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A Framework for Integration between Research and Development

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Resumo

The integration between research and development departments is not well explored in the organizational management literature. Usually, these two departments are seen as a single entity within the companies, known simply as R&D (Research & Development). Few studies have dealt with the complex interaction between research and development, which has its particularities. In order to understand and explain how the integration between research and development occurs for the intra-firm transfer technology (that is, new technologies delivered by Research are (best) used and applied by Development), we propose a theoretical framework covering this gap in the literature from the perspective of three approaches: contingent theory, dynamic capabilities and a systematic literature review. The framework proposed has three categories of mechanisms (technology, organizational design and individual) where the integrative role and knowledge management have a prominent function to connect all mechanisms involved in this integration. We suggest two methodologies to verify our propositions empirically and achieve an extension of the theory about the mechanisms and integration process involved in applying new technologies into new products. Even with the focus on intra-firm integration (internal technology transfer), this framework could also help organizations in open innovation interfaces.

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ABSTRACT

The integration between research and development departments is not well explored in the organizational management literature. Usually, these two departments are seen as a single entity within the companies, known simply as R&D (Research & Development). Few studies have dealt with the complex interaction between research and development, which has its particularities. In order to understand and explain how the integration between research and development occurs for the intra-firm transfer technology (that is, new technologies delivered by Research are (best) used and applied by Development), we propose a theoretical framework covering this gap in the literature from the perspective of three approaches: contingent theory, dynamic capabilities and a systematic literature review. The framework proposed has three categories of mechanisms (technology, organizational design and individual) where the integrative role and knowledge management have a prominent function to connect all mechanisms involved in this integration. We suggest two methodologies to verify our propositions empirically and achieve an extension of the theory about the mechanisms and integration process involved in applying new technologies into new products. Even with the focus on intra-firm integration (internal technology transfer), this framework could also help organizations in open innovation interfaces.

Keywords: integration, mechanisms, research, development, technology transfer

INTRODUCTION

This research was born from a real problem perceived in an organization, where some new technologies are provided by the Research Department, these were not fully implemented into new products. Although previous research offers some ways to solve this issue (e.g. Drejer (2002), Eldred & McGrath (1997a, 1997b), Iansiti (1998)), and we did not find any consolidated references for this subject: indeed, the literature remains largely fragmented and underdeveloped. Thus, this paper aims to advance the knowledge on integration mechanisms of Research and Development departments in the field of organizational and technology management.

The importance and the problematization of the integration between departments within organizations, for instance between R&D and Marketing or Planning and Production, is well addressed in the literature, but the interaction that occurs inside R&D is not well explored since these functional areas are seen as a unique department for the vast majority of papers and books. We consider that Research is in charge of new technologies development, and on the other hand, Development is responsible for applying these new technologies in new products (Boutellier, Gassmann, & Von Zedtwitz, 2000; Nobelius, 2004). Some works were developed to understand the proper management of these functions, but there is a lack of knowledge about the understanding of this complex interaction (Iansiti, 1998).

The transfer of new technologies to commercial projects is a critical step because it affects the scope of the future project, time for delivery of this project, cost and product quality (Nobelius, 2004). There is needed a process to manage and evaluate the new technologies, prepare them for commercialization and incorporate into new products (Eldred & McGrath, 1997a). Innovation management must consider the development of new technologies, the

development of new products and be efficient. This implies optimizing the integration between these developments, and the necessity for a clear understanding about different styles to manage the teams, monitoring, methods and tools (Chiesa, 1996; Nobelius, 2004).

Some models were reported in the literature in general based on a few case studies (e.g. Nobelius (2004), White (1977)), but these models do not present an in-depth evaluation considering theoretical bases that would allow a broad view of this complex problem of interdepartmental integration (Maranzato, Salerno, Gomes, Barbosa, & Brasil, 2019).

In recent years, especially using open innovation approach, much attention has been devoted to the interface between universities and industry. However, the problem of intra-firm integration stills remains a challenge.

The foremost opportunity is related to a deeper understanding of how the integration between Research and Development occurs. In the broad view, the framework proposed in this paper improves the understanding about how new technologies could be (better) applied, considering there is a bridge to be built in the complex interface between Research and Development departments. More specifically, how the mechanism of integration operates to the technology transfer between these departments to be effective, is translated in the following research question:

> *How do the integration mechanisms between Research and Development enhance the application of new technologies in new products?*

This paper continues with theories and systematic literature reviews that support the framework, followed by the framework itself using an analogy to facilitate comprehension, extending to future research suggestions to verify the framework empirically, and finishing with the conclusions and limitations.

THEORETICAL BACKGROUND

In this section, we will explore the theoretical background that underpins the framework proposed in the next topic. The first block concept that we will detail is the contingency theory, followed by dynamic capabilities and ending this section with a systematic literature review about the mechanisms involved in the integration of Research and Development.

Contingency theory

For this theoretical review about contingency theory, we resorted to the seminal authors in the field such as Jay R Galbraith, Paul R. Lawrence and Jay W. Lorsch. For the contingency theory, there is no one best way to organize all companies and it depends on the conditions (external and internal) of each company (Galbraith, 1973).

