



# AMBIDEXTERITY, ORGANIZATIONAL STRUCTURE, AND TYPES OF INNOVATIONS IN TECHNOLOGICAL R&D INSTITUTES IN BRAZIL

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## Abstract

**Objective:** This study examines how the organizational structure - mechanistic or organic - and exploration and exploitation can contribute to explaining the radical and incremental innovations in research and development institutes (P&D) of technology, aimed at products and services related to the Internet, software, hardware, telecommunications (Telecom), information technology (IT) and automation.

**Methodology:** The research was carried out in two phases: Qualitative with four case studies, two cases of national institutes, one private and one public, and two multinational private institutes located in Brazil. The quantitative used a closed questionnaire applied to 17 institutions.

**Originality / Relevancy:** A justification for the selection of TR&DI based on the fact that the literature on exploration, exploitation, organizational structure, and innovation shows that the areas of P&D of organizations, as well as high technology businesses, must be structured organically. Due to the need for decentralization, more fluid communications, greater autonomy, and the creation of knowledge are necessary as you flourish in turbulent and unstable environments.

**Main results:** The results will reveal a predominance of the organic model in 19 two 21 institutes studied, using both stages. However, it seems that, despite strong guidance for the organic model, there are elements of the mechanistic model: the ability to combine bureaucracy will lose the necessary flexibility. This study reveals that when two models of organizational structures and exploration and exploitation are discussed, there is a gap between theory and application.

**Theoretical/methodological contributions:** The study describes the analysis of the position of institutes in relation to obtaining, generating, and implementing expertise, examining how their organizational structures are configured to carry out related activities in a suitable way for exploration, exploration, and development of innovation in development. you root and increase.

**Social contributions / for management:** In practical terms, this study is relevant because it allows managers and government institutions to establish and implement innovative policies and procedures in this type of technology center. These implications are related to decision-making processes, knowledge creation, guidance for exploration, exploration, ambidexterity, and types of innovation. Consequently, it can be presumed that the organizational structure of these orientations can be mixed. By these arguments, we understand that innovation, ambidexterity (exploration and exploitation), and organizational structure have a strong relationship.

**Keywords:** Research and Development. Exploration. Exploitation. Ambidexterity. Innovation Technology.

## AMBIDESTRIA, ESTRUTURA ORGANIZACIONAL E TIPOS DE INOVAÇÕES EM INSTITUTOS TECNOLÓGICOS DE P&D NO BRASIL

### Resumo

**Objetivo:** Este estudo examina como a estrutura organizacional - mecanicista ou orgânica - e a exploração e exploração podem explicar as inovações radicais e incrementais em institutos de pesquisa e desenvolvimento (P&D) de tecnologia, voltados para produtos e serviços relacionados à Internet, software, hardware, telecomunicações (Telecom), tecnologia da informação (TI) e automação.

**Metodologia:** A pesquisa teve duas fases: A fase qualitativa utilizou um questionário semiestruturado em quatro estudos de caso, dois casos de institutos nacionais, um privado e outro público, e dois institutos privados multinacionais situados no Brasil. A fase quantitativa consistiu na aplicação de um questionário fechado a 17 instituições, utilizando uma escala do tipo Likert com sete pontos.

**Originalidade/Relevância:** A justificativa para a seleção de TR&DI baseia-se no fato de que a literatura sobre exploração, aproveitamento, estrutura organizacional e inovação mostra que as áreas de P&D das organizações, assim como os negócios de alta tecnologia, devem ser estruturados organicamente devido à necessidade de descentralização, comunicações mais fluidas, maior autonomia e criação de conhecimento, à medida que florescem em ambientes turbulentos e instáveis.

**Principais resultados:** Os resultados revelaram um predomínio do modelo orgânico em 19 dos 21 institutos estudados, utilizando ambas as etapas. No entanto, parece que, apesar da forte orientação para o modelo orgânico, existem elementos do modelo mecânico: a capacidade de combinar a burocracia sem perder a flexibilidade necessária. Este estudo revela que quando se

discute o papel dos modelos de estruturas organizacionais e de exploração e aproveitamento, há uma lacuna entre teoria e aplicação.

**Contribuições teóricas/metodológicas:** Esta análise descreve a posição desses institutos em relação à obtenção, geração e implantação de expertise, examinando como suas estruturas organizacionais são configuradas para executar atividades relacionadas de forma adequada à exploração, exploração e ambidestria enquanto buscam o desenvolvimento de inovações radicais e incrementais.

**Contribuições sociais / para a gestão:** Em termos práticos, este estudo é relevante porque permite que gestores e instituições governamentais conheçam e aprimorem procedimentos e políticas de inovação neste tipo de centros tecnológicos. Essas implicações estão relacionadas aos processos de tomada de decisão, criação de conhecimento, orientações para a exploração, exploração, ambidestria e tipos de inovação. Consequentemente, pode-se presumir que a estrutura organizacional dessas orientações pode ser mesclada. Por esses argumentos, entendemos que inovação, ambidestria (exploração e aproveitamento) e estrutura organizacional têm uma relação forte.

**Palavras-chave:** Pesquisa e Desenvolvimento. Exploration. Exploitation. Ambidestria. Inovação Tecnológica

## AMBIDESTREZA, ESTRUCTURA ORGANIZATIVA Y TIPOS DE INNOVACIONES EN INSTITUTOS TECNOLÓGICOS DE I Y D EN BRAZIL

### Resumen

**Objetivo:** Este estudio examina cómo la estructura organizacional - mecanicista u orgánica - y la exploración y explotación pueden explicar las innovaciones radicales e incrementales en los institutos de investigación y desarrollo (I + D) de tecnología, enfocados en productos y servicios relacionados con Internet, software, hardware, telecomunicaciones (Telecom), tecnología de la información (TI) y automatización.

**Metodología:** La investigación tuvo dos fases: La fase cualitativa utilizó un cuestionario semiestructurado en cuatro estudios de caso, dos casos de institutos nacionales, uno privado y otro público, y dos institutos privados multinacionales ubicados en Brasil. La fase cuantitativa consistió en aplicar un cuestionario cerrado a 17 instituciones, utilizando una escala tipo Likert de siete puntos.

