation at successive points along an innovation pathway or process (Klingebiel and Rammer 2014). Criteria for strategizing and decision-making are important and can include harder criteria (e.g. return on investment, technological uncertainty, consumer demand) as well as softer criteria (e.g. opinions, company identify and reputation, management support) when allocating resources (Behrens 2016). Innovation portfolio managers should have a basic level of understanding of the innovations and organizational innovation processes as this will influence their ability to interpret and judge innovation data and criteria (Röth, Spieth, and Lange 2019).

Klingebiel and Rammer (2014) describe how resource allocation strategies can change along the innovation pipeline, focusing on breadth of innovations at early stages (invest less resources in more innovations), and being more selective during later stages (invest more resources in less innovations). It emphasizes the need to be specific about pipeline stages, characteristics, gates and gate criteria to influence which innovations are advancing or put on hold.

It is important to mention that every set of criteria and resource allocation strategies comes with advantages and disadvantages. For example, prioritizing portfolio breadth in early-stage innovation can 'starve' individual innovation of sufficient resourcing, increase managerial complexity and hamper strategic focus (Klingebiel and Rammer 2014).

3.2.3. Invest in organizational innovation culture and capacity growth

Innovation portfolio management often goes hand in hand with organizational innovation culture change. Holtzman (2014) identifies five key organizational culture growth aspects in relation to innovation portfolio management:

1. Create an innovation mindset – put innovation at the heart of the business and foster a culture in which ideas are allowed to flourish;
2. Nurture creativity – support active experimentation, failure and learning as part of the innovation journey;
3. Prepare the path to profit – collectively define success and what a fruitful outcome looks like;
4. Match the metrics to different stages of innovation – allow innovative ideas space to breath while also providing a structured approach for more mature innovations;
5. Take a balanced view on innovation risks – ensure a healthy mix of innovations and tie this back to nurturing innovation mindsets to encourage employees to innovate in diverse ways.

Managing changes that are associated with a different approach to managing innovation in an organization is essential. Such innovation culture change should be mandated and nurtured by senior leadership in word and action. A fundamental building block for this is to formally integrate innovation management into the agenda of senior leaders to ensure that innovation is not only be actively encouraged, but also

actively managed, tracked and measured (Holtzman 2014). Having the right culture is equally important than having the right metrics (Cooper 2013).

Employees are expected to acquire new knowledge and skills that will enhance innovation portfolio management (Sicotte, Drouin, and Delerue 2014). Actively investing in and managing organizational innovation capabilities is as important as managing the actual products, services and other types of innovation that those capabilities eventually result in. Several studies mentioned that employees should be involved in innovation portfolio management, as this builds trust in the employees and makes them part of the system and the decision-making processes related to it (Holtzman 2014).

3.3. Challenges for innovation portfolio management

3.3.1. Data and information gaps and inappropriate decision-making criteria

Inadequate internal or external data and information to support decision-making is a challenge for innovation portfolio management (Kock and Gemünden 2016). Information, evidence and knowledge gaps can be both related to the innovation itself (Röth, Spieth, and Lange 2019), as well as to the market or political environment in which these innovations are expected to be used (Huvaj and Johnson 2019; Kock and Gemünden 2016). Klingebiel and Rammer (2014) add that such uncertainties influence the ability of managers, no matter how intelligent or experienced, to confidently predict key determinants of innovation success. It implies that organizations need to accept the risk of misjudging innovation's success potential. Innovations that look promising may ultimately fail, whereas innovations that seem unconvincing at first may eventually succeed (Klingebiel and Rammer 2014).

