

Research Article

A preliminary strategy framework for an academic technology center

Daniel Martins Teixeira^{1*} , Arthur Oliveira Alves¹ , Jonathan Simões Freitas² , Raoni Barros Bagno¹ 

¹Department of Production Engineering, Universidade Federal de Minas Gerais, Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte - MG - Brazil, CEP: 31270-901

²Department of Administrative Sciences, Universidade Federal de Minas Gerais, Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte - MG - Brazil, CEP: 31270-901

Abstract

Academic Technology Centers (ATCs) have been attracting increasing attention from scholars and practitioners due to their central role in fostering innovation in complex fields, particularly those based on hard sciences. ATCs are semi-autonomous university arms intended to conduct a portfolio of collaborative R&D Projects and offer services in high-specialized technology fields in the context of University-Industry partnerships. Their operations bear on market-driven development of research-based, cutting-edge technologies, which may culminate in technology transfer to established companies or even new ventures. However, despite such importance, strategizing for ATCs is challenging since business and management literature is highly biased to companies' business contexts. The present study outlines the development of strategic guidelines for an emerging Biotechnology Academic Technology Center with high innovative potential within a Brazilian University. By examining the current state of business planning and strategic management literature in academic settings, we investigate auxiliary methods as an intersecting domain to anchor the analysis. The study scrutinizes the distinct aspects of the context encompassing this particular ATC and strives to adapt a strategic planning approach to support the institution's path. As a result, we offer an adaptable roadmap tool with macro itineraries and influence factors for the context of the case analyzed.

Keywords: strategic planning, university-industry partnerships, academic technology center.

1. Introduction

The significance of technological innovation and entrepreneurship as contributors to economic development is increasingly recognized (Souza et al., 2022), with growing importance attributed to scientific and technological knowledge and innovation (Ghesti et al., 2019). These phenomena, associated with the rise of focus on research commercialization in academic settings, are intrinsically linked and crucial for value creation and value maintenance nationally (Araújo et al., 2005). In this context, Academic Technology Centers (ATCs) become increasingly prominent in advancing value generation derived from science-intensive projects.


ATCs, as defined by Freitas et al. (2011), are emerging ventures originating in academic settings, focusing on market-oriented development of research-derived frontier technology and products for technology transfer (TT) to established firms or spin-offs. They are considered strategic for fostering and developing technology parks and high-tech hubs, thus contributing to the capitalization of knowledge (Ezkowitz & Leydesdorff, 1998).

Despite the ATCs' strong potential for playing a central role in innovation initiatives, limited data is available on their development due to the recency of these organizations and their particularities (academic context, organizational design, and processes) when compared to a typical manufacturing or service company. This is reflected in the few publications investigating these units (Freitas et al., 2011; Freitas, 2014; Resende et al., 2021).

Given their close relations to the university environment, we can extend some concepts and insights from Academic Spin-offs literature to enrich the discussion. Several regions around the world have already successfully explored the potential of new technology-based organizations of academic origin deriving from local institutions of excellence in teaching and research (Freitas, 2014; Klofsten & Jones-Evans, 1996; Lee & Yang, 2000; Ndonzau et al., 2002; Roberts & Eesley, 2011; Smilor et al., 1990). Thus, they provide a solid comparative foundation.

Received: June 29, 2023. Accepted: November 9, 2023.

*Corresponding author: Daniel Martins Teixeira. E-mail: danielmartins.2008@gmail.com

 This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Management tools, methods, and techniques to harness the potential and stimulate the development of such institutions become progressively relevant. Tools are an essential lever for practitioners in their strategy efforts (Souza et al., 2022; Jarzabkowski & Wilson, 2006; Vaara & Whittington, 2012) as they shape the mental models of strategies and affect both the content and process of strategy work (Vuorinen et al., 2018). This work focuses on adapting strategic management and business planning activities, predominantly studied in the context of established companies, to improve decision-making, resource management, and action planning for ATC organizations. However, it is worth questioning the utilization of these tools for ATCs, as the literature still needs to properly address this type of organization.

As indicated by Melo Filho et al. (2021), structured approaches often originate from established industrial firms (Bagno et al., 2017; Salerno et al., 2015) or modern Digital Entrepreneurship settings (Souza et al., 2018). This leaves a gap in tailored methodologies for entrepreneurship in science and technology-intensive academic environments, characterized by high technical and market uncertainty, long development cycles, and disruptive potential (Ndonzuau et al., 2002; Shane, 2004).

Aiming to assist researchers in generating and promoting market-oriented research developments, we analyze academic and non-academic sources on business planning and strategic management, contrasting them with the context of ATCs. Then, we design a method to collect data from an ATC group of researchers throughout several previously selected dimensions of the ATC journey. For this effort, we worked with a Brazilian Biotechnology ATC from a highly recognized university in this field – here called the Technology Center for Advanced and Innovative Therapies (TCAIT). After analyzing data, we present possible strategic directions for the ATC studied and discuss the potential and limitations of such an applied approach for ATCs strategizing.

2. Literature review

In this study, we investigate two streams of thought to support the development of the field approach. First, the Business Planning literature is assessed, evaluating its relevance to the context of the institution under study. Second, the Strategic Management literature and its various perspectives are briefly analyzed to nurture the proposal of an adapted methodology that reinterprets a strategic tool and subsequently develops general strategic directions, considering the specific context of ATCs and the TCAIT. However, we start by delineating in more detail what ATCs are and the commonalities and distinctions from the more widespread concept of Academic Spin-offs.

2.1. Academic technology centers

ATCs are emerging ventures originating in academic settings, focusing on market-oriented development of research-derived frontier technology and products for technology transfer (TT) to established firms or spin-offs (Freitas et al., 2011). The term “ATCs” is a relatively recent designation and could fit into a broader definition of Academic Spin-offs (ASOs) in the sense that they are organizations that extend beyond the regular boundaries of the university and operate with a considerable degree of operational autonomy and interaction with the external market.