The integration problem has been studied since 1920s and 1930s by other classical authors such as Fayol, Culick, Mooney and Urwick, who considered the integrations as a rational and mechanical process, achieved by the clear division of tasks and (hierarchical) organizational structure of the company (Lawrence & Lorsch, 1967). What Lawrence and Lorsch (1967) argue is that this integration is not an automatic process by reason of each departmental specialist having its own vision about the direction to be considered to solve an issue, what causes conflicts between the departments involved, and the different visions must be solved to achieve an effective integration. They define integration as “the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by the demands of environment” (Lawrence & Lorsch, 1967: 11).

Improving the concepts introduced in 1973 by Jay R. Galbraith, this author with colleagues Downey and Kates in 2001, states that "regardless of how well thought out the organization's structure, it will create some barriers to collaboration. Information and decision-making must cross the boundaries created by the structure." (Galbraith, Downey, & Kates, 2001: 3).

Donaldson (2001) analyzing the different contingencies presented by other scholars in organizational structure research, argues that it is possible to group them into three underlying contingencies: task uncertainty, task independence and size. In the set of contingencies of uncertainty are those related to technology change and innovation among others, while in the interdependence are contingencies related to strategy, the way activities are connected with each other including the reciprocal independence described by Lawrence and Lorsch (1967) where innovation requires the interactions between Research and other functions/departments. Size contingency could be viewed as, in an approximate format, the number of employees involved in the structure needed to perform the tasks.

Considering our research question, we understand that contingency theory, underpinned by size and mainly by task uncertainty and task interdependence, fits our needs to evaluate the integration problem. We will also consider aspects of two models that correlate these contingencies in terms of strategy, structure and other aspects of organizations which are those proposed by Galbraith (1973) (improved by Galbaith et al. (2001)), and Mintzberg (1983).

The Galbraith's model, called StarModel^{TM}, considers five organizational elements (strategy, structure, processes and side skills, reward systems, and people systems). We point out in this paper the processes and side skills as a critical element to the framework proposed in the next section, which considers five mechanisms to achieve an effective integration: networks, lateral processes, teams, integrative roles and matrix structures.

Mintzberg (1983), building on Galbraith (1973), names as liaison devices the forms that organizations consider for mutual adjustments to achieve coordination (or integrations as we are considering in this paper) among the different departments. He reduced to four these devices: liaison positions, task force and standing committees, integrating managers and matrix structure.

Dynamic capabilities

Dynamic capabilities are especially relevant for organizations in competitive environments where technological changes are systematic and where different inventions must be combined to create new products and/or services that satisfy consumer needs (Teece, 2007).

Compared to contingency theory, dynamic capabilities is a recent approach that dates from the 1990s with its first conceptualization. A seminal paper in this field was published in 1997 by Teece, Pisano and Shuen (Peteraf, Di Stefano, & Verona, 2013), which is the evolution of a working paper shared between 1990 and 1994. The success of this approach could be measured by the citation made by very well recognized scholars, such as Prahalad and Hamel, Wernerlfelt, Leonard-Barton, Collis, Nonaka and Takeuchi, Iansiti and Clark, among others, when it was still a working paper.

Eisenhardt and Martin wrote another seminal paper in this field in 2000 (Peteraf et al., 2013), but with a distinct vision about what dynamic capabilities really are and the consequences of them compared to Teece et al. (1997). Wang and Ahmed (2007) argue that the lack of consensus between these views is caused by the theory development not focused on common aspects but based in individual cases. A deep understating of the origins of these divergences could be found in Di Stefano, Peteraf and Verona (2010). The central non-consensus aspect is related to whether dynamic capabilities are conditions sufficient (Teece,

Pisano and Shuen's view) or necessary (but not sufficient) (Eisenhardt and Martin's positioning) to achieve a competitive advantage (Peteraf et al., 2013).

Some studies have been conducted to unify (or at least reduce the divergencies) in this field. Starting with the definition of dynamic capabilities, each seminal work has its own proposition, but one statement looking for a consensus is: "a dynamic capability is the capacity of an organization to purposefully create, extend or modify its resource base" (Helfat, 2007: 1). We argue that an appropriate integration between Research and Development is a dynamic capability of an organization by reason of new technologies being applied in new generations of products that will actively contribute to organizational evolution. In this sense, we need to establish how to operationalize this approach in our reality.

A study presented in the direction of field unification which contributes to operationalization of dynamic capabilities was presented by Di Stefano, Peteraf and Verona (2014). Using an analogy, a bicycle drive train, these authors argue that both views are in fact complementary and not conflicting. With this model, they proposed the link between simple rules and complex routines through linking mechanisms, and also coupling and uncoupling mechanisms.

Integration as a dynamic capacity was discussed previously in the literature. Integration capability is an enabler to companies to innovate systematically (Helfat & Campo-Rembado, 2016). It is possible to exploit in new projects previous knowledge and skills acquired in the past, where this knowledge-based integration improves existing capabilities and creates new ones to new product development (Marsh & Stock, 2006). Iansiti and Clark (1994) argue that ability to integrate diverse knowledge through problem-solving in response to various contingencies is the foundation for knowledge creation, which leads to the generation of new capabilities of organizations. In their study in automobile and computer companies, they highlight the key role of integrators, where they combined the new technological possibilities with the existing environment, bringing to the companies' new competences evolving their capabilities. Also, they argue that the essence of integration is related to generation, fusion and accumulation of knowledge.