Challenges related to innovation portfolio management systems and tools include the absence or inappropriateness of innovation selection and appraisal criteria, difficulty in designing methodology for measuring specific criteria, and the lack of a clearly defined process that deals with the dynamic nature of innovation (Brook and Pagnanelli 2014; Spieth and Lerch 2014). Managing a portfolio of innovations by – for example – only assessing financial criteria (e.g. return on investment, profitability) may lead to favouring low-risk innovations being advanced (Cooper 2013). This can lock organizations into a cycle of investing only in the ideas of least risk (incremental over radical innovation) which limits the organization's growth and impact potential (Huvaj and Johnson 2019; Pashley et al. 2020; Üçler 2018). Having a clear resource allocation strategy and balanced set of decision-making criteria can avoid such organizational lock-in (Klingebiel and Rammer 2014). Assessing innovations against multiple financial, strategic and social dimensions is essential (Behrens 2016; Cooper and Sommer 2023; Röth, Spieth, and Lange 2019), as well as valuing managers' experiences, strategic foresight and business intelligence in making strategic innovation portfolio decisions (Pashley et al. 2020).

There exist different views on criteria related to managing internal and external innovation interdependencies across innovations in a portfolio. Roth *et al.* (2019) emphasize that interdependencies should be avoided as they increase innovation risk and vulnerability, and reduce the chances of terminating individual innovation projects. Meanwhile, Sicotte, Drouin, and Delerue (2014) mention that innovations often emerge from an organization's capacity to connect to other external parties to integrate different types

of dispersed knowledge, such as technological, market, finance and regulatory knowledge.

3.3.2. Organizational fear of taking risk and failure

Innovation and risk are two sides of the same coin, and – depending on the innovation portfolio intent and criteria – risk management could easily stifle innovation (Holtzman 2014). Innovation portfolio management should encourage innovative behaviour, such as risk taking, openness to new ideas, failure and learning. Rewarding short-term performance and maintaining a fear of failure do not contribute to an environment that encourages radical and disruptive innovation (Pashley et al. 2020). Progressive companies recognize that the best concepts are often the most fragile ones, and that nurturing and not 'killing' them too early is essential for breakthrough innovation (Cooper 2013).

Taking a balanced approach to innovation risk, and having clarity on the resource allocation strategy can overcome this fear. For example, investing broadly in early-stage innovations goes hand-in-hand with an expectation that only 10% of these innovations will mature and contribute to the organizational objectives and outcomes; implying that 90% should fail and be killed along the way (Klingebiel and Rammer 2014). An open risk climate and transparent communication about risks are essential for innovation and innovation portfolio management (Kock and Gemünden 2016). Failure should be appreciated, evaluated and widely communicated; what has been learned and what capability has perhaps been developed or enhanced. Learning should be stimulated in a way that does not discourage experimenting and penalize individuals and teams for failure (Holtzman 2014).

3.3.3. Organizational resistance to innovation portfolio management

For many, the systematized management of the creative process of innovation development feels counter-intuitive. Yet, having a well-balanced portfolio is important to achieve an organizational mission and impacts (Nagji and Tuff 2012). It is good to realize that innovation portfolio management is not necessarily embraced by the entire organization, and moreover can be costly and time consuming.

Reasons for resistance are often related to the criteria and resource allocation strategies. Decisions to withdraw resources from early-stage innovations that seem less promising are error-prone and could have implications for the employees and partners working on those innovations (Klingebiel and Rammer 2014). Innovation developers may not agree with the portfolio manager's decision which may demotivate, dissolve innovation team, and imply reassignment of employees to other innovation projects. In addition, employees may feel that innovation *start-stop* processes undermine R&D processes, increases transaction costs, and compromise strategic visioning and organizational planning (Kock and Gemünden 2016; Spieth and Lerch 2014; Üçler 2018).

Holtzman (2014) mentions that putting innovation at the heart of the organization may result in a clash of cultures between those responsible for developing innovations, and those managing innovations. Innovation portfolio management inherently implies change and trade-offs. Managing such sensitivities requires transparency, strategy and clear rules of the game, whilst not losing touch with human side of innovation portfolio management.

4. Discussion

In this section, we reflect on the main private sector reasons, success factors and challenges and discuss the extent to which key observations are relevant for innovation portfolio management in the public non-profit R&D sector.