ATCs display a high-technology nature that exhibits remarkable potential for socioeconomic influence – including through the generation of spin-offs (Freitas, 2014). Some differences between these types of organizations are shown in Table 1:

Table 1. ATCs and ASOs comparison.

Dimension	ATCS	ASOs (strict sense)
Organization type	University arm, fit in the Etzkowitz’s (2003) concept of quasi-firms.	New ventures.
Structure	Can reach dozens of employees.	Typically starts with small teams.
Governance	It is an arm of the university, internal governance is defined by the members in accordance with the parent organization's broad directives.	Initially, the parent institution and researchers are the major shareholders. The company can be valued and traded according to business life cycle in order to capture market capital. Governance is determined by its shareholders.
Core Product/Business	Collaborative R&D, laboratory services.	New product for the market, usually based on a single technology or a particular arrangement of technologies originated from research.
Intellectual property	Not essential to start the operation. R&D projects can generate intellectual property to be further explored together with partners.	Patents generated in previous research are the main asset of the nascent business.
Objective	Research/Technology development towards market maturity, transferred to other companies or through spin-offs.	Market exploration and exploitation of intellectual property originated from parent organization.

ATCs are not a localized phenomenon, however, given their strong connections to their universities, their mode of operation, degree of autonomy, processes, and governance are strongly shaped by local characteristics.

In Brazil, the Federal University of Minas Gerais has stood out in the generation of ATCs, currently operating 6 units, two of which have been established for long - 7 years (CT-Vaccines) and 13 years (CT-Nano) respectively. The units boast physical headquarters in the Belo Horizonte Technology Park (Universidade Federal de Minas Gerais, 2023; Fundação de Desenvolvimento da Pesquisa, 2020).

Therefore, for the purposes of the present study, we consider ATCs as the semi-autonomous university arms intended to conduct a portfolio of collaborative R&D Projects and offer services in high-specialized technology-fields in the context of University-Industry partnerships. Their operations bear on market-driven development of research-based, cutting-edge technologies, which may culminate in technology transfer to established companies or even new ventures (academic spin-offs).

2.2. Business planning

The idea of a Business Plan (BP), whether taken as a process or a written document outcome, is not clearly defined academically nor in entrepreneurial contexts. Regarding the academic definitions, Castrogiovanni (1996) and Delmar & Shane (2003) define business plans as those activities conducted by a venture founder to gather information to exploit a business opportunity and documented in a written business plan (Burke et al., 2010). This follows a more procedural based interpretation of planning activity that results in the business plan. Honig (2004), on the other hand, defines a business plan as a written document that describes the current state and the presupposed future of an organization, focusing on the written outcome of BP and the content of such documents. As we will discuss further, entrepreneurial non-academic sources focus on BP as a written outcome, mainly focused on advertising purposes as an instrument to raise investments.

The academic discourse on Business Planning predominantly concentrates on how planning impacts venture performance. Even though the precise effects of planning and business plans remain somewhat unclear (Brinckmann et al., 2010), research suggests a range of potential positive and negative outcomes from such undertakings. See some of these outcomes in Table 2.

Table 2. Business planning potential positive and negative effects.

Effect	Potential outcome	Reference
Positive	Context provision and the identification of opportunities and strategies	Burke et al. (2010); Greene & Hopp (2018)
Positive	Performance enhancement	Brinckmann et al. (2010)
Positive	Legitimization and resource procurement	Honig (2004); Brinckmann et al. (2010)
Positive	Resource management and appropriation	Greene & Hopp (2018)
Positive	Facilitation of cultural identity and personal guidance	Brinckmann et al. (2010); Burke et al. (2010)
Negative	A trade-off between time and resources	Bhide (2000); Brinckmann et al. (2010); Burke et al. (2010)
Negative	Rigidity and ignorance	Brinckmann et al. (2010); Honig & Samuelsson (2021); Greene & Hopp (2018); Honig & Samuelsson (2021)
Negative	Limited or harmful impacts	Bhide (2000); Honig (2004); Honig & Samuelsson (2021)
Negative	Ritualistic justifications	Meyer & Rowan (1977); Bird & Jelinek (1989); Honig (2004)

Even though academia has not reached a convergent conclusion, research aiming to pinpoint contexts in which business planning might be advantageous (rather than solely considering the overall effects of planning irrespective of context) supports the idea of positive impacts on venture performance. This implies that the specific context of the venture and the details of the planning process and implementation might be critical for leveraging the benefits of planning activities and mitigating their negative consequences.

A challenge in examining this literature arises due to the scarcity of formal recommendations for business planning as a process or a written outcome. This fact makes it difficult to conclude the success of ventures that did or did not implement planning in their entrepreneurial undertakings. Burke et al. (2010) and

Brinckmann et al. (2010) suggest that the planning method and its execution differ among organizations and that a lack of formal planning in small firms might hamper their development capacity. These analyses indicate that the inexperience of such firms could negatively impact planning behavior, highlighting mistakes in the planning process rather than its effects on venture performance.

Such a context implies that, on the one hand, if specific methods can be considered effective and associated with venture viability and performance. On the other hand, conclusions about the experience of employing them might be distorted due to the application of inappropriate methods by some firms.

Grey literature often recommends contents and requirements for business planning to improve business performance and the likelihood of venture success through better risk and resource management and decision-making. However, these resources tend to over-focus on fundraising and the written plan as publicity material (Goetz, 2008; FitzGerald, 2015; U.S. Small Business Administration, 2023) This fundraising bias is also evident in some online lectures from universities such as MIT (Hadzima, 2014), Wharton (FitzGerald, 2015), and Stanford (Goetz, 2008).

Many non-academic sources follow similar approaches, overemphasizing prior planning activities and a linear approach to entrepreneurship while neglecting aspects such as company context and the timing of planning activities. These factors contribute to the negative effects of planning, such as time-resource trade-offs and rigidity (Mintzberg, 1987; Brinckmann et al., 2010; Greene & Hopp, 2018; Honig & Samuelsson, 2021). Additionally, they reinforce ritualistic justifications for engaging in planning activities due to institutional pressure rather than perceived benefits.

