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Beyond the dichotomy: hybrid decision-making logics in technology-based women's entrepreneurship

Para além da dicotomia: lógicas decisórias híbridas no empreendedorismo feminino de base tecnológica

Más allá de la dicotomía: lógicas híbridas de toma de decisiones en el emprendimiento femenino basado en la tecnología

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ABSTRACT
Background: Women's entrepreneurship in technology-based companies has advanced in recent decades, but it remains hampered by gender asymmetries and challenges to legitimacy in knowledge-intensive environments. Despite the growth of research on Effectuation, Causation, and gender, studies integrating these dimensions in regional contexts of emerging economies are still limited.
Purpose: To analyze the articulation between the logics of Effectuation and Causation in the process of creating and developing technology-based companies led by women in Belo Horizonte, Minas Gerais.
Method: A qualitative approach was adopted, using a multiple case study involving four female entrepreneurs from different sectors. Data was collected through semi-structured interviews and document analysis and analyzed in two complementary stages: intra-case analysis and inter-case analysis, based on content analysis techniques.
Results: It is evident that the decision-making dynamic is hybrid and contextual, structured in four analytical dimensions: starting conditions, networks and ecosystems, uncertainty management, and transition and hybridization. In the initial stages, an Effectuation logic predominates, while the consolidation of the business demands the progressive incorporation of causal practices. However, this transition does not imply substitution, but rather a strategic articulation between improvisation and planning.
Conclusions: This demonstrates that the hybridization of decision-making logics is also shaped by institutional factors and gender legitimacy challenges, broadening the understanding of female entrepreneurship in technological contexts and emerging economies.
Keywords: entrepreneurial process; Effectuation; Causation; female entrepreneurship; technology-based companies.

RESUMO
Contextualização: O empreendedorismo feminino em empresas de base tecnológica tem avançado nas últimas décadas, mas permanece atravessado por assimetrias de gênero e desafios de legitimidade em ambientes intensivos em conhecimento. Apesar do crescimento das pesquisas sobre *Effectuation*, *Causation* e gênero, ainda são limitados os estudos que integram essas dimensões em contextos regionais de economias emergentes.
Objetivo: Analisar a articulação entre as lógicas de Effectuation e Causation no processo de criação e desenvolvimento de empresas de base tecnológica lideradas por mulheres em Belo Horizonte, Minas Gerais.
Método: Adota-se abordagem qualitativa, por meio de estudo de casos múltiplos envolvendo quatro empreendedoras de setores distintos. Os dados foram coletados por entrevistas semiestruturadas e análise documental e analisados em duas etapas complementares: análise intracasos e análise intercasos, com base na técnica de análise de conteúdo.
Resultados: Evidencia-se que a dinâmica decisória é híbrida e contextual, estruturada em quatro dimensões analíticas: condições de partida, redes e ecossistemas, gestão da incerteza e transição e hibridização. Nos estágios iniciais, predomina a lógica Effectuation, enquanto a consolidação do negócio demanda incorporação progressiva de práticas causais. Contudo, essa transição não implica substituição, mas articulação estratégica entre improvisação e planejamento.
Conclusões: Demonstra que a hibridização das lógicas decisórias é também moldada por fatores institucionais e desafios de legitimidade de gênero, ampliando a compreensão do empreendedorismo feminino em contextos tecnológicos e economias emergentes.

Palavras-chave: processo empreendedor; *Effectuation; Causation*; empreendedorismo feminino; empresas de base tecnológica.