Merging the key findings of integration capability, especially those from Iansiti and Clark (1994), with the conciliatory/operational model of Di Stefano et al. (2014), Maranzato and Salerno (2018) propose an evolution of the bicycle drivetrain analogy to the case of the integration between Research and Development with two refinements, where the simple rules and complex routines previously proposed are linked by the integrators' role and knowledge management.

Literature review

In this section, we will present the systematic literature review conducted about the integration of research and development.

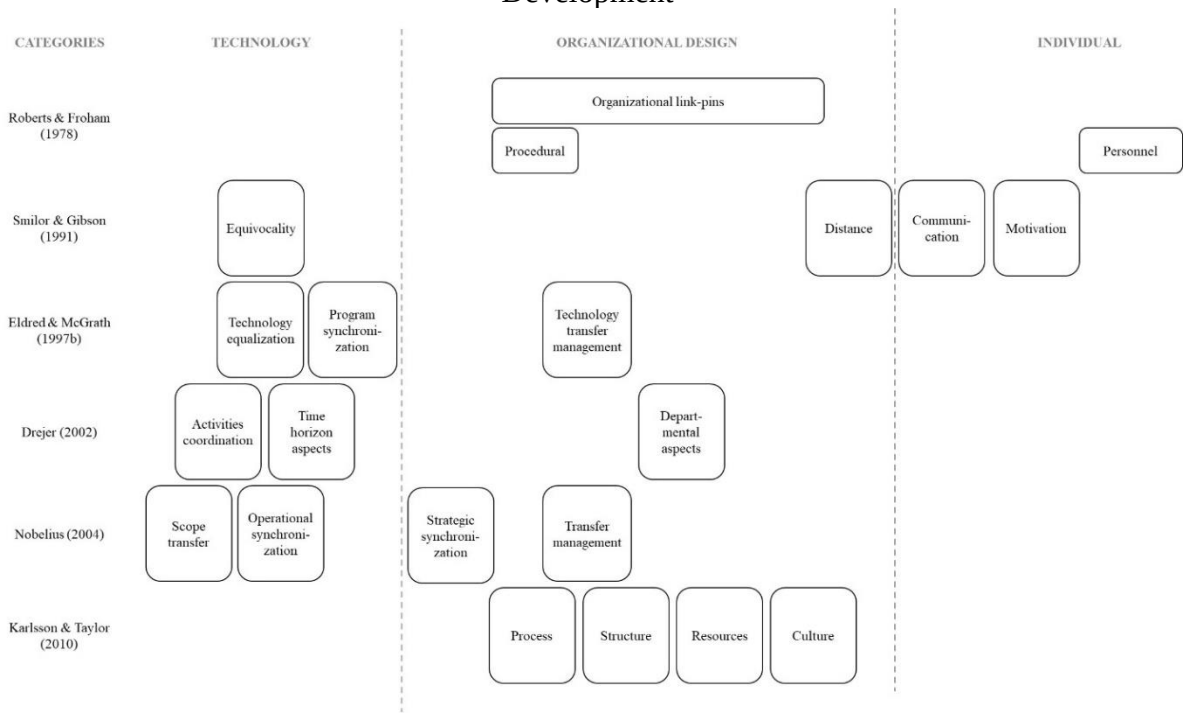
According to Maranzato, Salerno, Gomes, Barbosa, & Brasil (2019), there are few studies in the literature about this integration, with integration studies being more common when Research & Development are seen as a unique department inside the organization, and not as separated functional areas. These studies are mostly based on qualitative studies, with different details of analysis (some referred to strategic/high level, others to operational actions), and no previous work has shared a consolidated list of mechanisms reported in the previous literature (Maranzato et al., 2019).

Using Scopus® database and different combinations of research" and "development", "new technology", "integration", "separation", "transfer", "mechanism" and "process" in the strings searched, they started from 14.040 to 236 papers, whereby a first evaluation of title, key-words and abstract and later the full reading paper, they achieved a base of 118 documents.

Another 23 papers were identified by the "snowball"/backward search technique and nine other references that were presented by Maranzato and Salerno (2018), resulting in 150 papers in which a content analysis was performed to identify the mechanisms listed. A classification about the type of integrations was made: (1) intra-firm integration with R and D as separated functions, (2) intra-firm with R&D with other departments, (3) intra-firm but without a highlight in R&D, (4) external integration of the firm with other firms (5) external considering the integration of the firm with universities and research institutes and (6) external but departments involved were not explicit. The intention to expand to external integration, not just seeing the internal mechanism reported, was to verify if any of these external integrations listed could also be applied to intra-firm integration.

The first finding was a meta-analysis, where they performed a visual comparison of the models with a broad view of the integration problem (figure 1). They propose a division of 3 categories to group the mechanisms: technology, organizational design and individual behaviors and attitudes.

Figure 1 - Comparison between models of internal integration between Research and Development



Source: Maranzato et al. (2019).

The second finding is a definition of 27 different mechanisms. From these, four mechanisms were applied only for external integration, and 23 for both internal and external cases. The 23 mechanisms were grouped in the categories proposed in the meta-analysis, as shown in Exihibt 1. The definitions/concepts of each mechanism applied to internal (intra-firm) integration are listed in Appendix A.

