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STRATEGIC ALIGNMENT OF AN R&D PORTFOLIO BY CRAFTING THE SET OF BUCKETS

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ABSTRACT

The strategic buckets method is often posited as an approach to ensure the strategic alignment of an R&D portfolio with firm's strategy. Despite its popularity, crafting the right set of buckets to allocate resources is not a straightforward task. We consider the question of how to establish a set of buckets that aligns the R&D portfolio with the business strategy. We carried out a case based research, and investigate seven companies in order to propose a framework to assist decision makers in designing this set of buckets. Our framework is composed of four strategic constructs, namely technology, market, capabilities, and organizational processes. In addition to these four constructs, we suggest that the external environment also be taken into account. We discuss the key benefits and offer theoretical insights concerning the strategic constructs, which can be combined and divided, resulting in a set of buckets that better suits a company's strategy. In addition, we acknowledge the idiosyncratic nature of firms and, as opposed to prescribing a static approach for companies, we suggest the design of buckets as a dynamic process to be performed according to the four different constructs, together with a firm's interaction with the external environment. We close by discussing the implications of our approach.

MANAGERIAL RELEVANCE STATEMENT

In this paper, we consider the question of how to craft a set of buckets that aligns the R&D portfolio with a business strategy. Our main contribution is to offer a comprehensive framework to support the design of the set of buckets, which can be used to assist decision makers in the process of project selection and resource allocation in an R&D portfolio. In short, the use of the strategic buckets approach is necessary when decision makers are unable to compare in a satisfactory manner different projects' initiatives. Through the investigation of seven case studies, we were able to scrutinize how exemplar companies design the set of buckets. In addition, we thoroughly examine how the buckets design are associated with the three portfolio goals, namely value maximization, balance, and strong link with firm's strategy. Because a firm's strategy might have multiple goals, we suggest the use of buckets and sub-buckets as

building blocks to deal with non-comparable initiatives. Furthermore, we acknowledge the idiosyncratic nature of firms and, as opposed to prescribing a static approach for companies, we suggest the design of buckets as a dynamic process to be performed accordingly.

Key words: R&D Portfolio, Strategic Buckets, Strategic Alignment, Case Studies

I. INTRODUCTION

It is well known that a firm's strategy to develop new products leads to a sustained competitive advantage in the medium and long terms. However, in spite of its importance, decision-makers often struggle to align a company's strategy with the selection of projects and the allocation of resources in an R&D portfolio [10], [7], [16], [29]. The strategic buckets method is often posited as an alternative to deal with such a challenge as it secures resources for critical projects. Furthermore, its use has been strongly linked to positive performance in product innovation in many of the best-performing companies [11], [7].

Similar to [8], [12], [54], we consider the strategic alignment, or fit, between R&D portfolio and business strategy as a key lever for firm's performance. The importance of strategic alignment has been investigated in several contexts. For instance, [40] investigate the alignment between project management and business strategy, [6] and [31] investigate the alignment between IT projects and business strategy, and [1] examine forms of alignment and the performance of new product development (NPD) projects. In the context of an R&D portfolio, researchers have argued that a balanced portfolio assist companies in managing risk [8] and in ensuring strategic alignment to achieve its (firms) multiple goals [12].

Extant research has highlighted the role of balance and its impact on the performance of the R&D portfolio [39]. In line with that, the impact of strategic buckets to balance firm's effort with regards to the innovative level is investigated [7] – i.e., the balance between radical and incremental innovations, when forming the R&D Portfolio. Notwithstanding, the allocation of

resources in an R&D portfolio is also influenced by the available information, organization politics, and management intuition [33]. So, the strategic buckets is posited as a means to overcome the information asymmetry between senior management and the project manager [29], and the role of organizational enablers for NPD portfolio selection is scrutinized, for example, to better understand how explicit and implicit incentives affect innovative outcomes [30].

Of particular interest is the work of Cooper and Edgett, who thoroughly investigate the strategic buckets method (see, e.g., [12], [11], [16]). These authors propose a more flexible method, linking strategic buckets to the concept of strategic arenas—e.g., markets, industry sectors, applications, product types, or technologies—in which managers need to focus a firm's efforts to develop new products. The ultimate goal of a company is to allocate resources to each strategic arena to ensure enough assets to achieve the firm's objectives through product innovation. The key point when operationalizing the method is to define which dimensions should be used. According to Edgett ([16], pp.162), "They should be the dimensions that management finds the most relevant to describe their own strategy." However, as also discussed by [16], the question of how to establish a set of buckets that aligns the R&D portfolio with the business strategy is still unanswered. That is precisely the research question this paper investigates.

There have been noteworthy attempts to assign resources to fund NPD initiatives into buckets. For instance, [56], and [7] propose the allocation of resources according to the NPD innovative level. In general, these authors suggest that managers should balance their investments in an R&D portfolio to secure resources for critical projects, because a successful NPD portfolio may include projects that focus on minor product improvements and cost reductions, as well as projects involving radical and breakthrough R&D initiatives. A slightly different approach is

taken by [50] and [44], highlighting the need to consider not only the innovative level but also the market in which a company is willing to operate. In other words, the strategy for the R&D portfolio should focus on the types of NPD projects and on the target markets.

We remark that considering only the technology and market dimensions might not be enough to capture a company's innovation strategy. Other operational levers inherent to the firm can also be sources of a competitive advantage. These levers are usually grounded in such theories as resource-based view ([3], [4]), operations-based strategy ([21], [25], [26], [27]), and dynamic capabilities ([49], [19]). In addition to the operational levers, through multiple case studies, we were able to identify the need to position the company in a broader context, that is, position the company vis à vis the external environment in which it operates. The extant literature, however, has been silent with regards to these operational levers and the external environment when crafting the set of buckets.

Moreover, we consider the fact that portfolio decision making is a social and technical process that involves individuals with distinct goals and interests who aim to persuade each other through power relations ([18], [23], [33]). Individuals carry out a process of allocating resources with the limits of human rationality—i.e., they are bounded rational decision makers [48]. That is, in line with [23], the managers involved in the portfolio decision process do not have perfect knowledge of their set of choices, and they cannot anticipate all outcomes of funding a particular initiative. They have a limited attention capacity, and thus, they have difficulties in processing a large volume of information ([42], [43]). We suggest using strategic buckets as a mechanism to break the information structure that characterizes the R&D portfolio to reduce the set of options to allocate resources so that decision makers can compare projects in a more meaningful way. Thus,

the opportunity to select comparable initiatives is reduced to each bucket, and the projects inside each of them can be compared because they are more similar (but not identical).