4.1. Benefit of innovation portfolio management in the public sector

Public organizations are generally underdeveloped in innovation portfolio management (Megersa 2019; OECD 2020) which limits or even negatively affects their impact potential. Especially for larger public non-profit R&D organizations the benefits seem obvious, though few have adopted an innovation portfolio management approach (Holden et al. 2018).

The key reasons why private sector organizations invest in innovation portfolio management seem equally relevant for the public non-profit R&D sector. Similar to the private sector, public non-profit R&D operates in an unpredictable environment where resources are scarce, and making well-informed and transparent resource allocation decisions is important. Public non-profit R&D often has a very clear mission and innovation portfolio management can improve how organizations monitor and learn, manage risks, and prioritize investments against that mission (Urhahn and Spieth 2014; Üçler 2018). Having a systematic approach to innovation management can improve credibility and trust for both internal stakeholders (the researchers and innovators) as well as for external stakeholders (funders and partners).

The key private sector success factors and challenges identified apply to the public sector as well. Having clarity about different purposes of innovation along with clear metrics and monitoring mechanisms, having timely access to information, defining appropriate hard and soft criteria for decision-making, and a transparent process to guide innovation portfolio management is perhaps even more important in the public sector where accountability and traceability of investments made by funders is key (Behrens 2016).

There are also some key differences between the private for-profit R&D and public non-profit R&D sectors in relation to innovation portfolio management which are elaborated below.

4.2. Collaboration, integration and partnerships for innovation

Different views exist on whether and how to manage internal and external interdependencies across innovations in a portfolio. Roth *et al.* (2019) emphasize that interdependencies provide a risk as they reduce the chance of terminating individual innovation projects (see also: Khanna, Guler, and Nerkar 2018). In the private sector, creating internal innovation competition is used to manage uncertainty in innovation portfolios (Martinsuo and Vuorinen 2019). Intentional investments in parallel, competing solutions for the same challenge, and managing this competition, is a rather well-established strategy. The majority of global development challenges (such as climate change or biodiversity losses) that public non-profit organizations seek to tackle are incredibly complex. These challenges are multi-dimensional and multi-disciplinary, cut across

multiple sectors, and can therefore not be neatly boxed (Hall and Clark 2010). As a result, innovation to address such global challenges often emerges from a capacity to integrate different types of dispersed knowledge and skills.

Interdependencies within organizations refer to the synergies across different divisions within the R&D organization and how they can be incentivized to closely work together to (1) try to understand the nature of the challenge, and (2) come up with innovations that could tackle such problems. Different types of innovations can be explored and tested, but here collaboration rather than competition seems key. Interdependencies across organizations refer to the collaboration between the public non-profit R&D organization and other ecosystem players such as private companies, development organizations and governments. For example, whether or not a public non-profit R&D organization reaches its intended clients and mission (e.g. farmers adopting a drought-tolerant variety) depends on collaboration between research organizations (e.g. developing a new crop variety), governments (e.g. licensing the crop variety and allowing it to be released), the public extension system (e.g. promoting the new crop variety), and the private sector (e.g. providing a market). In this situation, no single organization could fulfil its mandate or achieve its goals without working together, which creates interdependencies and incentivizes collaboration, integration and partnerships for innovation.

Such high levels of interdependencies indeed come with increased complexity and coordination costs and could make it more difficult to stop innovations of low potential, as well as create ownership or intellectual property issues (Toh and Ahuja 2022). Furthermore, conflicting organizational objectives may compromise public-private partnerships for the development and deployment of public goods (Batjargal and Zhang 2021). To manage those and other challenges, the emerging field of 'innovation portfolio approaches' is gaining traction as it seeks to overcome fragmentation and silos in the innovation ecosystem by introducing directionality, reflexivity, coordination at the innovation system level (Hanson and Bleckenwegner 2021). The emerging body of literature on 'open innovation' shows how innovation processes can benefit from dismantling organizational knowledge boundaries both in the public and private sectors (Beck et al. 2022; Lifshitz-Assaf 2018).