**Originalidad / Relevancia:** La justificación para seleccionar TR&DI se basa en el hecho de que la literatura sobre exploración, explotación, estructura organizativa e innovación muestra que las áreas de I + D de las organizaciones, así como las empresas de alta tecnología, deben estructurarse orgánicamente debido a la necesidad, para la descentralización, comunicaciones más fluidas, mayor autonomía y creación de conocimiento, ya que florecen en entornos turbulentos e inestables.

**Principales resultados:** Los resultados revelaron un predominio del modelo orgánico en 19 de los 21 institutos estudiados, utilizando ambas etapas. Sin embargo, parece que, a pesar de la fuerte orientación hacia el modelo orgánico, hay elementos del modelo mecánico: la capacidad de combinar la burocracia sin perder la flexibilidad necesaria. Este estudio revela que al discutir el papel de los modelos de estructuras organizacionales y la exploración y explotación, existe una brecha entre la teoría y la aplicación.

**Contribuciones teóricas / metodológicas:** Este análisis describe la posición de estos institutos en relación a la obtención, generación y despliegue de experiencia, examinando cómo se configuran sus estructuras organizacionales para llevar a cabo actividades adecuadamente relacionadas con la exploración, explotación y ambidestria buscando desarrollar innovaciones radicales e incremental.

**Contribuciones sociales / a la gestión:** En la práctica, este estudio es relevante porque permite a los directivos e instituciones gubernamentales conocer y mejorar los procedimientos y políticas de innovación en este tipo de centros tecnológicos. Estas implicaciones están relacionadas con los procesos de toma de decisiones, la creación de conocimiento, las orientaciones de exploración, la exploración, la ambidestria y los tipos de innovación. En consecuencia, se puede suponer que la estructura organizativa de estas directrices puede ser mixta. Con base en estos argumentos, entendemos que la innovación, la ambidestria (explotación y explotación) y la estructura organizacional tienen una fuerte relación.

**Palabras clave:** Investigación e Desarrollo. Exploración. Explotación. Ambidestria. Innovación Tecnológica.

## Cite as / Como citar

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## Introduction

March (1991) states that adaptive systems that engage in exploration to the exclusion of exploitation are likely to find they suffer the costs of experimentation without gaining many of its benefits. Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibrium. Consequently, as a result, maintaining a stable balance between these two orientations is an essential condition for survival and prosperity. From this point of view of balance, other researchers (Zimmermann & Birkinshaw, 2016; Enkel, Heil, Hengstler & Wirth, 2017; Mathivathanan, Govindan, & Haq, 2017) have developed arguments focused on the concept of ambidexterity, originally coined by Duncan (1976).

Duncan (1976) argues that organizations must create dualistic organizational structures that can handle both innovation phases. One phase is related to starting radical innovation (exploration), while the other is connected to the implementation of incremental innovation (exploitation).

Tushman and O'Reilly (1996) note that organizational evolution must take place through periods of evolutionary changes that are incremental and revolutionary changes that are radical. To achieve this, managers must create an ambidextrous organization that can deal with incremental and radical innovations. The authors argue that the success of this model over the long term is related to the alignment of strategy, organization, people, and culture. As a result, ambidextrous organizations construct corporate architectures whose organizational structures are both compact and mobile, connected simultaneously. Consequently, in this type of organizational structure, connections are not mobile and do not alter among the various structures. In contrast, ambidextrous organizations consist of multiple subunits that are firmly linked together.

Thus, aligned with their orientations towards exploration or exploitation, organizations conduct their activities, adapting their structures, processes, and people to respond to market demands. Burns and Stalker (1994) in their seminal work identify two basic types of organizational structure: mechanistic and organic. The former consists of a high level of functional differentiation, a tiered control, focused on routine processes, communication, and authority arrangement resulting in a complex structure that is reflected in the level of centralization or decentralization. Consequently, it is suggested that this is more appropriate for organizations slanted more towards exploitation. The second, organic, consists of high levels of integration among people, specialized expertise, and the presence of a more fluid communications network, seems more appropriate for organizations slanted more towards exploration (Mintzberg, 1995; Wang & Jiang, 2009).

Sheremata (2000) stresses that other studies (Kanter, 1988; Duncan, 1976) identified that the elements in mechanistic and organic structures coexist in organizations seeking superior performances. In her study of the development of new products, this author uses two terms taken from the field of astronomy to describe two types of structures. She feels that organizational activities may be compared

with the orbit of the Earth around the Sun. Gravity tends to attract the Earth toward the Sun, but the speed of the Earth's rotation forces it away from this attraction.

The first force is called centripetal because it moves towards the center of the mass attracting it, the Sun. The second force is called centrifugal because it is the force pulling away from the center. Centripetal force prevents the Earth from drifting through sidereal space, while centrifugal force stops the Earth from being sucked in by the Sun. As these are opposing forces, a dynamic balance occurs between them.

Based on these initial words, we state the following question: How organizational structure, radical and incremental innovations, and ambidexterity (exploration and exploitation) are manifested in Technological Research and Development Institutes (TR&DI) in a selected sample in Brazil?

This paper was prepared based on multiple case studies involving a qualitative phase (four cases) and a quantitative phase (17 cases) with the following goals: i) to describe the type of predominant orientation in TR&DI – exploration, exploitation; ii) to describe the type of predominant organizational structure – mechanistic or organic; iii) examine the intensity of the prevailing radical and incremental innovations practices at these institutes; and iv) pinpoint evidence of associations between the exploration and exploitation orientations with the organizational structure and the intensity of radical and incremental innovation practices.

### *Justification and relevance*

The justification for the selection of TR&DI is based on the fact that the literature on exploration, exploitation, organizational structure, and innovation shows that the R&D areas of organizations, as well as high-tech businesses, should be structured organically due to the need for decentralization, more fluid communications, greater autonomy and the creation of knowledge, as they flourish in turbulent and unstable settings (Rothaermel & Alexandre, 2009; Fernhaber & Patel, 2012).

Thus, instead of examining the R&D areas of companies that are subject to corporate policies that could, in this case, interfere in the analyses pursued by this study, it was decided to limit this survey to relatively independent technology institutes. Another reason for this choice is that these institutes are endowed with trimmer structures, with administrators able to provide information based on more holistic overviews of their activities.

Furthermore, in recent years, Brazil has been striving to produce innovations in all fields of knowledge. For example, Leo Madeiras and Scopus Tecnologia (Popadiuk, 2012, Popadiuk et al., 2012), Embraer (2018), Petrobrás (2018) Natura (2018), and Agribusiness sector Bunge (2018), Cargill (2018), Brasken (ethanol) (2018) are recognized as Brazilian innovative companies.