In this paper, we used an inductive-deductive approach and proposed a framework to craft a set of buckets in an R&D portfolio. We developed first a preliminary theoretical framework based on in-depth case study. Then, we refined such a framework through a series of case studies conducted in seven leading corporations from different segments. Our framework is composed of four strategic constructs, namely technology, market, capabilities, and organizational processes. In addition, the external environment is also considered.

In addition to proposing a novel framework, we thoroughly discuss the key benefits of the strategic constructs that can be combined and split, resulting in a set of buckets that better suits a company's strategy. In short, as opposed to considering a set of predetermined dimensions (e.g., typologies concerning market and technology dimensions), our approach considers the allocation of resources in buckets as a dynamic process that should be constantly revisited to reflect a firm's strategy.

II. METHODOLOGY

Our research question asks how to establish a set of buckets that aligns the R&D portfolio to the business strategy. To answer this question, we first conducted an in-depth case study at Natura, a major cosmetics company. Moreover, we scrutinized R&D portfolio management theory and other theories from alternative management domains in an attempt to explain and understand the strategic buckets design. This fact motivated us to conduct multiple case studies. The multiple case analysis is shown to be more convincing and more robust for the research objective analysis [57]. Through this research approach, we interacted with companies in an

inductive way, and thereafter, we tested theory in a deductive way [55]. Figure 1 shows a summary of our research approach.

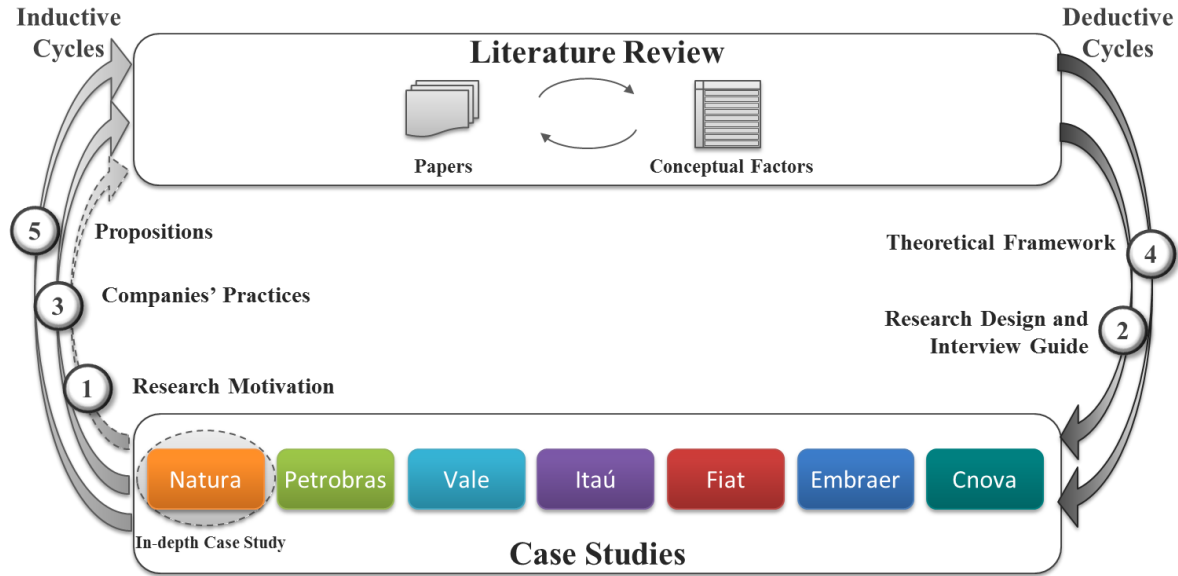


Figure 1: Research summary

According to [55], an inductive-deductive approach can be classified as theorizing, theory testing, and theory building. In the first cycle, we brought up the related literature to theorize about the delineation of buckets so that projects could be grouped and resources allocated. We identified five strategic dimensions that can play a role in such a process (we describe each dimension in the next section). Then, in the second cycle, we investigated the appropriateness of each dimension through a series of case studies. Thereafter, in the third cycle, the strategic dimensions/constructs were further refined, and our theoretical framework was shaped. In the fourth cycle, we returned to the companies to validate our analysis. From these interactions, in the fifth cycle, it was possible to offer a series of theoretical insights to assist decision makers in crafting a set of buckets.

A. Sample

We studied seven exemplar multi-national corporations with strong records of accomplishment that were market leaders during the research period. We chose companies from different segments (see Table 1) that pursue diverse management processes. The companies were Natura, Petrobras, Vale, Itaú, Fiat, Embraer, and Cnova. The unit of analysis was the entire company for all companies but Fiat, in which case we focused on the Brazilian branch.

Table 1: Companies' Profiles (2014 Figures)

Company	Sector	Gross Revenues	Employees	R&D Investment
Natura	Cosmetics	US\$ 2.8 billion	6,591	US\$ 81.3 million
Petrobras	Energy	US\$ 23.4 billion	80,908	US\$ 640.2 million
Vale	Mining	US\$ 37.5 billion	76,500	US\$ 734 million
Itaú	Bank	US\$ 34.5 billion	88,103	US\$ 3.9 billion ⁽¹⁾
Fiat Chrysler Automobile ⁽²⁾	Automobile Manufacturing	€ 96.1 billion	225,587 ⁽³⁾	€ 2.5 billion
Embraer	Airplane Manufacturing	US\$ 5.6 billion	19,167	US\$ 277.1 million
Cnova ⁽⁴⁾	E-commerce	US\$ 1.4 billion	2,500	US\$ 13.9 million

(1) Total investment between 2012 and 2014.

(2) The information listed refers to the entire FCA group. Specific figures of the LATAM branch were not disclosed.

(3) Number of employees in Brazil: 11,500.

(4) Cnova was previously named Nova Pontocom

According to [57], an aggregate analysis of six to 10 cases is preferred so that results can be generated and theoretical arguments can be supported, ensuring the validity of external data. In addition, multiple cases guard against observer bias [55]. As show in figure 1, we started by conducting an in-depth case study at Natura and, subsequently, added the other case studies until we reached saturation. After three case studies, we were able to validate the theoretical framework (i.e. we reached saturation after three case studies). The subsequent case studies were deemed to validate the conceptual factors to assist buckets design, and we reach saturation after six case studies.

B. Research Protocol

To ensure internal validity, we developed a research framework from extant literature. This instrument is the starting point of theory clarification, as well as a pattern to guide research development [55]. Because the framework reflected our research questions, we used it to limit the case studies' scope (as suggested by [57]). We developed an interview guide (see appendix) to guarantee the construct validity, the aim of which was to ensure the reliability of the data collected. The interview guide was validated in a pilot study, which was applied to an interviewee from one of the companies but which was not used as the final data for our analysis. The importance of validating the research protocol is emphasized by [57], as it provides greater security for researchers to deal with uncertainties during the study course.