4.3. Agility versus strategic long-term R&D

Ongoing responses to changes and innovation *start-stop* culture increases transaction costs and compromises strategic visioning and organizational planning (Kock and Gemünden 2016; Spieth and Lerch 2014; Üçler 2018). Though agility is often presented as good practice, it may be perceived as focusing on *quick wins* and addressing immediate needs, over investment in strategic long-term transformation agendas and pathways, which is a core mandate of many public non-profit R&D organizations. Furthermore, much of the innovation design and testing requires longer time horizons. For example, testing a new crop variety may easily require two growing seasons which – depending on the crop – may easily take up to 2 years. Investing in tech-enabled solutions and other innovations with a vision to scale requires planning and time horizons that go beyond typical donor-funded project durations of two to four years. A related challenges is the limited flexibility to diverge from the original project goals, even if the progressive

insights, learning or changing demands may require so. A study on community-driven development initiatives found that 'a phased program spread over perhaps 10–15 years may be the best course' for innovations to mature from idea to scalable solutions (Binswanger and Azyar 2003). A World Bank study on scaling up rural development programmes indicates even longer idea-to-scale pathways of between 25–30 years (World Bank 2003).

When making decisions on the design of innovation portfolio management structures, criteria and governance, organizations should consider what kind of review frequency and standard operation procedures align with both the short-term organizational goals, as well as medium- to long-term strategic vision and mission. For many public non-profit R&D sector innovation portfolios, meeting the expectations of stakeholders, particularly funders, will play an important role. As a result, public sector portfolio managers might decide to invest significant resources in interventions that can produce measurable results in shorter time frames. Here again, being clear about innovation portfolio ambition and intent, and having transparent decision-making criteria and resource allocation strategies should ensure that the portfolio also responds to longer-term R&D objectives.

4.4. Organizational innovation cultures

Innovation portfolio management goes hand in hand with organizational culture change or growth. Innovation portfolio management seeks to strengthen strategic clarity, process formality and transparency, quality control mechanisms, an environment for learning, and a risk-conscious climate to allow an organization to make better-informed decisions on which innovations have the highest impact potential (Kock and Gemünden 2016). In many public non-profit R&D organizations this will be experienced as a big change that may go against employees' intuitions that innovation is a creative 'process' that should not be 'managed'. The assessment or decision to stop or 'kill' an innovation that they have dedicated much of their career is something that employees could struggle with and that needs to be handled with care. Work by Lifshitz-Assaf (2018) at NASA shows that R&D professionals who receive refocusing coaching or capacity development are more successful in embracing novel innovation management approaches.

Innovation portfolio management seeks to bring greater balance between the support of new ideas, and the continuous incremental improvement and scaling of existing innovations (Kumpf and Proud 2022). Traditionally, public R&D employees might focus more on novelty and testing new ideas, and be less equipped or interested in supporting the scaling of these innovations with partners. An additional complicating factor is that innovation portfolio management is likely to be influenced by external actors (such as funders), who may prioritize investment in exciting novelty over increment innovation. Given the fact that innovation portfolio management is currently far from being mainstreamed in the public sector, resistance to change is realistic and needs to be acknowledged and managed sensibly.

Innovation portfolio management is as much about organizational mindset change as it is about the operational methods, and mechanisms to make it work. It is essential to find the right balance between expanding the organizational innovation culture and mindset boundaries on the one hand, whilst ensuring buy-in and support across

organizational levels on the other hand (Holtzman 2014). What would be important is to demystify some innovation portfolio management myths (e.g. that this increases top-down decision-making, innovation cannot be measured), and emphasize its advantages (e.g. that it provides a more transparent framework for risk management, that it can increase space for learning).