Given the specific context of ATCs, there is a need to reevaluate these prescriptions to determine their adherence and applicability. Therefore, we must shift the focus from a fundraising perspective to activity programming and decision-making improvement to assist the development of these organizations. While some papers align business planning priorities with evaluating opportunities and courses of action (Burke et al., 2010; Honig, 2004), academic and non-academic prescriptive literature fails to address these aspects in the context of ATCs.

2.3. Organizational strategy

Organizational Strategy is an ambiguous concept and research area. Freitas (2018) envisions organizational strategy as an “organization's navigation in the map of its environment.” The metaphor highlights the importance of identifying one's location, destination, means of transport, and trajectory while accounting for incidents and emerging routes.

Three relevant approaches to organizational strategy, as proposed by Freitas (2018), are “strategy-as-process” (SPRO), “strategy-as-content” (SCON), and “strategy-as-practice” (SPRA). SPRO refers to strategic planning processes based on institutional vision and objectives. SCON focuses on strategies existing companies use to achieve competitive advantage, whereas SPRA emphasizes dynamism and constant adaptation. Common to all these perspectives are three key variables (“from where?”, “to where?”, and to a lesser degree, “through where?”). SPRO also introduces the concept of “Logical incrementalism”, which emphasizes the need for incremental planning due to future uncertainties, reinforcing the idea of a flexible, adaptable map, bridging its body of knowledge with the SPRA perspective. Figure 1 presents the approaches, with the eye's orientations representing the different ways of viewing strategy.

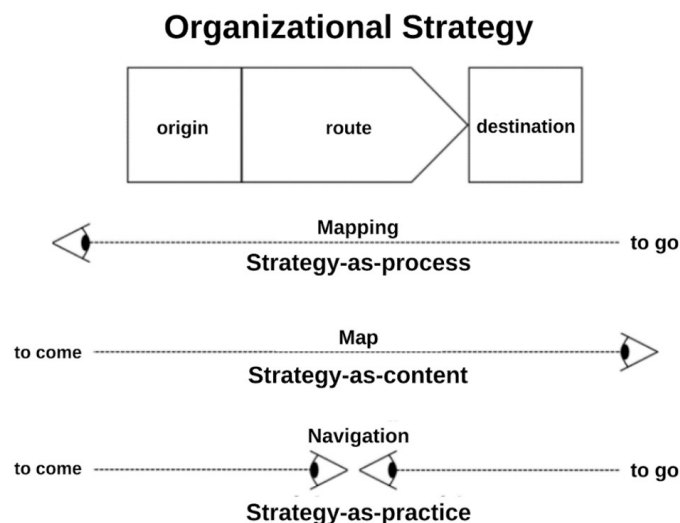


Figure 1. Viewpoints on organizational strategy adapted from Freitas (2018, p. 29).

According to Mintzberg et al. (2010), various strategy schools of thought exist, each with its principles, such as design, planning, positioning, entrepreneurial, cognitive, learning, power, cultural, environmental, and configuration. These schools are classified into three groups: (i) prescriptive, which focuses on how strategies should be formulated; (ii) descriptive, which describes how strategies are formulated; and (iii) configuration, which combines strategy formulation processes, content, organizational structures, and context, serving as a junction between the other formats. This study employed a mix of approaches, focusing on Prescriptive and Configuration Schools of thought due to the better adaptation of these formulations with SPRO and SPRA.

Using the navigation metaphor proposed by Freitas (2018), the paradigms (SPRO, SCON, SPRA) help one to understand organizational development. The chosen analogy approximates the available strategic perspectives to the researcher's reality, making it more comprehensible, which is critical to implementing them. In this study, we used tools for data collection built upon these paradigms to analyze and create milestones tailored to the TCAIT context, as detailed in the methodology section.

3. Methodology

This empirical study focuses on the Technology Center for Advanced and Innovative Therapies (TCAIT), a nascent ATC initially comprised of 12 researchers. Data were obtained from the TCAIT members, providing insights into the center's operations and objectives. The research process lasted about nine months, consisting of four main stages:

1. Studying TCAIT, its scientific and market general contexts, and its demands;
2. Exploring business planning and strategic planning approaches;
3. Conducting non-structured interviews with the coordinators and, after, proposing and adjusting an electronic formulary for collecting data from the members;
4. Data analysis and formatting results.

We undertook initial meetings with TCAIT members to contextualize the organization's problem and understand its projects and demands. The group showed strong expertise in associated scientific fields but needed to learn how to structure an organization. Consequently, the researchers decided to invest efforts in a business plan for TCAIT to bridge the gap between market objectives and academic projects. We first conducted a detailed study on business planning. However, we soon realized that a traditional approach to business planning would not offer an adequate solution for TCAIT due to the high uncertainty of such a venture. As Cheng et al. (2007) suggest, the generic nature of business planning literature is insufficient as a theoretical foundation for academic entrepreneurs. Hence, we revisited the literature to identify early-stage companies' critical points and generate a new, suitable approach for the ATC.

Organizational strategy concepts and approaches were considered appropriate, and the analogy of physical navigation processes with a company's journey through its environment was then adopted. Then, we held meetings to understand the ATC's current state and to create a formulary for researchers, seeking their perspectives on various aspects of the organization. The questions, comprising seven main sections, aimed to gather detailed insights from the researchers. The sections seek answers to the following points:

1. What are the main stakeholders (including competitors) involved with ATC activities? What measures can these stakeholders take for and against the development of the ATC? What are the Synergies and Altercations between the Stakeholders involved?
2. "Why"/"whereby"/"in order to contribute to what" should the ATC exist?
3. What products/services should the ATC generate? What are the main customers? Who are the main actors? Where should the ATC be installed?
4. What would make the ATC inspiring to stakeholders?
5. What milestones to reach in 12 months? In 3 years? In 5 years?
6. What should the ATC be, what areas should it work in, and what structures should it develop?