RESUMEN

Contextualización: El emprendimiento femenino en empresas tecnológicas ha avanzado en las últimas décadas, pero sigue viéndose obstaculizado por asimetrías de género y desafíos a su legitimidad en entornos intensivos en conocimiento. A pesar del creciente número de investigaciones sobre efectividad, causalidad y género, los estudios que integran estas dimensiones en contextos regionales de economías emergentes aún son limitados.
Objetivo: Analizar la articulación entre las lógicas de Efectividad y Causalidad en el proceso de creación y desarrollo de empresas tecnológicas lideradas por mujeres en Belo Horizonte, Minas Gerais.
Método: Se adoptó un enfoque cualitativo, utilizando un estudio de casos múltiples con cuatro mujeres emprendedoras de diferentes sectores. Los datos se recopilaron mediante entrevistas semiestructuradas y análisis documental, y se analizaron en dos etapas complementarias: análisis intracasos y análisis intercasos, basadas en técnicas de análisis de contenido.
Resultados: Es evidente que la dinámica de toma de decisiones es híbrida y contextual, estructurada en cuatro dimensiones analíticas: condiciones iniciales, redes y ecosistemas, gestión de la incertidumbre y transición e hibridación. En las etapas iniciales, predomina una lógica eficaz, mientras que la consolidación del negocio exig la incorporación progresiva de prácticas causales. Sin embargo, esta transición no implica sustitución, sino una articulación estratégica entre improvisación y planificación.
Conclusiones: Esto demuestra que la hibridación de las lógicas de toma de decisiones también está condicionada por factores institucionales y desafíos relacionados con la legitimidad de género, lo que amplía la comprensión del emprendimiento femenino en contextos tecnológicos y economías emergentes.
Palabras clave: proceso empresarial; Efectividad; Causalidad; emprendimiento femenino; empresas de base tecnológica.

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1 INTRODUCTION

Female entrepreneurship in technology-based firms has expanded in recent decades, alongside economic transformations and the strengthening of innovation ecosystems. Data from the Brazilian Micro and Small Business Support Service (Sebrae, 2025) indicate a 26.7% increase in the number of startups in 2024, with 50.5% operating in the business-to-business (B2B) market and 36% located in the Southeast region of Brazil. This growth, however, has taken place in a context still marked by gender inequalities and challenges related to building legitimacy in knowledge-intensive environments. Firms operating in these contexts face high levels of scientific, regulatory, and market uncertainty, requiring capabilities for experimentation, the strategic mobilization of resources, and legitimacy building (Shane, 2003). For women entrepreneurs, these challenges are compounded by symbolic barriers, restricted access to strategic networks, struggles for technical recognition (Ahl, 2006; Brush et al., 2018), and difficulties in accessing credit (Pereira Porto et al., 2022).

Pereira Porto et al. (2022) show that women's participation in entrepreneurship has increased, particularly in micro, small, and medium-sized enterprises, with 45% of women entrepreneurs being heads of household. Despite this progress, structural barriers continue to constrain the achievement of full gender equity. In the information technology sector, these inequalities are even more pronounced. Borges et al. (2025) highlight that the sector remains strongly male-dominated, contributing to women's underrepresentation, particularly in leadership positions, and intensifying the challenges associated with their entry, retention, and recognition in this field.

Recent research has broadened the understanding of entrepreneurship by emphasizing that entrepreneurial action is guided by cognitive logics that are sensitive to context, identity, and social interactions (Rumpel et al., 2024; Woldesenbet, 2025; Wang et al., 2025). Since the introduction of the Effectuation and Causation logics (Sarasvathy, 2001), literature has advanced in examining how entrepreneurs structure their decisions in unpredictable environments. However, although studies acknowledge that these logics may coexist and alternate throughout the venture life cycle (Read et al., 2009; Fisher, 2012), the conditions under which such articulation occurs in specific and socially situated contexts remain underexplored.

Causation is understood as a predictive rationality and goal-oriented logic, whereas Effectuation refers to means-driven action and non-predictive control, as well as to the articulation between these logics in decision-making. Through a qualitative multiple-case study involving four women entrepreneurs operating in distinct sectors—technology-oriented library science, biotechnology, digital marketing, and forest engineering—this study investigates how professional identity, technical expertise, relationship networks, and institutional requirements shape decision-making dynamics throughout their entrepreneurial trajectories.

This gap becomes particularly relevant when considering female entrepreneurship in technology-based sectors (Borges et al., 2025). Although gender and entrepreneurship literature has documented persistent structural asymmetries arising from stereotypes that hinder women's empowerment in this field (Borges et al., 2025), there is still limited dialogue with entrepreneurial decision-making theories. Likewise, studies on Effectuation and Causation tend to treat the entrepreneur as an abstract agent, with limited attention to gender, identity, and institutional context. Melo et al. (2019) emphasizes a relationship between gender and Causation. Nevertheless, there is still insufficient understanding of how women founders of technology-based firms mobilize and combine these logics in environments simultaneously characterized by technological uncertainty and structural inequalities.