C. Data Collection

The first step in conducting the field research was to identify the right people to interview and the relevant data in the organization, as suggested by [55]. We contacted the upper management team, who was directly involved in the process of selecting initiatives and allocating resources. Whenever it was not possible to have access to the manager directly in charge of the R&D budget, we contacted either a member of the executive committee in charge of selecting the initiatives to be funded or an intermediary analyst who participated in the portfolio meetings. In this first contact, we explained the aim of our research, and asked for a meeting with company's team members involved in the portfolio decision process, which would then be followed by interviews with selected informants. After establishing the first contact, we asked permission to study company's documents and to attend formal portfolio decision-making meetings. Company's documents were scrutinized to acquire familiarity with company's approach to the portfolio decision process, organizational structure, and some firm specific terms/words used in the process. Data was collected over a one and half year period.

At each company, the first meeting was retrospective in the sense that the team members prepared a presentation to describe the R&D portfolio management process and how initiatives were selected and funded. In most of the companies, the meeting featured PowerPoint slides, and set the ground for the interviews (see Table 2). In some companies, such as Natura, Petrobras and Vale (see Table 2), we had the opportunity to conduct subsequent meetings to further explore company's approach to the portfolio decision process. Note that these subsequent meetings were either formal portfolio meetings or retrospective ones, and all of them were driven by a company manager with the collaboration of key team members. Thus, these informal meetings were seen as an opportunity to triangulate the data, increasing validity and reliability of the data collected, and allowed us to perceive the interaction among the team members. These meetings lasted between 1 and 2 hours. Moreover, at Natura and Petrobras we had the opportunity to attend formal portfolio decision making meetings. The Natura's meeting lasted 4 hours and the Petrobras' one lasted 2 hours, both featured with power point presentations and detailed information about projects.

We followed the recommendation of [17] and [57], and we collected information from more than one decision maker so we could capture different perspectives, triangulate the information gathered, secure reliability of the data collected, and increase the validity of our constructs. As shown in Table 2, it was possible to gather multiple perspectives in all companies but Cnova. Nevertheless, the information gathered from Cnova was considered valuable for two reasons. First, there was a restrictive number of participants on the executive committee and the interviewee participated in all portfolio meetings. Second, at this point of the research, we were approaching saturation and the findings corroborated with the data collected from the other companies. We remark that in some companies the budget exclusively funded R&D projects

(e.g., Embraer, Fiat, Natura, Petrobras, and Vale). At CNova and Itaú the development funds covered initiatives corresponding to not only R&D projects but also initiatives associated with performance and process improvement.

Table 2: Collected Data

Company	# Initiatives funded per year	# Portfolio Meetings	# Informal Meetings	# team members at the informal meetings	# Interviewees	Types of Informants (interviewees are indicated by *, ** indicates two interviewees of the same type)
Natura	100	1	5	5	2	Science and Technology Director, Innovation Manager*, Program Manager, R&D Analyst*
Petrobras	500	1	4	4	4	Portfolio Manager*, Financial Analyst*, Senior Engineer**
Vale	400	0	3	2	2	R&D Analyst*, Senior Researcher*
Itaú	6000	0	1	2	1	IT Processes and Demand Management General Manager*, Project Panning and Strategy Analyst
Embraer	50	0	1	6	5	Program Director*, Program Manager*, Portfolio Manager*, Project Manager**
Fiat	20	0	1	2	1	Product Planning and Strategy General Manager*, R&D Analyst
Cnova	70	0	1	1	1	Project and Strategic Planning Manager*
Total		2	16	22	16	

After the first meetings with key decision makers and team members, we conducted the interviews according to the interview guide (see appendix). The interviews lasted at least 90 minutes, and they were carried out following an adaptive process in which several questions were formulated on the spot. Two interviewers conducted the interviews either simultaneously or independently. The authors opted for not recording the interviews for two main reasons. First, some of the interviewees opposed recording. Second, the authors realized that the interviews

would flow more naturally and the interviewees would not police themselves when talking about sensitive information. To ensure validity and reliability, the authors scrutinized the notes taken after each interview and send them back to the interviewees to ensure that the information collected was valid and reliable.

Each interviewer took notes independently, which were then triangulated with the other interviewers' notes and with secondary sources (e.g., company internal reports, publically available information). After triangulating the information, in case there was any divergence or inconsistency in the data, the interviewees were contacted by e-mail to rectify information.

After the first round of interviews, we reflected on the information collected from the cases and our framework, and then returned to the companies in the fourth cycle, as shown in figure 1, to validate the data collected. We also presented the constructs that were in line with each company's strategy. The interviewees raised several questions and engaged in a conversation with the researchers. Whenever we were unable to follow up in a face-to-face meeting with some interviewees, we sent an e-mail with the company's case description so the interviewee could validate the information gathered. Through this process, we were able to validate and finalize the data collection process.

III. RESULTS

Our theoretical framework, depicted in Figure 2, consists of four dimensions, in addition to the external environment. The starting point of appraising our framework involves considering two general strategies a company can pursue. The first, differentiation, is centered on the attempt to develop a product/service involving a valued technology or to offer it to a specific market segment. Therefore, the firm's goal is to achieve a superior performance through NPD to sustain

its market power. Such a strategy entails the technology and market dimensions. In the second strategy, the focus is on using the company’s resources/capabilities efficiently, and it encompasses the capabilities and organizational processes dimensions. Therefore, through the second strategy, the firm aims to secure a competitive edge either through product margins or through cost management, or to acquire an understanding of possible future technology/market landscape by developing new capabilities. The external environment consists of multiple factors that affect the decision process, such as culture, society, and resources [42]. Changes in the external environment can be reflected in changes in the other dimensions, which up to that point were a source of a competitive advantage (this observation is in line with [19]).

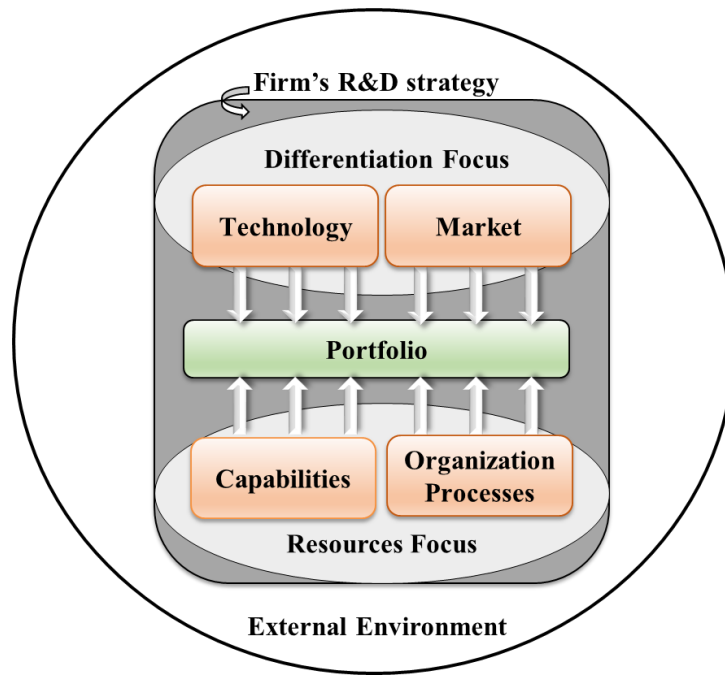


Figure 2: Theoretical framework

Note that the two strategy types—differentiation and resource focus—are not mutually exclusive. In addition, each of the four dimensions can be deployed into a group of conceptual factors to be used to design the set of buckets. In Table 3, we suggest a set of factors to craft the set of buckets. We further explore each of the dimensions next.