Exhibit 1 - Mechanisms of intra-firm integration between Research and Development

Category	Technology	Organizational Design	Individual
Mechanisms	- equivocality - market and consumer orientation - scope, specifications and prototypes - timing synchronization - technology fit	- cross-functionality - definition of roles, responsibilities and targets/objectives - geographical distance - processes and governance - technology transfer group - technology and strategic planning - allocation and job rotation - project management - culture - funding - rewards and incentives - integrative role - knowledge management	- communication - networking - senior leadership commitment - motivation - avoid “not invented here” syndrome

Source: Maranzato et al. (2019)

FRAMEWORK AND PROPOSITIONS

Adding to the theoretical background described above, we recognized that each mechanism could affect others (Gomory, 1989), the category division being an analytical model in order to enhance the general understanding about integration problematization. This fact warned that a didactic model could not be linear, because one mechanism inserted in one of the three categories proposed could affect mechanisms in the other two types.

From the model proposed by Maranzato and Salerno (2018) using the dynamic capability approach, two highlights are bright: the integrative role and knowledge management. In this sense, we argue that they must have a differentiated part in the framework proposed.

The importance of the integrative role is also supported by the contingency theory and by the literature review, where Galbraith and Mintzberg are very clear about their influence in the integration process. Regarding knowledge management, this is supported by the literature review, but is not directly associated with contingency theory, but we pointed out that in one of Galbraith’s references, it is recognized as one of the characteristics of the reconfigurable organization (those organizations capable of quickly responding to external environment through combination and recombination of skills, competences and resources) (Galbraith et al., 2001).

In this sense, we have chosen a 3D-analogy to represent the three categories where the mechanisms are placed (knowing the influence among them), giving special features to the integrative role and knowledge management, and the picture adopted is a barrel. The staves are the categories of mechanisms (technology, organizational design and individual behaviors and attitudes) that are well supported and linked by the hoops, in our case, the integrative role. Figure 2 represents this analogy for the framework.

Figure 2 - Barrel analogy for the proposed framework

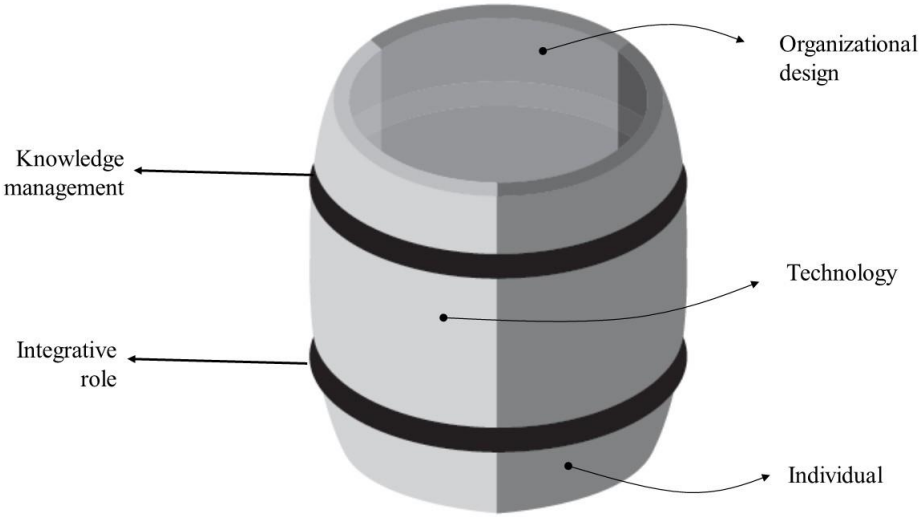
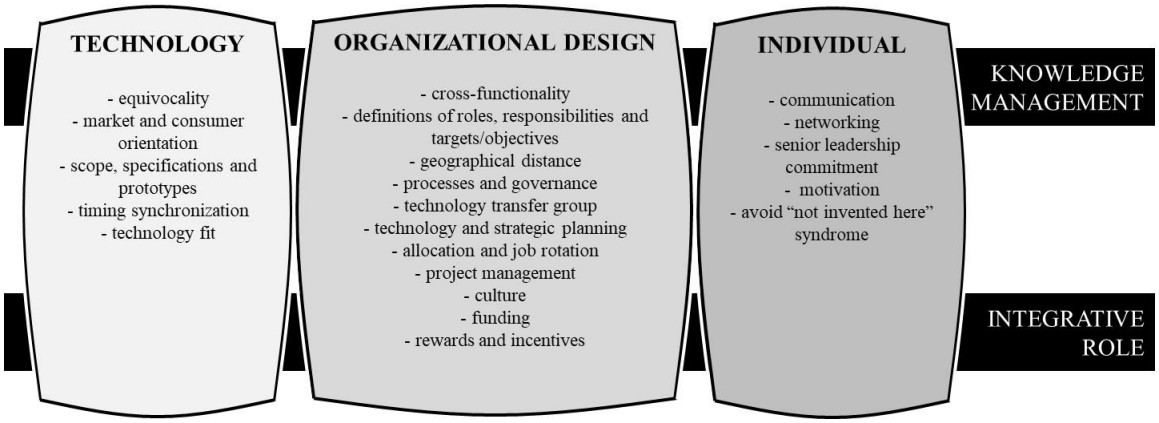


Figure 3 represents the open barrel, with a consolidation view with the categories:

Figure 3 - Detailed framework proposed



Considering this framework and the arguments that support it, we established these propositions:

Proposition 1 - Knowledge management is a leverage mechanism of the integration between Research and Development, and there are specific practices that improve its importance in the integration process.