In Brazil, public R&D public institutes are established under government administration, responding to demands from society. Brazilian or foreign private institutes are established by the Information and Technology Innovation Acts, and regulated by the Ministry of Science and Technology.

Thus, developing an organizational structure that responds to these conditions requires understanding the models and their current configurations, and above all being aware of the implications of their use.

These implications are related to decision-making processes, creating knowledge, orientations towards exploitation, exploration, ambidexterity, and types of innovation. Consequently, it may be assumed that the organizational structure of these orientations may be blended. Due to these arguments, we understand that innovation, ambidexterity (exploration and exploitation), and organizational structure have a strong relationship.

This analysis describes the current position of these institutes regarding obtaining, generating, and deploying expertise, examining how their organizational structures are configured to perform activities adequately related to exploration, exploitation, and ambidexterity while pursuing the development of radical and incremental innovations.

In practical terms, we consider that this study is relevant, from a business point of view. The contribution is given in the presentation to managers the need to know their institutions, and from there, structure them according to the strategy of exploitation and exploitation. In this sense, knowing the typologies of organizational structures to implement this strategy is a fundamental factor for the development of innovation and competitiveness. Thus, these typologies consist of mechanistic models that align the exploitation orientation linked to incremental innovation, and the organic models related to exploration guidance related to radical innovation

Thus, Chen (2017) understands that the mechanistic structure offers reliability and efficiency. Regarding exploration Chen (2017) argues that for a dynamically ambidextrous company, it is not recommended to impose existing structures. Instead, allow the organic structure model to have low levels of formalization and standardization.

## **Theoretical framework**

### *Exploitation, Exploration, and Ambidexterity*

An organization focused on exploration that fails to exploit its expertise, processes, and resources will probably bear the costs of experimentation without enjoying the benefits of using such innovations. Inversely, organizations engaged in the use, refinement, and upgrading of their expertise, processes, and resources, while remaining unconcerned with exploration, will probably become overly accustomed to a static balance, bound firmly to the past and unable to adapt to the contingencies prompted by their surroundings (March, 1991).

March (1991) argues that these adaptable processes, with faster and better-structured use spurred by exploitation instead of exploration, tend to be more effective over the short term. As knowledge expands rapidly in this sector, new expertise must be developed merely to keep pace with this progress (Zack, 2002).

In these situations, for an organization to focus on exploration, it must create or acquire the necessary expertise as required to keep it competitive and retain its strategic position. Zack (2002) proposes that organizations slanted towards expertise include some that are conservative and others that are aggressive. Conservative means mainly organizations that focus on their expertise and attempt to hamper their dissemination or transmission outside the company to protect it.

The advantage of an aggressive company comes from its ability to absorb outside expertise to develop new prospects faster than the competition (exploration) and extend this expertise throughout the entire organization (exploitation).

Along these lines, such orientations are implicitly encompassed by discussions of absorptive capacity (Flatten, Engelen, Zahra, & Brette, 2012). However, it may be assumed that organizations can drift towards exploratory conduct and then later opt for more exploitative behavior (or vice versa) in a dynamic manner (Zack, 2002). Depending on the strategic guidelines adopted by the organization, the construction of the organizational structure is fundamental to this strategic decision.

Ambidexterity is a complex concept that does not allow for a simple definition based on exploration and exploitation. Birkinshaw, Zimmerman, and Raich, 2016 and Chen (2017), among others, consider that ambidextrous behavior can manifest itself in organizations according to their structural configuration, revealing itself in a model of dynamic ambidexterity, adopting a structural, contextual, or sequential model (Frogeri et al., 2022; Chen, 2017; Úbeda-García, 2019).

Structural ambidexterity implies separate structures for exploration and exploitation. It demands structures, strategies, and processes associated with exploitation and exploitation (Gastaldi et al., 2022; Kolster, 2021; Popadić, 2015). In contextual ambidexterity does not exist structural separation, but people tend to possess a culture that contemplates the characteristics of exploration and exploitation (Minatogawa et al., 2020). Sequential ambidexterity focuses on optimizing performance over time. There is an exchange between exploration and exploitation and requires constant reconfigurations of strategies, structures, and processes (Chen, 2017; Nölleke et al., 2019).

Organizations must develop the ability to simultaneously accept multiple structures, processes, and different cultures within the same firm. However, non-alignment among strategies, organizational structures, cultures, and people may give rise to performance problems (Tushman & O'Reilly, 1996; Benner & Tushman, 2003; Enkel, Heil, Hengstler, & Wirth, 2017; Zimmermann & Birkinshaw, 2016; Lowik, Rietberg, & Visser, 2016).

Gupta, Smith, and Shalley (2006) assessed the concepts of exploration and exploitation, presenting reflections on the definition of these concepts. For these authors, both exploration and exploitation are self-feeding. As exploration frequently leads to higher failure rates, new research is conducted, and more exploration takes place, creating a mechanism known as a failure trap.

In contrast, exploitation often leads to success. This stresses more exploitation along the way, creating a success trap. The mental model and organizational routines require for exploration are radically different from those needed for exploitation. Consequently, the simultaneous pursuit of

exploitation and exploration is impossible. As a result, these two orientations are viewed as two ends of a continuum with a zero-sum.

Cao, Gedajlovic, and Zhang (2009) used different nomenclature to characterize the predominance of exploration or exploitation. They present an illustration, shown in Table 1, to prompt comments about the conceptualization of ambidexterity.

**Table 1**

*Example of an ambidextrous profile for two generic companies*

Firm	Level of exploration	Level of exploitation	Level of ambidexterity based on an even balance between exploitation and exploration	Level of ambidexterity based on a combination of exploitation and exploration
A	10	5	Low	High
B	5	5	High	Low

Source: Adapted from (Cao et al., 2009).

Firm A scores ten for exploration and five for exploitation. Firm B scores five for exploration and five for exploitation. Cao et al. (2009) raised the question: Which firm is more ambidextrous? In reply, they state that this depends on how the researcher conceptualizes ambidexterity.

If ambidexterity is conceptualized as an even balance between exploitation and exploration, then firm B would be more ambidextrous than firm A. However, if this conceptualization involves a blending of exploration with exploitation, firm A would be ranked as more ambidextrous than firm B.