Table 3: Examples of Conceptual Factors That Can Be Used to Design the Set of Buckets

Dimension	Conceptual factors to assist buckets design	Key Benefits	Evidence from the cases	Link to related literature to assist bucket design
Technology	Innovation Level	- Secure resources to fund projects at different innovative levels - Balance short term and long term goals	- Natura's goal was to increase portfolio diversification/balance. Thus it secured funds to develop initiatives related to its core business and to pursue the development of radical innovations. - Embraer used buckets to manage the time horizon of its development initiatives by clustering projects with expected duration of 2 to 3 years, and projects with expected duration of 4 to 5 years.	[56], [12], [45], [7]
	Technology Complexity	- Manage a wide range of knowledge - Ensure integration of different subsystems	Embraer clustered its projects and development teams according to the airplane systems in order to take advantage of learning routines and deal with knowledge gaps	[13], [47], [22], [7]
Market	Market Niche	- Secure resource to fulfill the needs of specific markets - More rapidly react to new market trends	- Natura sorted the development projects according to product characteristics (e.g., hair, body, face) and specific market features (e.g., baby products, premium makeup) - Embraer divided its business units according to the markets it operates (executive jets, commercial airplanes, military aircrafts)	[32], [14], [9], [2],
	Brands	- Fulfil brand-specific needs and purchasing behavior	- Cnova reserved resources to support the development of different initiatives to increase product mix of some brands.	[32], [24], [5]
Capabilities	Core Competences	- Make better use of scarce resources. - Foster some areas of expertise.	- Petrobras divided its R&D budget according to its engineering domains to reflect its core competences and support the continuity of company's business. - Natura organized its development team according to its area of expertise in order to foster its business in a balanced manner	[13], [38], [49], [19]
	Dynamic Capabilities	- Develop a set of capabilities to seize new market opportunities and deal with emerging technologies.	- Petrobras reserved a specific budget to fund projects under the category "vision of the future". - Natura allocated part of its development budget to fund projects entitled "knowledge initiatives".	[49], [34]
Organization Process	Value Chain	-Focus on firm's potential sources for differentiation at each step of the supply process.	- Petrobras had business units and allocated funds to NPD initiatives according to its supply chain.	[46], [21]
	Functions/ Operations	- Exploit organizational structure and functions.	- Vale managed its portfolio according to its business units, independently. Business unit managers had autonomy to focus their attention on specific issues related to their own business. - Itau structured its operations in business units and new development initiatives were launched to target specific needs of each business unit	[46], [15]
	Process	- Focus on specific process to increase productivity and efficiency, or differentiate.	- Cnova invested to reduce delivery time by focusing development efforts to improve the logistic process.	[15], [25], [46]
External Environment	Regulatory Environment	- React faster to new public policies and professional norms, intellectual property regimes, among others - Improve compliance of firm's processes	Cnova allocated one third of the portfolio budget to initiatives to cope with current legislation. Natura allocated development budget to develop new tests to cope with policies concerning the reliability and efficiency of its processes	[41], [45], [53]
	Partnerships	-Leverage resources through partnerships. -Develop off-the-shelf technologies	- Natura allocated part of its development budget to foster open innovation initiatives. - Petrobras and Vale partnered with universities to develop off-the-shelf technologies	[36]

A. Technology

Strategic buckets and technology differentiation are widely discussed in the literature (see, e.g., [56], [7], [50]). According to [47], the technology dimension is especially important to firms that operate in rapidly changing environments characterized by fierce competition. We suggest two factors to assist managers in breaking the information set, so projects can be compared and resources secured to fund certain strategic initiatives. The first captures the level of innovation (or uncertainty) involved in developing a certain technology, which could also be seen as a proxy for risk. The second captures the technology complexity associated with the development of the projects.

1) *Innovation Level:*

In dynamic environments, firms must deal with many uncertainties and risks inherent to the technology development process [45]. If one manages a firm's NPD portfolio using traditional NPD/portfolio assessment methods, quite often, the importance of highly innovative projects is undermined due in part to the longer payback period and the high risks involved in development [7]. Thus, if a firm allocates resources into buckets according to the innovation level (or underlying risk), resources to fund the development of breakthrough technologies are guaranteed, and, at the same time, the NPD portfolio can be balanced better according to its risk propensity.

For instance, one of the goals of Natura, the cosmetics company, was to increase portfolio diversification (or balance). To accomplish this, it reserved a certain share of its NPD budget to fund radical innovations and another part of its budget to fund initiatives related to its core business. Using this approach, Natura made its strategy clear to all stakeholders, providing an incentive to those working with NPD to propose different projects. This is in line with [7], who

argue that distinct projects with different underlying risks cannot compete for the same resources. By splitting the R&D budget in such a way, the firm can reduce projects that will be compared with each other, and decision makers need not ponder projects with intrinsic risk that differ completely from one another. The projects within each bucket have comparable underlying risks, which leads us to propose that firms aiming to develop disruptive technologies and at the same time focus on their core business can secure resources to accomplish this goal by crafting their set of buckets according to the innovation level intended for their projects.

2) *Technology Complexity:*

In other scenarios, the most critical factor in developing a technology is its (technology) complexity. Highly complex products demand a wide range of knowledge to integrate the different sub-systems. One alternative to deal with this issue is to divide the set of NPD projects into modules that involve similar functions and specific knowledge associated with their development [47]. Therefore, designing the set of buckets according to technology complexity secures resources to develop the modules. Furthermore, the firm can foster the development of some core capabilities related to specific knowledge domains.