Proposition 2 - Integrative role is a leverage mechanism of the integration between Research and Development, and there are evident characteristics that improve its importance in the integration process.

By “leverage mechanisms” we mean that these mechanisms improve the performance of the other three categories to work together. In other words, they are the binder that keeps the other mechanisms attached to each other. By “improve its importance” we consider that inside each mechanism there are sub-components that act in different ways to the final result of the mechanism performance over the integration process.

Another aspect to be considered in our project is the difference between the mechanisms applied. As Martin (1994) pointed out, “there is some evidence that innovations based upon technology-push are less likely to be successful than those based upon market-pull” (p.44). In this sense, we establish:

Proposition 3 – The mechanism utilized, and their relative importance, is different for projects technology push to market pull projects

.

This last proposition is also in accordance with the contingency theory of Lawrence and Lorsch cited above.

FUTURE RESEARCH

The proposed framework is a formulation about the integration of Research and Development until this moment that requires further validation, moving from a theoretical model based in review to an empirical evidenced contribution.

Considering the taxonomy presented by Colquitt and Zapata-Phelan (2007) about theoretical contributions in empirical articles, we can make a forecast for the future of this research. These authors combine in a two-dimensional perspective: the building new theory (scale: 1 – attempts to replicate previously demonstrated effects, 2 - examines effects that have been the subject of prior theorizing, 3 – introduces a new mediator or moderator of an existing relationship or process, 4 – examines a previously unexplored relationship or process, 5 – introduces a new construct or significantly reconceptualizes an existing one) with (*versus*) testing existing theory (scale: 1- is inductive or grounds prediction with logical speculation, 2 - grounds prediction with reference to past findings, 3 - grounds prediction with existing conceptual arguments, 4 - grounds prediction with existing models, diagrams or figures, 5- grounds prediction with existing theory). From the combination of these dimensions are established five zones: reporters, testers, qualifiers, builders and expanders, where the last three are considered as articles with a high level of theoretical contribution and the first two, a low level. We believe that following rigorous methodological steps, it is possible to achieve an expansion of the theory about the integration between Research and Development by reason of us bringing a new significant reconceptualization of the integrative role and knowledge management (as stated by propositions 1 and 2) combining the mechanism categories.

A science theory-building process requires a research strategy. Handfield and Melnyk (1998) provide a relation between the kind of research questions, research structure, data collection techniques and procedures with the purpose of the project. This purpose varies in its initial aim (discovery and description of the territory to be theorized) until the theory extension, aligned with Colquitt and Zapata-Phelan’s (2007) arguments. An intermediate purpose for Handfield and Melnyk (1998) is the “relationship building”, which fits to the research status which is the proposed model. For this purpose, these authors suggest as structure the

application of "case studies" (few-focused, in-depth, multi or best-in-class). "These studies often aim to unpack "what causes what," as researchers seek to understand the factors that can explain different outcomes" (Bansal, Smith, & Vaara, 2018: 1190)[1].

In line with the arguments presented by Gehman et al. (2018) built over the discussion about qualitative approaches to theory building in 2016 Academy of Management Annual Meeting, we recommend using the Eisenhardt method. This was stated in Eisenhardt's seminal paper of 1989, followed and improved in several of her papers over the last 30 years. Her method is the most appropriate to start for researchers with the aim of generating a theory that can be tested in a deductive way (Gehman et al., 2018).

We indicate a multiple case approach, where it is possible to face cases with different outcomes, which allow researchers to evaluate explanatory variables, and cases with the same outcomes that increase the theory reliability (Bansal et al., 2018). By doing this, we believe that further research can build upon our propositions and increase the understanding about the relationship between Research and Development by identifying patterns and indicating the validity or not of our propositions on an empirical basis. In this sense, the relationships present in our propositions may base the construction of deeper theories to explain what are beneficial or not for an integrative view of Research and Development.

Another methodology that can be applied to empirically test the propositions that we set is qualitative comparative analysis (QCA), especially fuzzy-set (fsQCA). The application of QCA is increasing in strategy and organization theories (Greckhamer, Furnari, Fiss, & Aguilera, 2018) that allows researchers to capture the complexity of management practice (Misangyi & Acharya, 2014).

This methodology is based on a set membership concept, where cases are seen as combinations of relevant attributes and the relationship of these attributes with the outcome of interest can be understood by the examination of the subset relation – the set membership (Misangyi & Acharya, 2014; Fiss, 2007). It is especially relevant for configurational approach, which advocates that "organizations are best understood as clusters of interconnected structures and practices, rather than as modular or loosely coupled entities whose components can be understood in isolation" (Fiss, 2007: 1180).