Data collection took place over 20 days, covering all researchers. A preliminary review of the responses was conducted, followed by individual interviews and a group meeting with four selected researchers based on their seniority roles within the ATC. Table 3 presents the purpose, duration, and date, along with information about other meetings/interviews conducted with the members of ATC. We undertook a group meeting to discuss and analyze data, prioritizing some prior responses, after which the final strategic plan was constructed.

The planning consisted of six dimensions: (i) Vision - Description; (ii) Mission - Basic definition; (iii) Identity; (iv) Stakeholders; (v) Mission - Detailing; (vi) Vision - Milestones. We prioritized the planning pillars based on their level of abstraction and proposed connections between each section. Finally, we compared the diagrams to identify lessons learned, questions, and conclusions. This effort led us to a milestones diagram outlining a relative timeframe for achieving each milestone.

Table 3. Interview/meeting information.

Interview/Meeting	Objective	Interviewees	Extension	Date
TCAIT Screening - Electronic Open Formulary	Contextualizing questions about the organization and future development plans and expectations	Ten out of the twelve members of the organization, including all steering committee members	Individually determined/ Variable	10/11/22 to 10/30/22
Individual interview with a member of the steering committee - Post Formulary	Discussion about the compilation of the formulary answers (anonymous) focused on market developments.	One steering committee member	approximately 1 hour	10/31/2022
Individual interview with a member of the steering committee - Post Formulary	Discussion about the compilation of the formulary answers (anonymous).	One steering committee member	approximately 1 hour	10/31/2022
Individual interview with a member of the steering committee - Post Formulary	Discussion about the compilation of the formulary answers (anonymous).	One steering committee member	approximately 1 hour	10/31/2022
Steering committee - Questions and Answers meeting	Questions and answers over issues raised during the analysis (contradictions, logic gaps, etc).	Full attendance of the steering committee	approximately 1 hour	11/25/2022
Group Presentation - Steering Committee	Presentation after the analysis of the answers and the construction of the diagrams and feedback.	Full attendance of the steering committee	45 min	12/01/2022
Group Presentation - 2 members of the Steering Committee and director of other ATC	Final presentation and discussion with ponderations and general feedback.	2 Elected members of the steering committee and a representative of another ATC	1h 30 min	12/21/2022

4. Analysis and results

4.1. TCAIT and its challenges

ATCs have gained recognition due to their capacity to generate economic value and contribute to social development, thereby capturing the attention of both public and private entities. To cultivate an effective strategy for the real-world implementation of ATCs, it is essential to consider the context of their emergence.

TCAIT, housed within the Federal University of Minas Gerais, one of Brazil's prominent research universities, is committed to developing cutting-edge therapies for human health. The organization encompasses 12 researchers from various disciplines divided between the departments of Biochemistry and Immunology (1); Physiology and Biophysics (5); Genetics, Ecology and Evolution (2); Morphology (1); Microbiology (1); Chemistry (1) and Production Engineering (1), all with postdoctoral degrees. Alongside, a coordinator, a sub-coordinator, and a four-member steering committee, which the coordinators are a part of, were established by the organization's members.

The formation of this collective represents an effort to extend academic advancements into applications beyond pure research, even though the team has limited prior experience in commercializing their research findings. Most have extensive experience in research development, ranging from basic to applied research; some have been granted patents, and one has had formal lessons in entrepreneurship at the Massachusetts Institute of Technology.

Assisting in the organization's structure provided an invaluable opportunity to delve into the realities of biotechnology ATCs. This experience facilitated a deeper understanding of their unique context and potential development methodologies. ATCs, such as TCAIT, engage with emerging technologies due to their consistent involvement with academic projects at different stages of readiness. These technologies exhibit varying levels of uncertainty, from the technical development phase to market acceptance and potentiality. It is worth noting that ATCs focusing on biotechnology, such as TCAIT, confront distinct challenges, including prolonged development cycles, stringent regulations, and substantial capital requirements (Freitas et al., 2019). Consequently, traditional strategies aimed at developing technology-based startups often fail to address the complexities associated with these organizations (Melo Filho et al., 2021; Melo et al., 2021).

Interacting with TCAIT highlighted the difficulties experienced by the researchers during the institution's nascent development stages. An investigation of the initial demand expressed by the researchers further reinforced this observation. Data collection emphasized regulatory aspects and infrastructure needs, demonstrating that the researchers considered fulfilling short-term capital requirements critical milestones to achieve industry standards. Such standards encompass:

- “The creation of a laboratory with “good laboratory practices” (GLP) and eventually “good manufacturing practices” (GMP) so that they could test products in toxicology experiments, proof of concept and initial studies in humans” (Mission - Basic definition - “through...”).
- “Identification of equipment and infrastructure (whether purchased or via a partner company) that allow the production of pilot batches of selected formulations, using scalable processes with good laboratory practices” (Vision - Milestones - “What milestones to reach in 12 months?”).
- “Laboratories accredited by the regulatory body (good practices...)” (Identity - “What should be in its structure?”).

4.2. Data collection and categorization

The investigation into TCAIT facilitated the examination of the organization's aims, ranging from abstract visions to concrete milestones. We proposed visual diagrams using an electronic form informed by a literature review of organizational strategic perspectives, iteratively updated through analysis and engagement with organization members. This process enabled the identification of gaps, contradictions, and alignment across different levels. The investigation incorporated six dimensions, with the relationships between these dimensions clarified using visual diagrams (Table 4).

Table 4. Diagrams explanation.