They consequently conclude that it is difficult to compare studies conducted by different researchers on this topic, as this depends on how each researcher defines ambidexterity Maijanen and Virta (2017), Birkinshaw, Zimmermann, and Raisch (2016), Kriz, Voola, and Yuksel (2014), García-Lillo, Úbeda-García, and Marco-Lajara (2015), Zimmermann and Birkinshaw (2016), Guerra, Tondolo, and Camargo (2016).

### *Organizational structures*

For companies engaged in activities whose markets and environments are more stable, few entrepreneurial decisions are required. In situations where markets and environments change rapidly, flaws in organizational structures become more apparent. For a corporate strategy to remain in place for a given length of time, an organizational structure must be established that can underpin this strategy, allocating resources that respond to market demands (Chandler, 1962; Xie, Wu, Xiao, & Hu, 2016; O'Reilly & Tushman, 2008; Li & Liu, 2014; Carter, 2015).

Ranson, Hinings, and Greenwood (1980) noted that the configuration of these structures is standardized and long-lasting. Each organizational structure model is endowed with important properties that ensure the efficiency and efficacy of the organization. For example, the level of

functional differentiation, integration, connectivity, centralization, decentralization, authority, and formalization may influence the control and dynamics of the organization. This control may give rise to a complex organizational structure.

In this composition, the organizational structure encompasses departmentalization that, according to Daft (2005), Vasconcellos and Hemsley (2000), and Mintzberg (1995) is the clustering of organizational units that give rise to hierarchical tiers and levels of authority, reflecting degrees of centralization or decentralization. Decentralization and centralization are related to the extent to which authority is delegated to lower tiers or retained by higher tiers (Stoner, 1985). Furthermore, this also includes the levels and intensities of authority that must be distributed among the various hierarchical tiers of the organization for taking decisions (Mintzberg, 1995).

A stable environment presents characteristics with few changes, where products, services, or processes alter slowly. Similarly, there are few variations on the market, which are insignificant and foreseeable. An organization surrounded by a stable environment presents a structure whose processes are standardized, with marked formalization and specialization, and few possibilities of flexibilization, pursuing short-term goals within briefer time frames. According to Kast and Rosenzweig (1980), organizations require an organic system for their R&D sections and a mechanistic system for their manufacturing activities.

Through a review of the concept of literature on the organizational structure, mainly based on seminal articles and classic books, it was possible to note that, to understand this, consideration must be given to a set of fourteen inherent dimensions, shown in Table 2. Based on the review of the literature presented in Table 2, it was possible to classify dimensions (1), (2), (3), (4), and (5) as inherent in the mechanistic models.

Thus, with predominant orientations focused on exploitation, dimensions (6), (7), (8), (9), and (10) refer to organic models, implying the predominance of orientation focused on exploration. However, it is stressed that characteristics (11), (12), (13), and (14) are inherent in any organization.

**Table 2**

*Organizational structures – Dimensions*

Dimension	Authors
<i>Predominance of mechanistic models</i>	
1 Specialization	Pugh, Hickson and Mintzberg (1980), Daft (2005)
2 Standardization	Mintzberg (1980)
3 Formalization	Vasconcellos and Hemsley (2000), Pugh, Hickson, Hinings and Turner (1968), Mintzberg (1980)
4 Centralization	Simeray (1977), Mintzberg (1995)
5 Configuration	Pugh, Hickson, Hinings and Turner (1968), Mintzberg (1995)
<i>Predominance of organic models</i>	
6 Flexibility	Pugh, Hickson, Hinings and Turner (1968)
7 Decentralization	Simeray (1977), Mintzberg (1995)
8 Complexity	Hall (2004)
9 Communication	Vasconcellos and Hemsley (2000), Hampton (1992)
10 Hierarchy	Simeray (1977), Hampton (1992)
<i>Inherent to any type of organization</i>	
11 Authority	Simeray (1977)
12 Bureaucracy	Mintzberg (1995), Bowditch and Buono (2000)
13 Autonomy	Maximiano (1995)
14 Systemic Approach	Bertalanffy (1968) Hampton (1992), Mintzberg (1995)

**Source:** Elaborated by the authors.

Under the remarks presented above on exploration, exploitation, ambidexterity, and organizational structure, two propositions are presented.

- P<sub>1</sub> = Predominance of characteristics of the organizational structure with a mechanistic configuration, reflecting an orientation geared toward *exploitation*.
- P<sub>2</sub> = Predominance of characteristics of organizational structure with an organic configuration whose orientation is oriented toward *exploration*.

*Innovation*

Dosi (2006) argues that innovation is linked directly to the progress of technological solutions. These innovations may be related to products, processes, or other organizational aspects, as well as market opportunities. This author affirms that innovation is the process of change that is also linked to imitation, searching, and experimentation, and thus what March (1991) defines as exploration.

Corroborating Dosi (2006), the concept of technological innovation presented in the Oslo Manual (OECD, 2018) encompasses the corporate development of products and processes that are significantly new, upgraded, and launched on the market. Thus, innovation consists of new technological developments, new combinations of existing technologies, or the use of other types of expertise acquired by the company.

Studies such as those by Fang, Palmatier, and Grewal (2011) disclose that interaction among assets related to customers and innovation may affect the financial performance of the company, while Sapprasert and Clausen (2012) argue for the importance of organizational innovation, demonstrating concern with exploring other standpoints that may lead to innovation.

In product dynamics, radical or disruptive innovations normally taper off when a dominant product appears and refers to exploration. It is reflected in new business, models, new sources of revenue, entry into new markets, and long-term survival (Myhren et al., 2018; Freixanet & Rialp, 2022). When expectations are shaped by product characteristics, innovations dwindle. Consequently, R&D focuses on incremental innovations that are associated with exploitation. They are reflected in process redefinitions, reduction of operational costs, search for competitiveness, adjustments in the business environment, explicit knowledge, structured routines (Myhren et al., 2018; Harmancioglu et al., 2019).

Based on the theoretical discussion conducted on exploitation, exploration, ambidexterity, and innovation, it is formulated the following proposition:

- P<sub>3</sub> - Predominance of exploration and exploitation orientation indicates a greater association with innovation.