4.5. Transition from established practices to explicit innovation portfolio management

Transitioning from established practices to explicit innovation portfolio management is undoubtedly a complex endeavour. However, our research sheds light on the challenges and success factors inherent in this process, offering valuable guidance for those embarking on such transitions. Central to this is the formulation of a clear and realistic roadmap for innovation portfolio management that is intricately linked to the organization's overarching vision and mission. Moreover, it is important to elucidate how existing organizational practices present obstacles and risks, and articulate how innovation portfolio management will address these challenges. Key components of a successful transition process include securing buy-in and support from investors and leadership, fostering transparency regarding criteria, resource allocation strategies, and governance, investing in organizational culture and capacity growth as part of change management efforts, and restructuring organizational incentive mechanisms to encourage tolerance for innovation failure and prioritize portfolio performance and impact over individual project achievements.

It is crucial to recognize that there are no universal solutions for transition processes, as each must be tailored to fit the unique vision and culture of the organization. Early case studies, such as that by Schut et al. (2024), offer valuable insights into the complexities and nuances of innovation portfolio management transitions within public non-profit R&D organizations.

4.6. Study limitations and future directions

We acknowledge that our literature review approach has limitations. An important limitation is that the search was conducted in English only. Another limitation is that our initial literature search was relatively unstructured. A more structured or systematic literature search (e.g. with more diverse search terms) would have resulted in a much larger sample of the literature. Nonetheless, we are confident that the study managed to identify the main reasons, successes and challenges for innovation portfolio management, which offers a crucial starting point for further studies to dive deeper into the specific results and conclusions.

5. Conclusions and outlook

Allocating scarce resources to innovation endeavours is a daunting task for many organizational decision-makers in both the private and public R&D sectors. While many public non-profit R&D organizations refer to innovation as being part of their core business, few explicitly lead and manage their portfolios intentionally, and ad hoc innovation

management still prevails over more systematic innovation portfolio management approaches.

Private sector organizations invest in innovation portfolio management to: (i) enhance transparent and quality decision-making, (ii) strengthen organizational agility and mission-orientedness, (iii) facilitate monitoring, risk management and prioritization, and (iv) improve overall organizational performance. These reasons are equally important to the public non-profit R&D sector. Success factors for portfolio management include (i) developing fit-for-purpose systems to ensure timely access to quality information and metrics, (ii) having clarity on innovation portfolio intent and related decision-making criteria, and (iii) investing in organizational innovation culture growth and capacity. The main challenges include: (i) data and information gaps and inappropriate decision-making criteria, (ii) organizational fear of taking risk and failure, and (iii) organizational resistance to innovation portfolio management.

For innovation portfolio management to succeed in the public non-profit R&D sector it is important to acknowledge some key similarities and differences compared to the private sector. Similarities are related to the importance of having clarity on the organization innovation portfolio intent and having transparent hard and soft criteria and resource allocation strategies to ensure a healthy and diverse innovation portfolio that delivers against the short- and long-term organizational mission. Differences can be found in the importance of internal collaboration and external partnerships for innovation to address complex or wicked global challenges; the incumbent organizational innovation cultures and mindsets and how these are being reinforced by funders and incentive mechanisms; and finally, the tension that may result from a focus on immediate needs and emergent opportunities, over investment in strategic long-term transformation agendas and pathways.

There are no *plug-and-play* solutions for innovation portfolio management in the public non-profit R&D sector. Innovation portfolio management is as much about putting in place methods (systems and tools to have timely access to quality data on innovation) and mechanisms (incentives and decision-criteria to align the portfolio with the organizational mission), as it is about growing the organizational capacities and mindsets (the underlying cultural and capacity (change) dimension) in a transparent way that embodies trust and confidence among employees and funders. What constitutes the right set of Methods, Mechanisms and Mindsets will vary across organizations, and has to be tailored to their mission, portfolio intent, and organizational culture.

Note

1. Innovation portfolio management takes an organisational approach to managing innovations and is distinct from mission-driven or systemic innovation portfolio approaches that combine the interventions of multiple organisations towards a shared mission or intent.

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