Embraer, the airplane manufacturer, is one example. The design of an airplane is complex, requiring a high reliability level to operate once the product is launched onto the market. To secure product quality in all modules, Embraer divided its projects and development team according to the airplane systems: avionic and hydraulic systems, flight control, and landing gear, among others. According to [13], such procedures are a consequence of applying learning routines to deal with knowledge gaps. By allocating resources in such a way, the firm fostered the development of operational procedures characterized by high performance [22], which are essential to developing technologies characterized as highly complex and risky. Therefore, we

infer that firms willing to ensure the operational reliability of highly complex and risky technologies should craft their set of buckets according to the NPD modules.

B. Market

The importance of assessing this dimension lies in the straightforward fact that one of a company's overarching objectives is to establish a permanent relationship with its customers [14]. Nevertheless, it is not possible, perhaps not even desirable, to fulfill the broad needs of customers from a vast market range. Furthermore, firms willing to differentiate themselves in this dimension should focus their resources on markets and customer needs that are related to their own strategy. Thus, we consider that strategic alignment in the market dimension is achieved by clustering the projects in the NPD portfolio into the conceptual factors market niche and brands. In doing so, the firm can secure resources to develop projects that fulfill the needs of its strategic markets.

1) Market Niches:

Similar to [14], we consider market niche as a smaller market consisting of an individual client or a group of customers that has similar needs and characteristics. By dividing the NPD portfolio budget according to targeted niches, a firm can better direct its development efforts and resources to fulfill customers' needs and, therefore, more rapidly react to new market trends [2]. In this way, companies secure resources to develop projects that target only strategic niches. Moreover, in doing so, firms can allocate resources to enter into new markets.

One example is Natura, the cosmetics company, which sorted its projects according to product categories that were associated with product characteristics (e.g., hair, body, face) or specific market characteristics (e.g. baby products, premium makeup). One of the firm's goals was to

increase its participation in the perfume market by launching products in price segments in which it had not been operating at the time of the research. To accomplish this goal, Natura secured resources for NPD projects within this category, hindering other development projects within other categories that could be cannibalized by this one. Another example of NPD initiatives oriented to market niches is Embraer, the airplane manufacturer, which divided its business units according to its clients (e.g., executive jets, commercial airplanes, military). Given the fact that an airplane is a product characterized by its high value and long product lifecycle, the firm needed to keep a close connection with its clients to fulfill their expectations. Therefore, by separating its NPD portfolio initiatives, the firm was able to follow its clients closely from each segment. For example, for the executive jet clients, Embraer developed different versions of the same product so that each client had the option to acquire a customized product. Itaú, the bank, also structured its business units according to the market segments, and by doing so, each unit set out specific strategies, focusing on its own customers.

In short, by designing a set of buckets according to market niches, firms can focus their attention on the trends of their target markets and, therefore, better understand customer behaviors. In line with this, we conclude that firms aiming to develop products/services that target specific market niches can secure resources to accomplish such a strategy by crafting a set of buckets as a function of the market niches.

2) *Brands:*

Brands could also be seen as a way that customers can express their preferences and behaviors [32], and one can argue that brands represent a market niche or a group of niches with a similar demand. In fact, as shown by [5], brands that are positioned differently require different firm capabilities and resources. Thus, many corporations structure their product portfolios with

multiple brands so that different customer segments can be targeted. In addition, as discussed by [24], companies usually structure their business units as a function of their brands, which led us to hypothesize that resources could be allocated in an R&D portfolio in a similar fashion. By independently managing their brands, firms aim to fulfil better market needs by, in part, understanding brand-specific markets better.

Cnova, the e-commerce company, could be seen as a multi-brand firm, where each brand targets a specific market, characterized by well-defined needs and purchasing behaviors. One of Cnova's strategies was to increase the product offering of a certain brand in its virtual stores. To achieve such a goal, the firm reserved resources to support the development of different initiatives, with the aim to increase its product mix from that particular brand. One particular insight from this example was the fact that designing buckets according to brands can support a company's idiosyncratic strategy. That is, if a firm has distinct strategies for each one of its brands, it might be warranted to divide the development budget accordingly so that resources are secured to foster each brand. Therefore, we posit that firms aiming to manage different brands with distinct strategies should secure resources to support the development of their products by crafting a set of buckets according to their brands.

C. Capabilities

The capability approach emphasizes that the performance of a firm is a function of its knowledge, abilities, experiences, and institutional structures, as well as its interrelations with other firms ([4], [49], [19]). Such a dimension is of particular importance to firms that engage in developing technologies that, for instance, require capabilities that cannot be acquired easily. Thus, a firm operating in a dynamic environment with the goal to excel through technology

development or by fostering new markets should allocate part of its development budget to leverage capabilities that support such a goal. As noted by [51], a firm should develop both its core competences, as well as its dynamic capabilities, as both are needed to foster the development of new technologies, to assess new customer needs, and to ensure that new products fulfil them. Thus, core competences and dynamic capabilities, to some extent, support the development of new technologies and markets [52].

1) Core competences:

Core competences consist of selecting effectively the functions, routines, or practices that capture a successful approach to specific problems [38]. Such competences can be found in product lines, or they can even transcend the boundary of the firm through partnerships [49]. The degree to which a core competence is unique depends on how well positioned the company is in terms of its competitors, as well as on how difficult it is for a firm's competitors to imitate it [4].

The case of Petrobras illustrates the importance of core competences. The company divided its R&D budget as a function of its engineering domains (e.g., maritime oil wells, land and shallow water, deep waters, ultra-deep waters, refining, operations, logistics, natural gas, energy), reflecting the company's core competences. The engineering domains were meant to be a structural base to support the continuity of Petrobras' business. Similarly, Natura strategically managed its core competences, as they were seen as critical to developing new initiatives or technologies. Natura organized its development teams according to its areas of expertise (e.g., ingredients, formulation, and packaging). In doing so, the company aimed to foster the development of each area of expertise and, in addition, to identify weaknesses more easily that require initiatives for improvement.

Through the case studies, we were able to determine that firms divide their R&D budgets according to their core competences when they need to either make better use of scarce resources or foster some of their areas of expertise. Through this approach, the companies accumulated specific knowledge in different areas of experience, which improved learning on each development team (such an observation is in line with [13]). Therefore, we propose that a firm aiming to excel through its current areas of expertise must secure resources to accomplish such a goal if the set of buckets is crafted according to the firm's core competences.

2) *Dynamic Capabilities:*

A firm should aim to develop a set of capabilities that enables it to operate in a more proactive way so that it can seize new market opportunities and deal with emerging technologies. Dynamic capabilities are associated with a firm's processes that enable it (firm) to react to market changes or to create new opportunities by integrating, reconfiguring, or leveraging the company's routines [49]. Such capabilities are defined as being transformational experiences associated with a firm's ability to reconfigure its resources to respond rapidly to new market entry opportunities [34].