## Method

The survey used for this paper was exploratory (Stebbins, 2001) and descriptive (Hair, 2006). Through a sample based on accessibility and convenience (Sekaran, 2000), this survey was conducted in 17 Technological Research and Development Institutes in Brazil, accredited with the Ministry of Science and Technology – MCT (2010) and belonging the Brazilian Technological Research Institutions Association – ABIPTI (2010) and the National Research, Development, and Engineering Association for Innovative Enterprises – ANPEI (2009). Through a study of these three registries, 48 institutes were identified in ten Brazilian states.

The R&D technology institutes focus mainly on Internet-related services and products, software, hardware, telecommunications (telecom), information technology (IT), and automation. As the topic of this study was directly related to the strategies of these institutes, their respondents were located mainly at strategic hierarchical levels: CEOs, Executive Board members, or the corresponding hierarchical levels, depending on the individual, and organizational structures of the institutes studied.

Malerba and Orsenigo (1997) argue that the specificity of the sectors implies activity patterns, highlighting two points, one related to the characteristics of the technological context that are common in industrial clusters, and the other addressing the institutional environment. However, they stress the differences that may emerge among countries in some technological categories.

They believe that as an outcome of both points, specific institutional factors are linked to national innovation systems. In Brazil, this system includes development agencies, such as the National Council for Scientific and Technological Development – CNPq; the Graduate Education Coordination Unit – CAPES; the São Paulo State Research Support Foundation – FAPESP; and the Studies and Projects Financing Agency – FINEP.

To collect data, the interview technique was used (Creswell, 1998) with a semistructured guide completed by four institutes during the qualitative phase. During the quantitative phase, seventeen institutes were assessed by completing closed, structured questionnaires whose statements were measured on a seven-point Likert-type scale. Completion of the questionnaire was requested through telephone calls and e-mails. Some of the institutes requested the questionnaire in advance, to check its contents.

The follow-up process included phone calls and messages requesting replies. The semi-structured guide and the questionnaires were based on previous studies and a review of the literature striving to maintain an even balance between statements related to the mechanistic and organic models.

Statements on orientations towards exploitation and exploration and innovation practices, as well as the scale, are found in Popadiuk (2012). For the specific situation addressed by this survey, the wording of some statements was slightly altered, while others were introduced or eliminated.

For the qualitative data collection phase, four main sources were used, according to the recommendations drawn up by Yin (2014): individual interviews, observations, published documents, websites, and the completion of a structured closed, questionnaire. Furthermore, after transcribing the interviews and preparing a preliminary report on each of the four institutes, this report was discussed with each of the respondents, underpinning adjustments in the analyses and interpretations arising from the triangulation of these data (Flick, 2009). During the quantitative phase, two sources were used: the structured questionnaire, and the website analysis.

With this set of sources for the qualitative and quantitative phases, tighter controls could be imposed on the quality and validity of the survey. As a result, the *construct validity* (Yin, 2014) in the qualitative phase was obtained from several sources of evidence, the evidence chain, characterized by spoken remarks, and a subsequent review of the preliminary report by the respondents.

The internal validity may be ascertained through the application of pattern matching and explanation building techniques, for all four institutes. The external validity may be confirmed from only the analytical point of view (Yin, 2014) through the idea of replication in the qualitative phase (four cases) as well as in the quantitative phase (seventeen cases). As the study designed with the precautions suggested by Yin (2014) in preparing a protocol and a database for each case, this underpins belief in its *trustworthiness*, also allowing other researchers to replicate this study by adopting the criteria set forth here.

## Research Design

The study was carried out to characterize the institutes in an institutional manner, not by their parts, meaning in their specific fields of activity. The findings reflect the institutional configurations for each institute, represented through how their senior management organizes them, regarding their organizational structures as well as their orientations slanted towards exploration and /or exploitation.

To analyze the data of the qualitative phase, we used the interpretative analysis according to Flores (1994), pointing out the categories and meta categories of each construct. Due to this, the categories were segmented, and from the grouping of these, by affinity, the meta categories originated, extracted from four institutes that were personally visited by the authors of this article, interviewing the four executives (Table 3).

For the interviews, a semi-structured script was used based on the theories and was later transcribed. Thus, it was possible to evidence the convergent and divergent associations found in the case studies, investigated with the theory, thus seeking to explain the behavior of the phenomena. Secondary data could also be obtained using an initial version of the questionnaire. This phase offered a more detailed understanding of the environments of these institutes, helping to streamline data collection procedures and update the questionnaires completed by the other seventeen institutes.

To characterize the structure as mechanistic or organic, 32 indicators were used as a base in the literature review, as presented in Table 4. Innovation practices were identified through three indicators: focus on radical innovations of products, focus on radical innovations in processes, and focus on radical innovation in services. All the indicators were measured on a seven-point scale where one meant that the indicator was present to a lesser extent, and seven indicated the highest level of presence for this indicator in the institutes surveyed.

**Table 3**

*Characterization of the respondents*

Institute	Origin	Office	Genre
A	Private Foreign	Innovation Management	Female
B	Private Foreign	General Superintendent	Male
C	Private Brazilian	General Superintendent	Male
D	Public Brazilian	General Manager	Male

**Source:** Elaborated by the authors.

The exploration and exploitation scale encompassed six dimensions, measured through 43 indicators (Popadiuk, 2012). Four dimensions reflected exploitation and two dimensions reflected exploration (Table 4). For example, the ‘Competition Dimension’ was measured using seven indicators. Should all these indicators be assigned scores of seven, the highest score for this dimension would be 49, resulting from the total scale (Popadiuk, 2012).

But if the assessments for each indicator of this dimension were assessed at scores between one and seven, resulting in 35, for example, this amount would represent 71% (35/49) of the maximum score for the dimension. Consequently, based on the total score, each dimension was recoded in percentages, based on the maximum score in each dimension.

Table 4 synthesizes the total number of indicators by dimension and shows the respective possible maximum score in parentheses.