Moreover, most empirical investigations are concentrated in developed economies, with relatively few studies examining regional innovation ecosystems in emerging countries from the perspective of entrepreneurial decision-making and the interplay between Effectuation and Causation in Brazil. An exploratory search was conducted in the Spell (Scientific Periodicals Electronic Library) database using the keyword "female entrepreneurship." A total of 106 articles were identified. Of these, only four included technology-related terms in their titles and keywords. These findings point to an underexplored field of research at the intersection of STEM, gender, and women's entrepreneurship in technology.

Contexts such as Brazil exhibit specific dynamics characterized by unstable markets, limited resources, and a strong dependence on institutional networks for the legitimation of new ventures. Against this backdrop, understanding how decision-making logics are mobilized by women entrepreneurs can broaden the debate on the entrepreneurial process beyond universalist models.

Mari et al. (2024) argue that, although female entrepreneurship and innovation have gained increasing visibility in political, social, and academic debates, the articulation between these two fields remains insufficient and superficial. This gap reveals not only a theoretical limitation but also a structural problem in the way innovation has traditionally been conceptualized, often through narrow perspectives that overlook experiences, practices, and contributions led by women.

Considering these gaps, this article aims to analyze the articulation between Effectuation and Causation logics in the process of creating and developing women-led technology-based firms in Belo Horizonte, Minas Gerais, Brazil. It is proposed that the female entrepreneurial process in technology-based firms is characterized by a dynamic and context-dependent articulation between Effectuation and Causation. It is argued that, in the early stages, the mobilization of available means and the contingent construction of opportunities prevail, whereas practices associated with planning and formalization emerge as the venture becomes consolidated and requires greater institutional legitimacy. This alternation

does not constitute a merely linear transition between logics; rather, it represents a hybrid, relational, and adaptive process influenced by gender-related conditions and the regional innovation ecosystem.

By integrating the perspectives of decision-making processes, gender, and institutional context, this study contributes to the advancement of entrepreneurship theory by demonstrating that the articulation between Effectuation and Causation assumes specific configurations when examined through the lens of female entrepreneurship in technologically complex sectors. More specifically, it is argued that the hybridization of decision-making logics is shaped not only by the degree of environmental uncertainty, as suggested by part of the literature, but also by legitimacy challenges and institutional expectations that influence women's entrepreneurial activities in technological fields. Additionally, the study provides empirical evidence from a Brazilian regional innovation ecosystem, thereby broadening the international dialogue on entrepreneurship in emerging economies.

The remainder of this article is structured as follows. First, the theoretical framework underpinning the analysis of the decision-making logics of Effectuation and Causation, as well as female entrepreneurship in technology, is presented. Next, the methodological approach adopted in the study is described. The findings are then presented and analytically organized. Finally, the theoretical contributions and implications of the study are discussed.

2 THEORETICAL FRAMEWORK

2.1 Female entrepreneurship in knowledge-intensive technological contexts

Entrepreneurship is understood as a consolidated field of study at the intersection of economics, management, psychology, and sociology, concerned with understanding how opportunities emerge and how individuals and groups perceive, interpret, and transform them into new businesses, products, services, or forms of organization (Baron & Shane, 2014). From this perspective, entrepreneurship is not restricted to business creation but encompasses cognitive, social, and institutional processes that influence entrepreneurial action, as also discussed in both classical and contemporary literature in the field.

Female entrepreneurship, in turn, is influenced by institutional, cultural, and social conditions that affect access to resources, networks, and market legitimacy (Camargo et al., 2018; Fabrício & Vizeu, 2024). The growth of female entrepreneurship in recent decades has been widely documented in the international literature. However, this growth is not evenly distributed across economic sectors. It is also important to emphasize the relevance of entrepreneurial education based on the development of critical competencies, such as creativity and communication, as well as technical competencies associated with practice, knowledge seeking, and experimentation. These elements can contribute to venture development, together with family support, both in informal economy contexts (Maciel et al., 2025) and in technological innovation settings (Dana et al., 2021).

Women remain significantly underrepresented in technology-based ventures, particularly in fields related to science, technology, engineering, and mathematics (STEM) (Mari et al., 2024; Brush et al., 2018). Recent research indicates that women operating in technological sectors face additional challenges related to legitimacy building and access to strategic networks, reinforcing structural inequalities within the innovation ecosystem (Castellano & Rocca, 2018; Nguyen, 2019).