Considering the arguments presented in the previous section about the connection between the categories proposed for the integration mechanisms, we see a close match with the configurational approach because the mechanisms are not totally independent from each other. One successful study using fsQCA in an organizational study with some degree of similarities with our research problem is presented by Misangyi and Acharya (2014), where these authors analyzed how governance mechanisms work together to achieve firm profitability. In our case, the relation is how integrative mechanisms improve the application of new technologies into new products.

CONCLUSIONS AND LIMITATIONS

With the framework proposed through the barrel analogy, we provide to academic and practitioner communities a novel model to improve the integration between Research and Development. Before our paper, the models reported in the literature have not demonstrated a consolidated view about this organizational aspect, critical to achieving a competitive advantage through return on technology investment.

Based on a merger of theoretical approaches (contingency theory and dynamic capabilities) and with previous integration mechanisms reported in the literature, the model

[1] Named as "variance-based case studies" by Bansal et al. (2018)

reflects three categories of mechanisms with two other "leverage" mechanisms. The first category is related to aspects directly involved with the *technology* itself, such as equivocality and fitting the existing capabilities base of the firm. The second category corresponds to elements of *organizational design*, such as processes and governance, and allocation and job rotation practices, and the third category brings the *individual* (personnel) contribution to the integration, such as motivation and networking. The two leverage mechanisms are the *integrative role* and *knowledge management* that improve the performance of the other mechanisms and act to keep them connected to each other, improving the process overall.

As exposed in the Future Research session, this model requires further empirical verifications, with the potential of extending the theory through the re-significance of integrative role and knowledge management importance. We suggested two methodologies that can be applied to allow the extension of the theory. The first one is a traditional case study methodology, building upon "Eisenhardt's method" using multiple cases, and the second methodology is qualitative comparative analysis (QCA), which has been gaining the attention of scholars of strategy and organizational studies more recently. QCA will help to identify interdependencies in operating the integrative mechanisms through a configurational view, which means a viable and internally compatible set of mechanisms that are used together (Misangyi et. al (2017)).

Even being a theoretical model until this moment and with a focus on intra-firm interface, we believe that the model proposed can help organizations today to improve their integrations mechanisms, also considering their open innovation initiatives.

REFERENCES

Bansal, P., Smith, W. K., & Vaara, E. (2018). New ways of seeing through qualitative research. *Academy of Management Journal*, *61*(4), 1189-1195.

Bond III, E. U., & Houston, M. B. (2003). Barriers to matching new technologies and market opportunities in established firms. *Journal of Product Innovation Management*, *20*(2), 120-135.

Boutellier, R., Gassmann, O., & Von Zedtwitz, M. (2000). *Managing global innovation: uncovering the secrets of future competitiveness* (2ª ed.). Berlin: Springer-Verlag.

Chiesa, V. (1996). Separating research from development: evidence from pharmaceutical industry. *European Management Journal*, *16*(6), 638-647.

Chiesa, V. (1999). Technology development control styles in multinational corporations: A case study. *Journal of Engineering and Technology Management - JET-M*, *16*(2), 191-206.

Chiesa, V. (2000). Global R&D project management and organization: A taxonomy. *Journal of Product Innovation Management*, *17*(5), 341-359.

Cohen, H., Keller, S., & Streeter, D. (1979). Transfer of Technology from Research to Development. *Research Management*, *22*(3), 11-17.

Colquitt, J. A., & Zapata-Phelan, C. P. (2007). Trends in theory building and theory testing: A five-decade study of the Academy of Management Journal. *Academy of Management Journal*, *50*(6), 1281-1303.

De Luca, L. M., Verona, G., & Vicari, S. (2010). Market orientation and R and D effectiveness in high-technology firms: An empirical investigation in the biotechnology industry. *Journal of Product Innovation Management*, *27*(3), 299-320.

Detz, C. M. (1996). Corporate-supported research in a reengineered technology organization. *Research Technology Management*, *39*(4), 30-32.

Di Stefano, G., Peteraf, M., & Verona, G. (2010). Dynamic capabilities deconstructed a bibliographic investigation into the origins, development, and future directions of the research domain. *Industrial and Corporate Change, 19*(4), 1187-1204.

Di Stefano, G., Peteraf, M., & Verona, G. (2014). The organizational drivetrain: A road to integration of dynamic capabilities research. *The Academy of Management Perspectives., 28*(4), 307-327.

Donaldson, L. (2001). *The contingency theory of organizations.* Thousand Oaks, CA: Sage.

Drejer, A. (2002). Integrating product and technology development. *International Journal of Technology Management, 24*(2-3), 124-142.

Eidt, C. M., & Cohen, R. W. (1997). Reinventing industrial basic research. *Research Technology Management, 10*(1), 29-36.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they? *Strategic management journal, 21*(10-11), 1105-1121.

Eldred, E., & McGrath, M. (1997a). Commercializing new technology – I. *Research Technology Management, 40*(1), 41-47.

Eldred, E., & McGrath, M. (1997b). Commercializing new technology – II. *Research Technology Management, 40*(2), 29-33.

Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *Academy of Management Review, 32*(4), 1180-1198.

Galbraith, J. R. (1973). *Designing complex organizations.* Reading: Addison-Wesley Longman Publishing Co.