Dimension	Diagram Number	Name of Diagram	Explanation
1	1	Vision Analysis	It offers an abstract overview of the organization's direction. It presents a syntactic structure diagram that defines an inspiring vision for stakeholders: “TCAIT aims to enhance human health via technologies that facilitate the development of internal and external projects to reach the market, becoming a reference in advanced and innovative therapies.”
2	2	Mission Analysis	It narrows TCAIT's focus, outlining its purpose, mechanisms, and contributions, demonstrating consistency with the vision: “TCAIT exists to transform academic and partnership-derived knowledge into innovative therapeutic solutions, bridging the gap between academia and technology-based companies, contributing to the advancement of Brazilian technologies and impacting our health system through translational science”.
3	3	Identity Analysis	It captures TCAIT members' perception of the organization's identity. The primary concerns identified among researchers were coordinating efforts and creating technologies, products, and services in line with the Vision and Mission diagrams.
4.1	4	Stakeholder Analysis	It represents the proportions of various stakeholder groups and subcategories. The Health System has the most significant representation as potential partners and clients, followed by the state as both a possible partner and regulator. This relates to the three main concerns of regulatory aspects, infrastructure, and capital needed, as presented in section 4.1.
4.2	5	Stakeholder Analysis – Dimensions	This diagram maps different forms of interference TCAIT may experience within three dimensions: Legislative/Political, Financial, and Operational.
4.3	6	Stakeholder Analysis – Synergies Table	This table identifies possible stakeholder synergies to guide TCAIT's efforts and build partnerships.
4.4	7	Stakeholder Analysis – Altercations Table	This table identifies potential stakeholder conflicts, enabling TCAIT to prepare for such scenarios. Interviewees raised no concerns about direct competitors. The development of projects tightly links to the research and expertise of the members and the interaction between them; therefore, it is likely to have little direct competition.
5	8	Mission Detailing Analysis	Further elaborates on the mission statement, specifying outputs, clients, and responsibilities, providing a tangible sense of the institution's operations and expected results.
6	9	Vision - Milestones Diagram	This diagram illustrates the expected milestones for TCAIT's development and the timeframe for their achievement, acknowledging increased uncertainty over time.

The 10th Diagram - DMSC (Diagram - Milestones vs Stakeholders - Complete) - relates the milestones that need to be achieved based on a timeline with the key stakeholders involved in this process. The building of the DMSC diagram results from the cross-validation of the information between each of the diagrams into a visual representation over time (Figure 2).

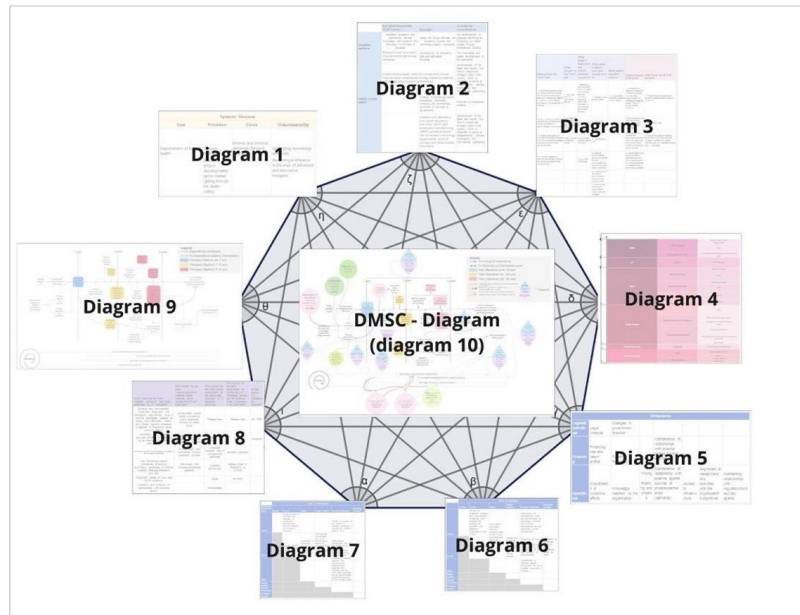


Figure 2. Cross-validation of diagrams.

In order to obtain validation from the TCAIT, three meetings were conducted with the TCAIT steering committee and a leader from another ATC to share perspectives and approaches (Table 3). Two of these three meetings focused on showcasing the progress and obtaining validation of contradictions between the information summarized in the diagrams, while the final meeting involved presenting the final diagram to receive constructive feedback for improvement. The results are available in Figure 3.

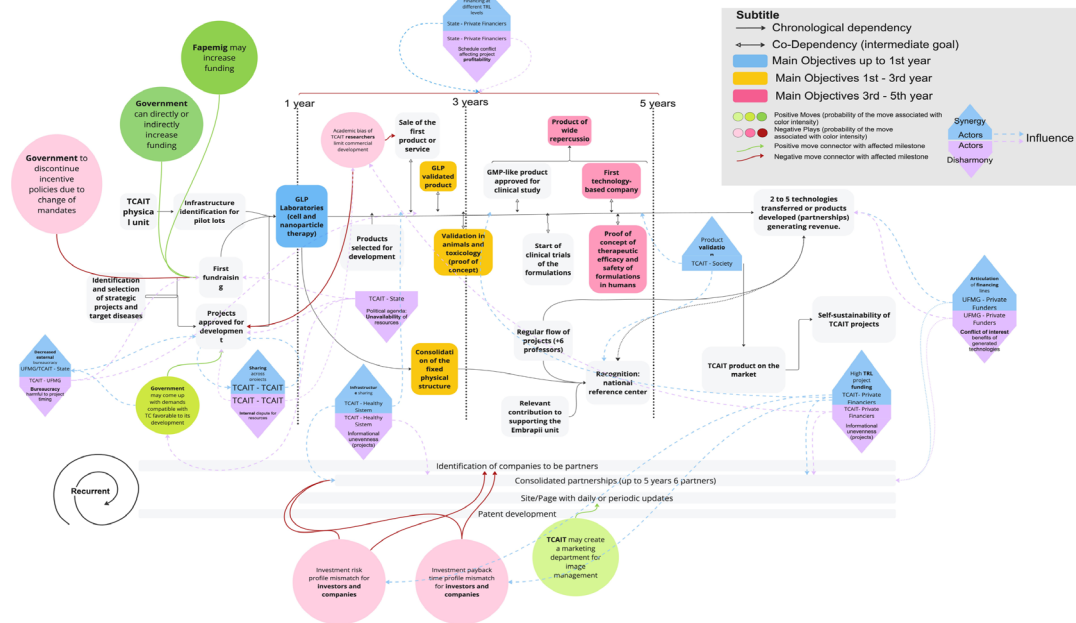


Figure 3. DMSC - diagram for TCAIT.