**Table 4**

*Indicators and dimensions related to the concepts*

Concept	Dimensions	Indicators	Authors
Exploitation	Competition	7 (49)	March (1991), Levinthal and March (1993), Jansen, Bosch and Volberda, (2006), Popadiuk et al. (2012)
	Partnerships	8 (56)	
	Efficiency	7 (49)	
	Short-term strategic orientation	2 (14)	
Exploration	Knowledge practices	10 (70)	Tushman and Nadler (1986), March (1991), Levinthal and March, (1993) Popadiuk et al. (2012)
	Innovation practices	6 (42)	
Mechanistic model	Mechanistic model	15 (105)	Chandler (1962), Duncan (1976), Burns and Stalker (1994), Daft (2002)
Organic model Innovation	Organic model	17 (119)	Duncan (1976), Burns and Stalker (1994) Nonaka and Takeuchi (1995), Vasconcellos and Hemsley (2000), Daft (2002)
	Innovation	3 (21)	
Total		75	

**Source:** Elaborated by the authors.

*Qualitative Phase Results – General Profile of the Institutes*

In the qualitative phase, four institutes were surveyed: One public and three privates. This segmentation is justified by the assumption that the behaviors of public and private institutes may differ. To ensure the anonymity of these institutes, they have been renamed institutes A, B, C, and D, as shown in Table 5

**Table 5**

*Academic qualifications – Institute Staff*

Institute	Origin	Staff qualifications (%)			Total Employees
		Graduate	Undergraduate	Technicians and Specialists	
A	Private Foreign	20.7	57.7	21.6	251
B	Private Foreign	6.6	82.0	11.4	298
C	Private Brazilian	10.4	65.1	24.5	335
D	Public Brazilian	47.9	31.6	20.5	244

**Source:** Elaborated by the authors.

Figure 1 presents the indexes for the five concepts analyzed in this study for the four institutes during the qualitative phase. These indexes arise from transformations of the scale, as explained in previous paragraphs. To identify them, each of these four institutes was assigned a code number indicating whether it was private or public.

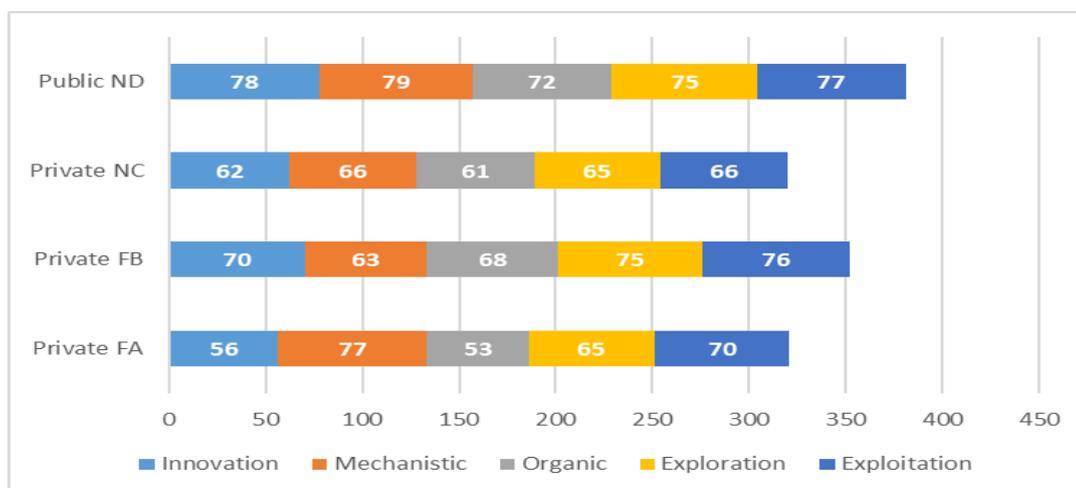
The first institute in Figure 1 (private FA), foreign private, with the hatch mark more to the left, shows the lowest level of innovation practices (56), as well as a lower intensity of exploration practices (65), reflecting a loss-associated with the organic model (53).

On the other hand, it shows greater intensity for activities associated with exploitation (70) and an association with a mechanistic model (77). These findings are consistent with what was noted during the interviews and nonparticipant observations. It is stressed that this institute was set up by its subsidiary through the spin-off of a department of the European corporation focused on internet products and services, together with mobile technologies. Its main customer was its subsidiary.

Its rigid, bureaucratic organizational framework is designed to comply with Brazilian law on information technology, structured into three tiers, namely models by project design, by function, and by specialization, based on responding to dual commands: the CEO functionally, and the Directors hierarchically. It focuses on incremental innovations and fine-tuning existing technologies.

**Figure 1**

*Concept predominance rates at institutes – qualitative phase (%)*



**Source:** Elaborated by the authors.

The second institute (Private FB) shows similar intensities between practices related to exploration (75) and exploitation (76). There is also a more uniform balance between the organic (68) and mechanistic (63) structure models, thus indicating more intensive radical and incremental innovation practices.

This institute was established by the subsidiary and develops software and systems for the Telecom, IT, and automation fields. Its customers consisted of the subsidiary itself, other clients, and universities. Its organizational framework was flexible but bureaucratic, divided into three levels: project design, function, and specialization, with the organic model dominant.

The presence of flexibility and dynamism indicators was noted in the areas, together with adaptations of the organizational structure, decentralization, and autonomy characteristic of this model. Its entities presented clear duties and responsibilities, with means-areas servicing end-areas, adaptable to market conditions. The innovation funnel was adopted as a standard. Its activities are focused strongly on routines and new expertise. Incremental innovations addressed products and their vocation for development.

The third institute (Private NC), private Brazilian, presents very similar levels of exploration, exploitation, organic model, mechanistic model, and innovations practices, at indexes varying between 61 and 66. This Institute was a nonprofit civil association operating nationwide and certified as a Civil Society Organization in the Public Interest, focused on research and development in the information and communications technology fields, as well as training human resources for this market.

With major corporations as its clients and global projects, it has become a benchmark for technology-based solutions in the businesses of its customers and partners, including Texas Instruments, INTEL, and Mentor Graphics. Its organizational structure was flexible and bureaucratic, with clear duties and responsibilities adapted to market conditions, divided into three levels: executive

management, departments, and coordination units. The main innovations were incremental upgrades of existing products.

The fourth institute, (Public ND), public Brazilian, stands out from the others, with indexes topping 70%, noting that it scored the highest for innovative practices. It is also stressed that due to compliance with legal constraints imposed on a state-run organization, exploitation practices are more intense (77), associated directly with the mechanistic model (79), although still engaging in exploration practices (75) and adopting actions inherent to the organic model (72).