Galbraith, J., Downey, D., & Kates, A. (2001). *Designing dynamic organizations: A hands-on guide for leaders at all levels.* New York: Amacom.

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A., & Corley, K. G. (2018). Finding theory–method fit: A comparison of three qualitative approaches to theory building. *Journal of Management Inquiry, 27*(3), 284-300.

Gomory, R. E. (1989). Moving IBM's technology from research to development. *Research Technology Management, 32*(6), 27-32.

Greckhamer, T., Furnari, S., Fiss, P. C., & Aguilera, R. V. (2018). Studying configurations with qualitative comparative analysis: Best practices in strategy and organization research. Strategic Organization, 16(4), 482-495. *Strategic Organization, 16*(4), 482-495.

Griffin, A., & Hauser, J. R. (1996). Integrating R&D and marketing: A review and analysis of the literature. *Journal of Product Innovation Management, 133*, 191-215.

Guerin, T. F. (2001). Transferring environmental technologies to China: Recent developments and constraints. *Technological Forecasting and Social Change, 67*(1), 55-75.

Handfield, R. B., & Melnyk, S. A. (1998). The scientific theory-building process: a primer using the case of TQM. *Journal of Operations Management, 16*(4), 321-339.

Helfat, C. E. (2007). Dynamic capabilities: foundations. In C. Helfat, S. Finkelstein, W. Mitchell, M. Peteraf, H. Singh, D. Teece, & S. Winter, . *Dynamic Capabilities: Understanding Strategic Change in Organization* (pp. 30-45). Oxford: Blackwell Publishing.

Helfat, C. E., & Campo-Rembado, M. A. (2016). Integrative capabilities, vertical integration, and innovation over successive technology lifecycles. *Organization Science, 27*(2), 249-264.

Iansiti, M. (1995). Technology integration: Managing technological evolution in a complex environment. *Research Policy, 24*(4), 521-542.

Iansiti, M. (1998). *Technology integration: making critical choices in a dynamic world.* Boston: Harvard Business School Press.

Iansiti, M., & Clark, K. B. (1994). Integration and dynamic capability: evidence from product development in automobiles and mainframe computers. *Industrial and corporate change*, *3*(3), 557-605.

Katz, R., & Allen, T. J. (1982). Investigating the not invented here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D Project Groups. *R&D Management*, *12*(1), 7-20.

Lakemond, N., Johansson, G., Magnusson, T., & Safsten, K. (2007). Interfaces between technology development, product development and production: critical factors and a conceptual model. *International Journal of Technology Intelligence and Planning*, *3*(4), 317-330.

Lawrence, P. R., & Lorsch, J. (1967). Differentiation and integration in complex organizations. *Administrative Science Quarterly*, *12*(1), 1-47.

Leenders, M. A., & Wierenga, B. (2002). "The effectiveness of different mechanisms for integrating marketing and R & D. *Journal of Product Innovation Management*, *19*(4), 305-317.

Malik, K. (2001). How BICC cables transferred a new process technology from R&D to manufacturing. *Research Technology Management*, *44*(4), 55-59.

Malik, K. (2002). Aiding the technology manager: a conceptual model for intra-firm technology transfer. *Technovation 22.7 (2002): 427-436*, *22*(7), 427-436.

Maranzato, F. P., & Salerno, M. S. (2018). Integration between research and development: A dynamic capabilities perspective. *RAE-Revista de Administração de Empresas*, *58*(5), 460-474.

Maranzato, F. P., Salerno, M. S., Gomes, L. A., Barbosa, A. P., & Brasil, V. C. (2019). Mechanisms for the integration between research and development: a literature review. *R&D Management Conference*, (pp. 1-20). Paris.

Marsh, S. J., & Stock, G. N. (2006). Creating dynamic capability: The role of intertemporal integration, knowledge retention, and interpretation. *Journal of Product Innovation Management*, *23*(5), 422-436.

Martin, M. J. (1994). *Managing innovation and entrepreneurship in technology-based firms.* New York: John Wiley & Sons.

Mintzberg, H. (1983). *Structures in fives: Designing effective organizations.* Englewood Cliffs, NJ: Prentice Hall.

Misangyi, V. F., & Acharya, A. G. (2014). Substitutes or complements? A configurational examination of corporate governance mechanisms. *Academy of Management Journal*, *57*(6), 1681-1705.

Misangyi, V. F., Greckhamer, T., Furnari, S., Fiss, P. C., Crilly, D., & Aguilera, R. (2017). Embracing causal complexity: The emergence of a neo-configurational perspective. *Journal of Management*, *43*(1), 255-282.

Nobelius, D. (2004). Linking product development to applied research: transfer experiences from an automotive company. *Technovation*, *24*(4), 321-334.

O'Connor, G. C., Richard, H., & Rice, M. P. (2002). Assessing transition readiness for radical innovation. *Research Technology Management*, *45*(6), 50-56.

Peteraf, M., Di Stefano, G., & Verona, G. (2013). The elephant in the room of dynamic capabilities: Bringing two diverging conversations together. *Strategic Management Journal*, *34*(12), 1389-1410.

Rice, M. P., O´Connor, G. C., & Pierantozzi, R. (2008). Implementing a learning plan to counter project uncertainty. *MIT Sloan Management Review, v. 49, n. 2, p. 54, 2008.*, *49*(2), 54-62.