DMSC Diagram elucidates TCAIT's major short, medium, and long-term milestones (in blue, yellow, and pink squares, respectively) in their sequential order, emphasizing the most critical ones. Additionally, it exhibits the potential actions of stakeholders influencing the milestones (denoted by green and red circles), as well as synergies (light blue pyramids) and altercations (light pink inverted pyramids) connecting stakeholders and their interactions affecting both actions and milestones. Figure 3 amalgamates data from various dimensions examined in the preceding diagrams.

4.3. Implications for ATCs

The proposed milestones delineate the tangible objectives that the organization strives to achieve. Taking the mapping metaphor from the literature review, we can view these milestones as significant macro-itineraries, a route that TCAIT must navigate to align its efforts with the vision articulated by the researchers.

This outcome showcases these itineraries without constraining TCAIT's potential strategies for their achievement. Herein lies a dichotomy: While broad objectives can be established, there is no guarantee that short-term activities will necessarily contribute effectively to attaining these milestones. The relative timescale does not provide exact deadlines for each milestone, thus necessitating researchers to establish deadlines dynamically, adjusting the plan according to evolving events, setbacks, and expectations. Continuous updating of the diagram is essential to maintain the alignment of the organizational strategy with the institutional context.

This outcome aligns with the strategic planning aim of guiding the organization's activities. The utilization of the form, followed by the subsequent diagrams and analyses, proved effective, at least within the specific context of TCAIT, meeting the researchers' needs to identify an initial strategic direction.

4.4. Practical utility of the approach to the ATC literature

The environment of ATCs inherently entails numerous uncertainties and risks tied to their activities, as is typically associated with new technology developments (Resende et al., 2017). TCAIT's scenario is no exception. This uncertainty diminishes the effectiveness of detailed plans, requiring periodic revisions, which is typical of high-uncertainty environments. This fact led us to dismiss a traditional Business Plan (BP) approach.

The DMSC enables crafting a visually comprehensible plan that can be updated more efficiently than a traditional BP, facilitating the development of emergent strategies based on overarching objectives. Milestones serve as intermediary reference points that affirm the directionality of the organization's vision, mission, and identity.

The DMSC aids in mitigating uncertainties surrounding certain milestones, mainly due to the role of regulation in TCAIT's development. Such regulation tends to decrease the ambiguity around specific milestones within the DMSC, facilitating a trajectory less prone to drastic changes as the plan progresses.

Using other diagrams resulting in the DMSC is vital because the milestones are cross-validated and aligned with elements from other diagrams. This cross-comparison allows for a systematic analysis of changes in a specific dimension and their influence on other organizational dimensions across various levels of abstraction.

4.5. Practical utility of the approach for the TCAIT

In the short term, TCAIT can adopt emerging strategies to accomplish the next milestones outlined in the DMSC. Short-term efforts can concentrate on milestones, cards, synergies, and disagreements during the organization's first year while maintaining alignment with long-term objectives. In the medium to long term, changes in the identified dimensions can be integrated into the diagram to analyze new courses of action. Integrating new aspects into the diagram demands a fresh cross-assessment to evaluate the impact of the change on other dimensions, resulting in an updated DMSC. This process can be repeated when new relevant information is identified and incorporated into the diagrams.

The tool's focus on stakeholder dynamics affecting these steps is essential, underscoring the importance of directing specific relationships to achieve particular objectives. For instance, to attain the "project approved for development" milestone, TCAIT must consider factors influencing its achievement, such as the positive impact of the Stakeholder "State" on project approval through demands compatible with TCAIT's competencies. Moreover, internal ATC discussions can influence the milestone, including competitions for financial and human resources for projects and considerations on researchers' access to existing laboratory structures, the level of development of their research, or the expected project development timeframe. Researchers' Academic Bias can also influence project selections with low market potential due to personal interests.

To reach the milestone, TCAIT should strengthen its relationship with stakeholders like the state, actively seeking issues of public interest in which the organization presents technical expertise. Additionally, TCAIT should engage with the state and the university to enhance synergy effects concerning bureaucracy. Internally, TCAIT should reduce resource competition attrition and promote infrastructure sharing and reusing their existing laboratory infrastructure. Furthermore, applying portfolio management methods that minimize individual bias

effects conflicting with TCAIT's interests and access until which development stages the organization expects to germinate the selected projects and when to withdraw from them.

TCAIT researchers know how to determine short and medium-term routes to achieve defined milestones and identify factors that alter milestone dynamics from the DMSC. In the short term, the organization benefits from technological developments from rich academic research. However, organization members must gain an understanding of regulatory aspects tied to research environments and Good Laboratory and Manufacturing Practices (GLP and GMP) as they progress.

Regarding the route metaphor, it is essential to consider that throughout the process, one gets informed about new incidents on the route and new routes that may have become faster. In this context, the DMSC can point to macro-itineraries that do not restrict the perception of alternative routes in the face of new information flows collected by the organization while developing its activities. Consequently, TCAIT can concentrate on the next steps, more confident in alignment with the organization's objectives.

5. Conclusion

In its pursuit of understanding and strategic planning for TCAIT's development, this study has surfaced valuable insights and strategic guidelines. The DMSC approach has proven beneficial in mapping out the complex dynamics among the stakeholders influencing TCAIT's strategic path. The substantial role of the state, serving both as a potential collaborator and regulator, underlines the importance of diligent relationship management within this distinctive context.

The strategic guidelines put forward hold significant implications not just for TCAIT but for comparable ATCs. They offer informed decision-making and optimized resource allocation, providing a practical route for these entities to accomplish their missions. Furthermore, the insights drawn on stakeholder dynamics could foster more robust relationship and partnership building, elements critical in technological progress and innovation.