This Institute was a government-run facility working with research and development in information technology, interacting intensively with academic sectors. Its main fields of action include electronic components, microelectronics, systems, software, and IT applications such as robotics, decision-support software, and 3D technologies for industry and medicine. Its organizational structure was flexible and bureaucratic, with three tiers: matrix, specialization, and project design.

Its general management included an administrative coordination unit with five divisions covering basic support functions: budget and finance, logistics and back-office support, materials, and assets, human resources, and procurement. In terms of innovations, this Institute gathers together people and resources for their implementation, seeking backers or development agencies.

Ideas were implemented, demonstrated, and recorded in-house, stockpiling concepts that could not be implemented at the time until attracting interest in the future; in brief, ideas were protected by the Institute. New technology-based processors and products were based on existing technologies and were consequently incremental.

### *Quantitative phase – Results*

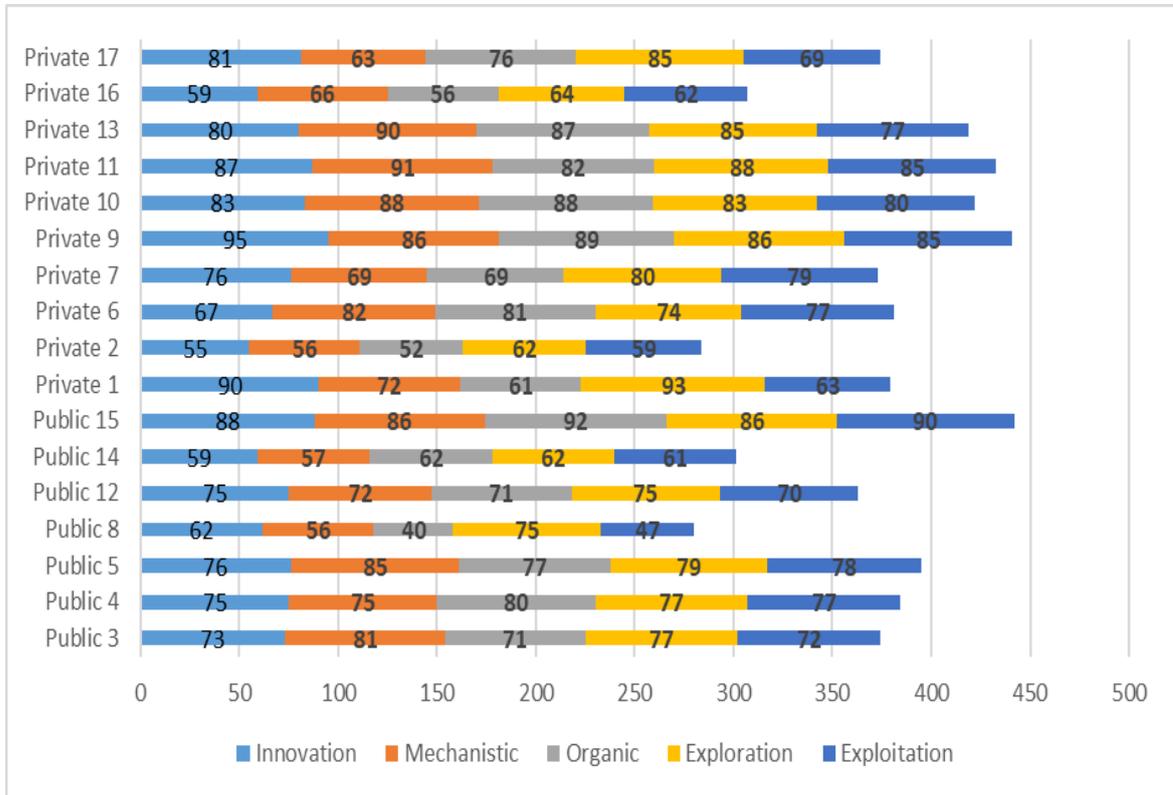
Of the 44 institutes examined during the quantitative phases, 17 participated in the survey (35.4%). Among them, ten were private and seven were public, with ten private institutes founded after 1991 when Brazil's Information Technology Act was promulgated. Among these institutes, 35.2% had up to 100 employees, while 52.0% employed 101 to 500 professionals.

The respondent profile was: 57% male; 91% university graduates; 24% no more than 30 years old; 28% between 31 and 40 years old; 20% between 41 and 50 years old and 28% over 51 years old. Figure 2 presents the percentages for the predominance of exploration, exploitation, organic model, mechanistic model, and innovation practices identified in the seventeen institutes, like the presentation of the four institutes in the qualitative phase.

Through this figure, it is possible to pursue the four goals presented at the start of this paper. Each rectangle shows the predominance of the concept at the institute, while at the same time reflecting associations among these concepts.

Figure 2

Concept predominance rates at institutes – quantitative phase

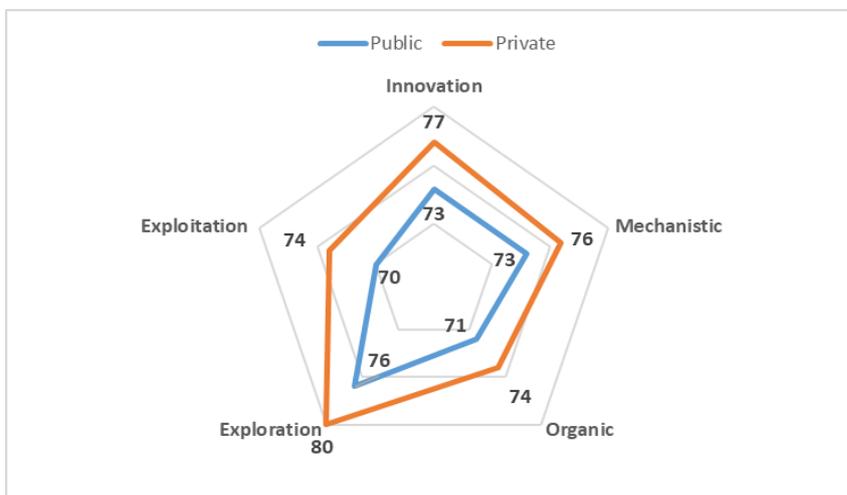


Source: Elaborated by the authors.

It may be noted that there is greater variability among the indicator indices for the five concepts assessed. Segmentation by public or private ownership is presented in Figure 3.