At Petrobras, there was a specific budget to fund projects under the category "vision of the future." Through these projects, the company aimed to anticipate possible future scenarios by funding NPD projects to deal with such circumstances. Embraer also allocated part of its resources to fund R&D projects that are not directly embedded in its products. The focus of such initiatives was not on developing a particular product or component, but rather on acquiring state-of-the-art knowledge and, therefore, keeping up with technology improvements. Natura allocated part of its R&D budget to fund projects entitled "knowledge initiatives." Such projects aim to acquire and diffuse knowledge associated with current trends in science and technology.

Based on such observations, we infer that firms aiming to acquire knowledge from different technology domains or to extend the technology frontier should secure resources to accomplish such a goal by crafting their set of buckets according to dynamic capabilities.

D. Organization Processes

The processes of an organization are also an important dimension for designing the set of buckets. This fact becomes more evident in firms that operate in a competitive landscape in which there are few technology and market barriers for other players' entry [27]. That is, companies that have direct access to technologies or that compete for clients whose needs are already fulfilled by incumbent firms often aim to excel through organizational processes. Thus, a firm that chooses to differentiate itself in this dimension should establish some processes with which it wants to be distinctly associated and then allocate resources to achieve such a goal. The value chain approach, proposed by [46], is one alternative for a firm to identify which processes have the potential to offer a competitive advantage.

Through our case studies, we identified three disaggregation levels. The first corresponds to the value chain, which can be divided into specific operations. Vertically integrated firms (e.g., Petrobras) need to appraise this first level of disaggregation when allocating resources in the NPD portfolio. The second level encompasses business operations and functions concerning business and operational units, which is the case with Itaú and Vale. The third level is more specific, as it deals with individual processes through which a company might want to excel, which is the case with Cnova and Embraer.

1) Value Chain:

A vertically integrated firm can usually benefit from not having supplier markups, and this fact might differentiate a firm from its competitors [46]. Nevertheless, the portfolio decision process in vertically integrated firms is complex, and one must break down its complexity to be able to assess (some) projects meaningfully [20]. Therefore, at the first level of analysis, we can design a set of buckets according to a firm's value activities [46]. In doing so, firms aim to understand better the costs drivers and potential sources for differentiation at each step of the supply process. In short, firms should identify possible factors that will lead to a competitive advantage and should allocate resources to develop initiatives in line with their core business.

Petrobras, for instance, had business units configured according to its supply chain (oil and gas exploration and production, refining, supply of natural gas, distribution, petrochemicals and fertilizers, generation of electric energy, biofuel production, and transportation and trade, among others). The resource allocation to fund NPD projects followed this logic somehow. By dividing the R&D budget according to its supply process, the firm was able to set clear goals for each business unit, and it allocated resources to each of them. We thus posit that vertically integrated firms can secure resources to develop their different initiatives by crafting a set of buckets according to their value activities.

2) Functions & Operations:

According to [46], a business might be defined as a series of functions (e.g., technology development, operations, marketing & sales, etc), and the organizational structure might cluster some of these activities into functional units. The rationale behind the clustering idea is that similar activities might be better exploited if they are grouped together in a department. Therefore, by using the value chain approach, a firm can identify which business functions or

operations offer potential opportunities for differentiation and which offer a competitive advantage.

In the case of Vale, the management of its R&D portfolio was decentralized to its business units (e.g., mining, base metals, fertilizers, logistics, and energy). Each of these business units has its own supply chain, operations, and markets that, consequently, led to the setting of specific goals. Thus, by designing a set of buckets to allocate R&D investments according to these business units, managers were able to focus their attention on specific issues related to their own business.

Itaú also allocated its investment portfolio according to the initiatives proposed by its business units. Some of the business units were centered on the bank's clients (e.g., branches, credit cards) and, therefore, had their specific goals in mind. Other business units were associated with the bank's internal operations (e.g., human resources, legal department, IT), which in turn led to its goals being centered on their own operations. By dividing the R&D budget according to its units, the bank was able to focus its attention on key operations. This fact facilitated the identification of opportunities to fulfill clients' needs and the bank's operations better. In line with this, we propose that firms characterized by a wide range of business functions/units can secure resources to accomplish their strategy by crafting a set of buckets according to their operations.

3) *Process:*

A process can be defined as the sub-components of a firm's operations, such that they (operations) are realized through individual steps [15]. Even though a firm does not necessarily have to divide its operations into micro units of analysis, it might be worth considering this option to improve competitiveness [25]. Therefore, a firm can leverage a competitive advantage

by differentiating itself from its competitors in terms of the way it executes and manages its key processes.

Cnova, for instance, identified the logistic process as critical. One of the company's goals was to reduce delivery time, so to secure resources to achieve such a goal, Cnova divided its R&D budget according to its processes, and it set goals for each. In Embraer's case, a certain supply unit also had its development projects structured according to its production process. Because these projects were characterized by a high level of complexity, allocating the R&D budget according to the production process improved the focus on process efficiency and assured quality and reliability. Therefore, we conclude that firms characterized by a wide range of critical processes can secure resources to accomplish their strategy by crafting a set of buckets according to their key activities.

E. External Environment

It is self-evident that the interaction between a firm and its external environment determines its performance and shapes its long-term strategy (see, e.g., [28]). In the case of innovation portfolio management, [35] investigate how responsiveness to changes in the environment influences portfolio decision making, and [1] examine environment munificence as an external driver of strategic alignment and NPD performance. For this reason, in addition to appraising the strategic dimensions that are under the company's influence/control, managers also need to assess the interactions between the firm and its external environment. Some factors might directly affect the allocation of the R&D budget to an extent that justifies the design of a set of buckets that contemplates such idiosyncrasies. Through the cases studies, we identified two

recurrent conceptual factors that affect the allocation of the R&D budget, namely the regulatory environment and partnership formation.

1) Regulatory Environment:

The regulatory environment can directly affect a firm's investment decisions [45]. Some examples of changes in the regulatory environment that impact the NPD strategy include new public policies and professional norms [41], intellectual property regimes, liability laws, regulatory policy making, and antitrust laws [53]. These new policies might motivate the development of initiatives to deal with them.

The case of the Cnova showed how the regulatory environment affects portfolio decisions. While our research was taking place, one third of the portfolio budget was being allocated to initiatives to cope with current legislation. Natura also allocated part of its R&D budget to develop new tests to cope with policies concerning the reliability and efficiency of its processes. In line with that, we infer that firms, which operate in stringent regulatory environments, should craft a set of buckets not only to adapt to current legislation but also to ensure readiness to cope with potential changes that might occur.

2) Partnerships:

A new perspective on the resource-based view can transcend the boundary conditions of a firm by creating value through resources available in partnerships [36]. Partnership resources encompass intangible assets and partners that involve human resources, financial assets, marketing efforts, R&D investments, and reputation. The use of such resources is warranted, especially in those companies operating in dynamic environments or in those that develop complex technologies. In general, companies that need to leverage resources through partnerships usually need a wide range of capabilities/competences that cannot be easily attained

exclusively by the firm. Another situation occurs when firms need to count on a partner to access scarce resources.