Upon reflection of the research methodology, the DMSC approach and visual diagrams proved effective despite initial challenges. This methodology facilitated a successful exploration into the ATC's strategic planning, indicating its potential value for future studies in similar contexts. Nevertheless, improving the interview process and data analysis through more specialized input could enhance understanding and mitigate potential biases.

These findings also signpost future research opportunities. This study has contributed to understanding strategic planning within ATCs, and subsequent studies could validate and refine the approach across different ATCs. Moreover, incorporating additional dimensions, such as financial planning and resource allocation, could augment the comprehensiveness and effectiveness of the strategic guidelines.

In terms of practical implications, the study's insights can inform strategic planning endeavors of ATCs, offering a model to navigate the intricate web of stakeholder relationships, regulatory considerations, and organizational goals. One can adapt the iterative, data-driven approach provided to each organization's unique requirements.

However, the study has some limitations. While the findings are insightful, they stem from a specific ATC. Hence, the generalizability to other contexts requires caution. Furthermore, there can be unidentified biases in the data collection and analysis processes, requiring a careful interpretation of the results.

As a recommendation, TCAIT could employ the DMSC tool for its strategic planning and use the strategic guidelines and insights as a base for further development. It is also noteworthy that TCAIT works towards strengthening relations with key stakeholders like the state and strives to reduce internal resource competition to fulfill its milestones. Moreover, we recommend regularly reviewing and updating its strategic plan according to changing circumstances.

Finally, this study has offered a robust strategic planning framework for TCAIT, marked by critical insights into the organization's stakeholder dynamics and strategic objectives. It highlights the necessity for adaptable and data-driven strategies in navigating the complex environment of ATCs. While additional research is needed to refine and validate the approach, this study represents a crucial step toward an effective strategic planning process for ATCs.

6. References

- Araújo, M. H., Lago, R. M., Oliveira, L. C., Cabral, P. R., Cheng, L. C., Borges, C., & Filion, L. J. (2005). "Spin-Off" acadêmico: criando riquezas a partir de conhecimento e pesquisa. *Química Nova*, 28, S26-S35.
- Bagno, R. B., Salerno, M. S., & Silva, D. O. (2017). Models with graphical representation for innovation management: a literature review. *R&D Management*, 47(4), 637-653.
- Bhide, A. (2000). *The origin and evolution of new businesses*. Oxford: Oxford University Press.
- Bird, B., & Jelinek, M. (1989). The operation of entrepreneurial intentions. *Entrepreneurship Theory and Practice*, 13(2), 21-30.

- Brinckmann, J., Grichnik, D., & Kapsa, D. (2010). Should entrepreneurs plan or just storm the castle? A meta-analysis on contextual factors impacting the business planning–performance relationship in small firms. *Journal of Business Venturing*, 25(1), 24-40.
- Burke, A., Fraser, S., & Greene, F. J. (2010). The multiple effects of business planning on new venture performance. *Journal of Management Studies*, 47(3), 391-415.
- Castrogiovanni, G. J. (1996). Pre-startup planning and the survival of new small businesses: theoretical linkages. *Journal of Management*, 22(6), 801-822.
- Cheng, L. C., Gomes, L., Leonel, S., Drummond, P., Mattos Neto, P., Paula, R., Reis, L. P., & Cota Júnior, M. (2007). Plano tecnológico: um processo auxiliar ao desenvolvimento de produtos de empresas de base tecnológica de origem acadêmica. *Locus Científico*, 1(2), 32-40.
- Delmar, F., & Shane, S. (2003). Does business planning facilitate the development of new ventures? *Strategic Management Journal*, 24(12), 1165-1185.
- Etzkowitz, H. (2003). Research groups as ‘quasi-firms’: the invention of the entrepreneurial university. *Research Policy*, 32(1), 109-121.
- Etzkowitz, H., & Leydesdorff, L. (1998). The endless transition: a “triple helix” of university-industry-government relations. *Minerva*, 36, 203-208. <http://dx.doi.org/10.1023/A:1017159001649>.
- FitzGerald, P. (2015). *Business plan writing 101*. Retrieved in 2022, January 25, from https://www.youtube.com/watch?v=zlrB_X6fYZ0&list=WL&index=77
- Freitas, J. S. (2014). *Eventos críticos para a formação de centros tecnológicos de origem acadêmica* [Thesis Ph.D.]. Universidade Federal de Minas Gerais, Belo Horizonte.
- Freitas, J. S. (2018). Estratégia organizacional. In R. B. Bagnó & M. C. Pereira (Eds.), *Tópicos selecionados em organização industrial* (pp. 26-48). Belo Horizonte: Fabrefactum.
- Freitas, J. S., Bagnó, R. B., Bertollo, C. M., Alves, T. M. A., Zani, C. L., Cheng, L. C., & Gonçalves, C. A. (2019). Adapting the roadmapping approach to science-intensive organizations: lessons from a drug development program for neglected diseases. *Journal of Engineering and Technology Management*, 52, 3-15.
- Freitas, J. S., Gonçalves, C. A., Cheng, L. C., & Muniz, R. M. (2011). Structure and agency in academic spin-off creation: a retrospective roadmapping approach to characterize entrepreneurs' mental models. In D. Kocaoglu (Ed.), *2011 Proceedings of PICMET'11: Technology Management in the Energy Smart World (PICMET 2011)* (pp. 1-13). Institute of Electrical and Electronics Engineers.
- Fundação de Desenvolvimento da Pesquisa. (2020, November 6). *Centro de Tecnologia em Nanomateriais e Grafeno da UFMG celebra 10 anos com programação de webinários temáticos*. Retrieved in 2023, November 5, from <https://www2.fundep.ufmg.br/centro-de-tecnologia-em-nanomateriais-e-grafeno-da-ufmg-celebra-10-anos-com-programacao-de-webinarios-tematicos/>
- Ghesti, G. F., Martin, A. R., & Barbalho, S. C. M. (2019). Innovation habitats from University of Brasilia-case study of Macofren-Chemical Technologies startup. *Product: Management & Development*, 16(2), 134-140.
- Goetz, J. (2008). *Business plans*. Retrieved in 2022, January 27, from <https://www.youtube.com/watch?v=gnmYSze9M2g&list=WL&index=85>
- Greene, F. J., & Hopp, C. (2018). *When should entrepreneurs write their business plans?* Retrieved in 2022, August 25, from <https://hbr.org/2018/05/when-should-entrepreneurs-write-their-business-plans>
- Hadzima, J. (2014). *Session 1, part 1: introduction and overview of business plans*. Retrieved in 2022, January 25, from <https://www.youtube.com/watch?v=ZcPNcoTbkIU&list=WL&index=87>
- Honig, B. (2004). Entrepreneurship education: toward a model of contingency-based business planning. *Academy of Management Learning & Education*, 3(3), 258-273.
- Honig, B., & Samuelsson, M. (2021). Business planning by intrapreneurs and entrepreneurs under environmental uncertainty and institutional pressure. *Technovation*, 99, 102124.
- Jarzabkowski, P., & Wilson, D. C. (2006). Actionable strategy knowledge: a practice perspective. *European Management Journal*, 24(5), 348-367.
- Klofsten, M., & Jones-Evans, D. (1996). Stimulation of technology-based small firms: a case study of university-industry cooperation. *Technovation*, 16(4), 187-213.
- Lee, W.-H., & Yang, W.-T. (2000). The cradle of Taiwan high technology industry development: Hsinchu Science Park (HSP). *Technovation*, 20(1), 55-59.
- Melo Filho, L. D. R., Bagnó, R. B., Barroso, M. B. C., & Costa, M. D. D. (2021). BM-QFD: an approach to technology entrepreneurship in creating academic spin-offs. *Product: Management and Development*, 19(2), e20210014.
- Melo, J. C. F., Bagnó, R. B., & Salerno, M. S. (2021). COVID-19 fueling innovation capabilities: the case of medicine innovation Lab (MIL). *Product: Management and Development*, 19(2), e20210016.
- Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: formal structure as myth and ceremony. *American Journal of Sociology*, 83(2), 340-363.
- Mintzberg, H. (1987). The strategy concept II: another look at why organizations need strategies. *California Management Review*, 30(1), 25-32.
- Mintzberg, H., Ahlstrand, B., & Lampel, J. (2010). *Safári da estratégia: um roteiro pela selva do planejamento estratégico* (2nd ed.). Porto Alegre: Bookman Editora.
- Ndonzuau, F. N., Pirnay, F., & Surlémont, B. (2002). A stage model of academic spin-off creation. *Technovation*, 22(5), 281-289.
- Resende, R. G., Bagnó, R. B., Freitas, J. S., & Silva, G. G. (2021). Fatores mediadores do processo de colaboração entre universidade e empresa para a realização de projetos de P&D: uma aplicação ao Centro de Tecnologia em Nanomateriais e Grafeno