**Figure 3**

*Concept predominance rates by type of institute*



**Source:** Elaborated by the authors.

Among the private institutions, it is noteworthy that the indexes for all the concepts tend to be relatively higher than those for government-run institutes (Figure 3). In other words, they engage in more exploratory activities, tending to have more organic structures simultaneously with their mechanistic counterparts, engaging more intensively in practices pursuing innovation.

To identify statistical evidence of the levels of association among the concepts, a correlation analysis was conducted among them, considering the 17 institutes and the five indicators, with these findings presented in Table 6. The first point to be stressed is that there is a correlation between exploration and exploitation (0.551) and between organic structure and mechanistic structure (0.853). It is also noted that innovation is correlated with exploration and exploitation. These correlations lead to the conclusion that the institutes reflect dualities in terms of their orientations towards exploration and exploitation, which may be viewed as constituting ambidexterity, as well as duality in terms of their structures.

**Table 6**

*Correlations among the concepts*

	Exploration	Organic	Exploitation	Mechanistic	Innovation
Exploration	1.000				
Organic	.569 (*)	1.000			
Exploitation	.551 (*)	.936 (**)	1.000		
Mechanistic	.631 (**)	.853 (**)	.850 (**)	1.000	
Innovation	.935 (**)	.712 (**)	.704 (**)	.699 (**)	1.000

**Notes:** \* Correlation is significant at the 0.05 level (2-tailed). \*\* Correlation is significant at the 0.01 level (2-tailed).

**Source:** Elaborated by the authors.

The correlation between exploration and innovation is 0.935, with exploitation and innovation reaching 0.704. To some extent, this shows that Proposition III may be evidenced. In other words, more exploration leads to more innovation, while also identifying a close correlation between exploitation and innovation (0.704), which supports the presence of ambidexterity at these institutes.

Proposition II, associating exploration with an organic structure, also shows evidence confirming that the correlation reached 0.569, less than the correlation between exploration and mechanistic structure (0.631). For Proposition I, linking a mechanistic structure with exploitation, the correlation reached 0.850.

It was also noted that exploitation is more closely associated with the organic structure model (0.936). Furthermore, innovation was correlated at almost the same intensity for the organic structure model (0.712) as the mechanistic structure model (0.699).

## Discussion

The findings presented in this survey show that it cannot be stated that technology-based research and development institutes are more slanted towards exploration or exploitation, nor even that they follow more organic or more mechanistic structures. In other words, all the institutes may be considered to be following ambidextrous orientations with dual structures.

This leads to the conclusion that organic structural models cohabit with mechanistic models in technology-based research and development institutes. Orientations slanted towards exploration or exploitation are handled in parallel, steered by organizational control requirements, keeping a sharp eye on the competition, partnerships, long or short term strategic guidelines, organizational knowledge practices, and innovation practices. In other words, all the institutes examined through this survey may be considered ambidextrous.

Therefore, Propositions P<sub>1</sub>, P<sub>2</sub>, and P<sub>3</sub> may be considered as confirmed as, with the institutes rated as ambidextrous, their orientations towards exploration and exploitation are consistent with the type of organizational structure. Furthermore, all the institutes focus strongly on practices associated with innovations. These findings lead to the conclusion that it is not possible to characterize an organization through only one side of the dichotomy or even having any kind of configuration related to structural, contextual, or sequential ambidexterity according to the literature presented by Birkinshaw, Zimmerman, and Raich (2016), Chen (2017), Frogeri et al. (2021), Úbeda-García (2019), Gastaldi et al. (2022), Kolster (2021), Minatogawa et al. (2020), Nölleke et al. (2019).

Due to the specific characteristics of their businesses, all organizations must be endowed with mechanisms that are reflected in exploitive actions, simultaneously with mechanisms that reflect explorative actions. Each implies dual structural configurations, either mechanistic or organic. However, since the literature typically suggests that the organizational structure model found in R&D Institutes is

organic, one of the contributions of this study was to identify that R&D institutes perform their activities through dual structures, with an ambidextrous orientation toward the generation and application of knowledge, engaging simultaneously in activities focused on exploration and exploitation.

### **Contributions**

The main implication of the scholarship is the transposition of the concepts of exploration, exploitation, and ambidexterity from the industrial sector, as discussed in March (1991) to the service sector. The conclusions presented show that the concepts of exploration, exploitation, and ambidexterity may be applied to the services sector, provided that their operationalization is tailored to the specific characteristics of the activities encompassed by this sector.

### *Applied implications*

From an applied implications point of view, this study allows technological research institutes managers to diagnose points for adjustments in the organizational structures and learning processes inherent to exploration and exploitation, by using the tools and techniques developed for this survey.

Even though the concepts presented here, particularly those related to exploration, exploitation, ambidexterity, organic and mechanistic structures are not part of the terminology of the professionals working at these institutes and elsewhere, the theoretical, methodological, and analytical content presented in this study may offer insights for fine-tuning management and decision-making processes, to pursue the goals established by the senior management of these institutes.

### *Limitations and future research directions*

This study is subject to limitations on its development, initially due to the sample. As this consisted of 21 institutes in the qualitative and quantitative phases, it was not possible to use multivariate statistical techniques. The second limitation lies in the fact that there is no registry in Brazil listing all R&D institutes by operating area and origin.

Only an assortment of sources was available, each presenting list of their members or accredited institutes, which were sometimes repeated. This made it difficult to establish an accurate or ideal number of technological R&D institutes. A third limitation was related to the concepts of exploration, exploitation, and ambidexterity. The characteristics of ambidextrous structures are found in studies by Duncan (1976), Tushman and O'Reilly (1996), Benner and Tushman (2003), O'Reilly and Tushman (2004), Jansen, Bosch, and Volberda (2006).

However, a brief review of the literature showed that each researcher uses different scales to measure these concepts. This is because the context of each study is different, with almost all of them

analyzing companies in the industrial sector. This study used a scale developed by Popadiuk (2012) that encompasses considerations on six dimensions related to knowledge practices and innovation practices, focused on efficiency, partnerships, competition, and the strategic orientation of the organization.

A final limitation is related to the scale drawn up to measure the organizational structure. Due to the size of the sample, it was not possible to apply tests to check its validity and trustworthiness. However, by an in-depth review of the literature underpinning its preparation, it was possible to achieve the goals set for this paper, at least in descriptive terms. This validity and trustworthiness can be assessed more accurately through future studies with larger samples and different contexts.

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