We realized that some of the companies we investigated were allocating part of their R&D budgets to initiatives developed together with partners. Natura, for instance, allocated part of its development budget to foster open innovation initiatives by posing challenges to universities and research centers so that the potential solutions and knowledge could be shared among participants. Vale and Petrobras, as well, required a wide range of competences to develop their technologies. Therefore, Vale also funded open innovation initiatives to develop projects together with universities and other research institutions, while Petrobras, in turn, fostered a network to develop off-the-shelf technologies by investing in state-of-the-art facilities to equip universities. We therefore propose that firms, which operate in a complex environment or need a wide range of capabilities to innovate, should craft a set of buckets that considers potential partnerships.

IV. DISCUSSION AND IMPLICATIONS

Through the investigation of these seven case studies, we were able to scrutinize how the set of buckets were crafted to allocate the R&D development funds. In particular, we examined how the buckets design were associated with the three portfolio goals, namely value maximization, balance, and strong link with strategy (see, e.g., [12]), and when the use of buckets would be beneficial to a firm. Lastly, since the resource allocation in a R&D portfolio is a social technical decision process, fraught with limited rationality, we discuss the theoretical implications of designing a set of buckets through the lens of the three portfolio goals, and the role of

information, organization politics, and management intuition in the allocation of resources on buckets.

A. Managerial Implications

1) Buckets as Strategic Building Blocks

Because a firm's strategy might have multiple goals, we suggest the use of buckets as building blocks to deal with non-comparable initiatives to accomplish such diversity. In that regard, a company has the option to use buckets within a bucket. That is, decision makers might sub-divide a bucket even further, such that sub-buckets are used to guarantee R&D resources to fund projects clustered in a particular bucket. The combination of buckets/sub-buckets is necessary when the R&D budget needs to be allocated across multiple dimensions.

For instance, a firm might be willing to secure a certain amount of resources to fund NPD projects that target some strategic markets and, at the same time, secure resources to improve its current operations. Figure 3 depicts some examples of the bucket architectures used by the case companies. We suggest managers to design the set of buckets in line with firm's primary goals or business units. In accomplishing that, managers should ensure that the set of buckets is enough to compare projects within each bucket (see Vale, figure 3c, as an example). Otherwise, managers can use other conceptual dimensions to sub-divide the buckets (see Figure 3b, 3d, 3f) or sub-divide them even further (see Figure 3a and 3e). By observing all companies in figure 3, one can see that conceptual factors were used as building blocks for the companies to accomplish their R&D strategies.

2) When the Use of Strategic Buckets is Unnecessary

As discussed, the use of the strategic buckets approach is necessary when decision makers are unable to compare in a satisfactory manner different projects' initiatives. However, if the number

of projects is small or if the projects are substantially similar, strategic alignment might be achieved through a pairwise comparison of the projects or even through an overall assessment of the initiatives. In these cases, the use of buckets is not essential, as managers can assess the projects despite being bounded rational decision makers.

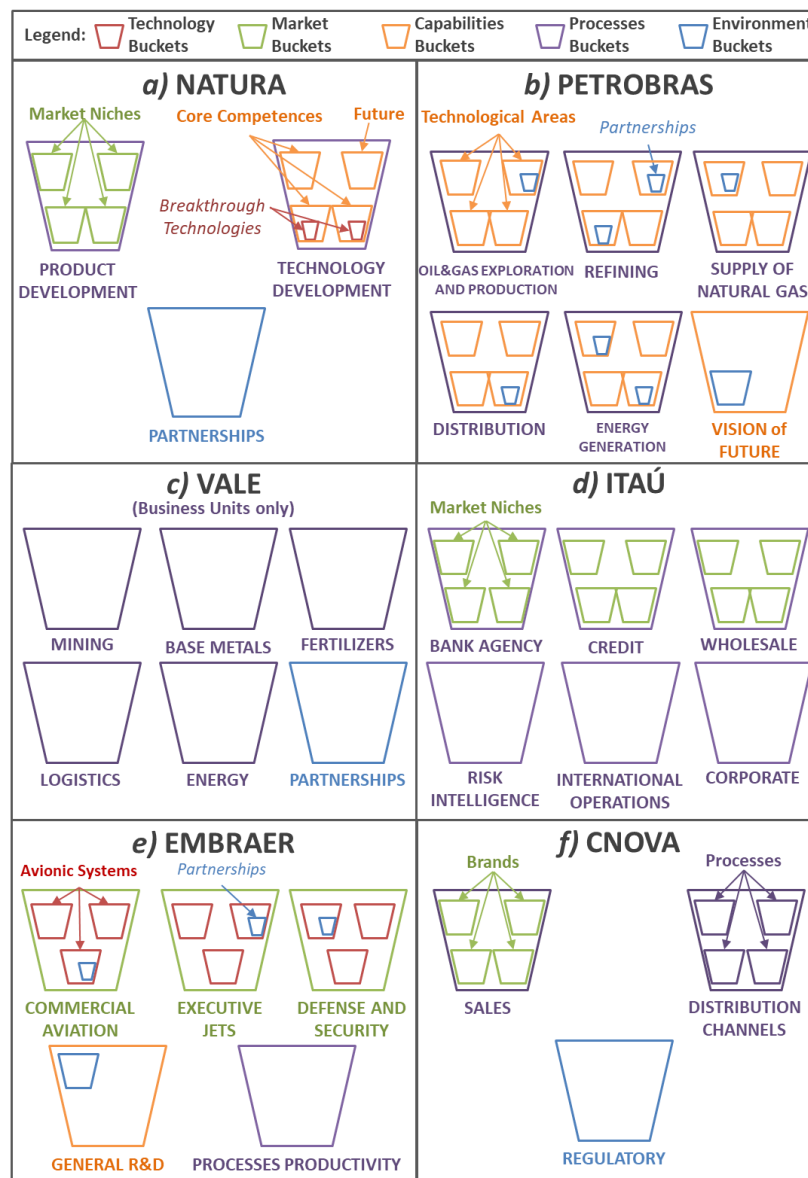


Figure 3: Examples of the bucket architectures

Fiat illustrates this case. The manager of its NPD department has one budget, and all initiatives compete for the same resources. The firm's main bottleneck in developing new

products is the number of product development teams. During our research, Fiat had enough resources to support the launch of two major NPD programs per year and to fund initiatives to improve products that have already been launched into the market. The company's portfolio was formed by 20 projects that were ranked according to financial, technical, commercial, and strategic criteria. The selection of programs and the allocation of resources were performed through a pairwise comparison and an overall assessment of programs. If the firm's strategy was not being reflected in the NPD portfolio, managers revisited their selection to ensure the portfolio was reflecting the company's strategy.