Roberts, E. B., & Frohman, A. L. (1978). Strategies for improving research utilization. *Technology Review*, *80*(5), 32-39.

Sadowski, M., & Roth, A. (1999). Technology leadership can pay off. *Research Technology Management*, *42*(6), 32-33.

Smilor, R. W., & Gibson, D. V. (1991). Technology transfer in multi-organizational environments: The case of R&D consortia. *IEEE Transactions on Engineering Management*, *38*(1), 3-13.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal*, *28*(13), 1319-1350.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, *28*, 509-533.

Von Zedtwitz, M., & Gassmann, O. (2002). Managing customer oriented research. *International Journal of Technology Management*, *24*(2-3), 165-193.

Wang, C. L., & Ahmed, P. K. (2007). Dynamic capabilities: A review and research agenda. *International Journal of Management Reviews*, *9*(1), 31-51.

White, W. (1977). Effective transfer of technology from research to development. *Research Management*, *20*(3), 30-34.

APPENDIX A

EXIHIBIT A1 - Mechanisms definitions/concepts

Mechanism	Definition/concept	Reference example(s)
Equivocality	Level of "concreteness" of the technology, technology readiness, support technology availability	Eldred & McGrath (1997b), O´Connor, Hendricks, & Rice (2002), Smilor & Gibson (1991)
Market and consumer orientation	Technology must respond to market and consumer needs, being the responsibility of the whole company	Bond III & Houston (2003), Malik (2002), Roberts & Frohman (1978)
Scope, specifications and prototypes	It refers to "what" will be transferred, varying from blueprint to know-how	Nobelius (2004)
Timing synchronization	Combination of the technology development life cycle that will support the next generation of products	Drejer (2002)
Technology fit	How new technology affects the actual *modus operandi* of the company	Nobelius (2004)
Cross-functionality	Teamwork with specialties from different groups/expertise	Von Zedtwitz & Gassmann (2002)
Definition of roles, responsibilities and targets/objectives	Establishment of clear goals, how will the hand-over be between the department involved; what will each person be in charge of during the project	Lakemond, Johansson, Magnusson, & Safsten (2007)
Geographical distance	Eye-to-eye direct contact. New communication technologies do not replace the need for direct contact from time to time	Von Zedtwitz & Gassmann (2002)
Processes and governance	Establishment of minimum rules, such as Stage-gate®, keeping some flexibility to adapt to a creative/discovery process	Eidt & Cohen (1997), Sadowski & Roth (1999)

(cont.)

EXIHIBIT A1 - Mechanisms definitions/concepts (cont.)

Mechanism	Definition/concept	Reference example(s)
Technology transfer group	Formation of a group that consists of individuals that have general knowledge in how the new technology will affect the existing bases, not being specialists in all tasks that will be performed	Cohen, Keller, & Streeter (1979), Iansiti (1995), White (1977)
Technology and strategic planning	Guide the Research group to focus its efforts, determining which technologies will be developed, connected to market and consumer orientation mechanism, including for example technology roadmapping	Chiesa (1999), Von Zedwitz & Gassmann (2002)
Allocation and job rotation	People allocation practices as well as a rotation between the research and development group to facilitate the integration	Malik (2002)
Project management	Application of some project management techniques, where non-traditional could be more effective as a learning plan	Rice, O´Connor, & Pierantozzi (2008)
Culture	Recognition that research culture is different from development culture, where some specific training could be done, and the culture of trust must be encouraged	Bond III & Houston (2003), Chiesa (1996, 2000), Malik (2001)
Funding	How the budget for technology development will be provided	Detz (1996), Von Zedtwitz & Gassmann (2002)
Rewards and incentives	Alignment of the rewards and incentives of all involved in the technology development and the technology application/use	Chiesa (2000), Leenders & Wierenga (2002)
Integrative role	Named as integrators, liaison or third-party coordinators, is a role in charge to managerially coordinate the integration without being involved in technical details.	Roberts & Frohman (1978)

(cont.)

EXIHIBIT A1 - Mechanisms definitions/concepts (cont.)

Mechanism	Definition/concept	Reference example(s)
Knowledge management	Generation, fusion, accumulation, sharing and transfer of knowledge acquired about the new technology	De Luca, Verona, & Vicari (2010), Von Zedtwitz & Gassmann (2002)
Communication	Direct communication between the involved, not just speaking but also listening.	Malik (2002), Smilor & Gibson (1991)
Networking	Personal links made in past projects are significant in the new projects, also seen as “informal social systems”.	Griffin & Hauser (1996), Guerin (2001)
Senior leadership commitment	Daily attitudes from leadership to encourage the teams to work in a high degree of uncertainty and long-term projects, removing corporate barriers	Malik (2001)
Motivation	Keep people involved in a high level of motivation	Malik (2002), Smilor & Gibson (1991)
Avoid “not invented here” syndrome	Not invented here syndrome is defined as “the tendency of a project group of stable composition to believe it possesses a monopoly of knowledge of its field, which leads it to reject new ideas from outsiders to the likely detriment of its performance” (Katz & Allen, 1982: 7)	Malik (2002)

Source: Maranzato et al. (2019)