da UFMG (CTNano/UFMG). In M. S. Rapini & C. Q. B. Allan (Eds.), *Inovação, ciência, tecnologia e gestão: a UFMG em perspectiva* (pp. 435-469). Belo Horizonte: FACE/UFMG.

Resende, R. G., Bagno, R. B., Silva, G. G., Moreira, L. C., Amaral, A. M. A., & Guerra, P. V. (2017). Processo de desenvolvimento de produtos integrado com a metodologia de avaliação de prontidão tecnológica: proposta para um centro de tecnologia em nanomateriais. In Instituto de Inovação e Gestão de Desenvolvimento do Produto (Org.), *11º Congresso Brasileiro de Inovação e Gestão de Desenvolvimento do Produto* (Vol. 3, n. 12, pp. 1030-1039). Blucher. <https://doi.org/10.5151/cbgdp2017-108>.

Roberts, E. B., & Eesley, C. E. (2011). Entrepreneurial impact: the role of MIT. *Foundations and Trends® in Entrepreneurship*, 7(1-2), 1-149.

Salerno, M. S., Gomes, L. A. V., Silva, D. O., Bagno, R. B., & Freitas, S. L. T. U. (2015). Innovation processes: which process for which project? *Technovation*, 35, 59-70.

Shane, S. A. (2004). *Academic entrepreneurship: university spinoffs and wealth creation*. Cheltenham: Edward Elgar Publishing.

Smilor, R. W., Gibson, D. V., & Dietrich, G. B. (1990). University spin-out companies: technology start-ups from UT-Austin. *Journal of Business Venturing*, 5(1), 63-76.

Souza, M. L. P., Bagno, R. B., & Melo Filho, L. D. R. (2022). Setting the P-Start for digital entrepreneurship: an idea-to-company process model integrated with innovation management tools. *Product: Management and Development*, 19(2), e20220001.

Souza, M. L., Melo Filho, L. D., Bagno, R. B., Souza, W. C., & Cheng, L. C. (2018). A process model integrated to innovation management tools to support technology entrepreneurship. In D. F. Kocaoglu (Ed.), *Portland International Conference on Management of Engineering and Technology*. Portland: PICMET..

U.S. Small Business Administration. (2023). *10 steps to start your business*. Retrieved in 2023, June 17, from <https://www.sba.gov/business-guide/10-steps-start-your-business>

Universidade Federal de Minas Gerais. (2023). *Centros Institucionais de Tecnologia e Inovação*. Retrieved in 2023, November 5, from <https://www.ufmg.br/prpq/cts/>

Vaara, E., & Whittington, R. (2012). Strategy-as-practice: taking social practices seriously. *The Academy of Management Annals*, 6(1), 285-336.

Vuorinen, T., Hakala, H., Kohtamäki, M., & Uusitalo, K. (2018). Mapping the landscape of strategy tools: a review on strategy tools published in leading journals within the past 25 years. *Long Range Planning*, 51(4), 586-605.