Therefore, if the number of projects in the NPD portfolio is small, the use of the strategic buckets approach has a limited benefit, as there is no need to break the information set into smaller parts. In this case, the decision set to select initiatives is limited, and managers can appraise them effectively at the same time. Thus, we posit that the use of strategic buckets is only essential when decision makers have difficulties in comparing projects from a firm's portfolio or when they want to secure resources to fund specific initiatives.

B. Implications for Theory and Research

If the main goal of a bucket is to guarantee resources to fund non-comparable projects so that the development projects are in line with a firm's strategy, a natural question that arises is how to deal with the other two portfolio goals, namely maximizing value and balancing the portfolio. That is, should a firm seek to maximize the value and balance of the whole portfolio or focus on each bucket appraisal? We argue that the answer to this question hinges on three sub-questions: how many buckets are to be funded, how much should be invested in each bucket, and how will the projects within each bucket be pondered?

When considering how many buckets to fund, management should have an understanding of the set of buckets, including how the set of buckets is aligned with the firm's strategy—i.e., have a portfolio mindset [33]. A balanced portfolio can be reflected in the number of buckets being funded, as well as in the projects grouped inside each bucket. Furthermore, a balanced portfolio is usually associated with an improved performance [39], and the precise number of buckets to fund depends not only on the nature of the projects (evidence-based assessment of potential projects) but also on organizational politics (power-based portfolio decision making) and on managerial intuition (opinion-based decision making). For more details on evidence-, power-, and opinion-based decisions, see [33].

So, first, decision makers should consider the relationship between short-term initiatives and long-term goals. Such a balance motivates the use of buckets to guarantee non-permeable partitions and, thus, manage the development pipeline over time [7]. Furthermore, the focus on the tradeoff between short term and long term naturally has a cost, which is often translated into the need to guarantee a positive net operating cash flow. In other words, projects characterized by high risk, by a long development cycle, or by a long payback time have their value assessments naturally downplayed, and comparing these projects with those with distinct features (e.g., short time, low risk) does not offer a meaningful assessment. Thus, in line with [39], we remark that even though the focus on value assessment is quite often the price of entry for projects to be funded, value maximization should not be overemphasized.

Regarding the amount of resources that should be invested in each bucket, this depends on a firm's strategy vis à vis each particular bucket. As discussed by [33], the resource allocation per bucket also depends on organizational politics and management intuition (power- and opinion-based decisions), and it is likely that all strategic decisions are made through some interplay

between these three types of decisions. Regardless, we believe our framework can work as a means to enact an effective portfolio decision-making process. More specifically, when appraising projects within each bucket, a comparison among projects could be performed that relies more on a project's evidences than on power or on managerial intuition. Therefore, managers should consider the several approaches used to maximize value and balance the projects clustered in a particular bucket (see, e.g., [12] for methods to maximize value and balance the portfolio). Of course, the three types of decisions still play a role when assessing each bucket and should be considered as an integrated system [37]. Nevertheless, because the projects are grouped into buckets so that they can be compared in a more meaningful way, it is expected that evidence-based decisions will be preponderant within each bucket.

We remark that this paper offers an initial attempt to shed light on how to craft a set of buckets. Even though we investigated a set of exemplar multi-national corporations, further generalizability of our model is warranted. One way of doing so is to conduct an empirical test of our framework and assess the key benefits of crafting the set of buckets according to it. For instance, it would be interesting to shed light on the benefits of combining two or more buckets.

In addition, as this research focuses on cross-sectional data to investigate our main research question, another potential avenue for future research is to conduct a longitudinal study and investigate how bucket formation evolves throughout time. For instance, it would be interesting to investigate the relationship between bucket formation and a company's lifecycle. We hope this initial attempt will unleash research initiatives to understand further the architectures of buckets and their impact on portfolio performance.

V. CONCLUSION

In this paper, we consider the question of how to define a set of buckets that aligns the R&D portfolio with a business strategy. Our research extends the current literature by offering a comprehensive framework and suggesting potential constructs to design a set of buckets that can be used to support the process of project selection and resource allocation in an R&D portfolio. Through a series of case studies, we tackled our main research question from a novel perspective that offers an operational vein for managers to craft a set of buckets.

As opposed to static dimensions, for example, to cope with technology and market features, we suggest that the design of buckets be a dynamic process performed according to four different dimensions, as well as in consideration of a firm's interaction with the external environment. Similar to [19], we believe that seldom will a unique framework fit all kinds of organizations and environments. Therefore, we posit that firms should not force the buckets to be determined according to off-the-shelf solutions but rather to be carefully crafted so that they (buckets) reflect a firm's strategy.

We acknowledge the idiosyncratic nature of firms and, as opposed to offering a normative approach for companies, we offer a set of constructs and guidelines that can help them craft a set of buckets. We certainly believe there might be other conceptual factors than can affect the design of the buckets. Nevertheless, the main logic discussed in this paper to design a set of buckets can still be considered.

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APPENDIX: Abbreviated Interview Guide

General Questions		
(1) How is the overall budget allocated among projects?		
(2) Is there a formal approach (or even a committee) that acts as a guide to align the strategic goals to NPD projects?		
(3) Who are the decision makers that deal with the selection of projects and the allocation of resources in the R&D portfolio? Is there a gate for project approval/termination?		
(4) How are project teams formed? Is there any interaction between members of different business units in the same project?		
Questions Concerning the NPD Process		
Dimension	Item	Question
Technology	Technology Complexity	Does the company develop complex technologies? How is its development carried on?
	Innovation Level	How does the company manage the projects' innovation level? Is there any division between radical and incremental projects?
Market	Market Niche	What are the market niches in which the company operates? What are the company's actions to meet each niche's needs?
	Brands	What are the company's main brands/is there a trademark? How are the brands managed?
Capabilities	Core Competences	Is there any kind of division into research groups? How are the development teams structured?
	Dynamic Capabilities	How is knowledge managed within teams? Are there specific projects for this purpose?
Processes	Supply Chain	Does the company operate at more than one level of its supply chain? Are these different levels managed in an integrated way or independently?
	Functions/ Operations	What are the main business functions or operations? Is there any division of the R&D budget as a function of the firm's operations?
	Processes	Does the company develop specific projects to improve its processes? Do process developments in initiatives and NPD projects compete for the same resources?
External Environment	Regulatory Environment	Is there any legislation or regulation in the market that requires the development of exclusive projects?
	Partnerships	Does the company develop partnerships with research institutions or other companies? How many partners does the company have? How are the interactions among partners?