This inequality cannot be explained exclusively by individual factors such as qualifications or professional preferences. Critical literature on gender and entrepreneurship demonstrates that the very concept of the entrepreneur has historically been constructed around attributes associated with masculinity, such as competitive aggressiveness, high risk tolerance, and technical authority (Ahl, 2006). This symbolic construction produces institutional effects that influence women's legitimacy in technology-intensive environments, where scientific expertise and technical recognition are central to business consolidation.

Mari et al. (2024) identify a gap arising from an analytical void, highlighting the need to inform more inclusive public policies aimed at building an entrepreneurial ecosystem that genuinely values women's participation as central agents of innovation and economic development. Fabrício and Vizeu (2024) emphasize that violence against women entrepreneurs constitutes a mechanism of social control which, although illegitimate, is mobilized to preserve the status quo and reaffirm asymmetric power relations based on female subordination. From this perspective, women's advancement into historically male-dominated spaces—particularly those associated with leadership, economic autonomy, and decision-making power—tends to intensify violent reactions precisely because it challenges established privileges. Thus, the closer women move toward positions of power traditionally occupied by men, the greater the potential incidence of attacks and multiple forms of violence, revealing that such practices are not incidental but rather structural responses to the disruption of an exclusionary social order.

As highlighted by Brush et al. (2018), such spaces, including incubators, technology parks, and innovation ecosystems—not only provide infrastructure and technical support but also function as symbolic mechanisms of legitimation. For women operating in fields marked by gender inequalities, these environments may serve as mechanisms for mitigating structural barriers, although they are not sufficient to eliminate them, particularly given the persistence of gender stereotypes (Pereira Porto et al., 2022; Borges et al., 2025).

Therefore, understanding female entrepreneurship in technology-based firms requires an approach that integrates individual agency (Effectuation and Causation logics), relationship networks, and institutional structures. This articulation becomes particularly relevant when examining the decision-making processes that underpin the creation and development of these ventures.

2.2 Causation logic: predictive rationality and goal orientation

The Causation logic, formulated by Sarasvathy (2001), is grounded in predictive rationality. From this perspective, entrepreneurs begin with predefined goals and select the means considered most appropriate to achieve them. The future is regarded as partially predictable; therefore, decisions tend to be structured around strategic planning, market analysis, financial projections, goal setting, and formal control mechanisms. This approach is consistent with classical models of the entrepreneurial process that emphasize opportunity identification, business plan development, and risk reduction through systematic analysis (Gartner, 1985; Hisrich et al., 2014).

Alzamora-Ruiz et al. (2021) demonstrate that, for technology-based SMEs characterized by resource constraints, successful innovation represents a structural challenge. In contexts of high uncertainty, decision-making becomes more complex, making Effectuation and Causation central logics for understanding their innovation strategies. Thus, both Effectuation and Causation influence innovation, reinforcing the need for a less dichotomous analysis of decision-making processes in uncertain environments. However, in technology-based firms, Causation tends to gain relevance as the venture matures. Regulatory requirements, technical certifications, intellectual property management, and the need for production scalability impose increasing levels of formalization. In such contexts, structured planning and predictability become central elements for credibility and sustainability.

Nevertheless, the literature has questioned the limitations of predictive rationality in environments characterized by high levels of technological and market uncertainty. When the future cannot be adequately predicted, planning may prove insufficient as the sole mechanism for strategic guidance (Read et al., 2009).

2.3 Effectuation logic: means-driven action and non-predictive control

The theory of Effectuation, developed by Sarasvathy (2001, 2008), proposes an alternative decision-making logic based on non-predictive control. Rather than starting with predefined goals, entrepreneurs begin their actions with the means available to them, their identity, knowledge, and relationship networks—and progressively interactively construct opportunities. Subsequent studies have shown that effectual logic has been observed across different organizational contexts, particularly in environments characterized by uncertainty and limited resources (Read et al., 2010; Matalamäki, 2017; Ferreira et al., 2022). Effectuation is structured around five fundamental principles, as presented in Table 1.

Table 1
Principles of Effectuation

Principles	Actions
Bird-in-hand	Act based on the means available
Affordable loss	Assess affordable losses rather than maximizing expected returns
Crazy quilt	Build strategic partnerships
Lemonade	Leverage unexpected contingencies
Pilot-in-the-plane	Focus on controlling the future through action

Source: Developed by the authors.

Read et al. (2009), in their meta-analysis, demonstrate that experienced entrepreneurs tend to employ effectual logic in contexts of high uncertainty. From this perspective, opportunities are not simply discovered but are constructed through interactions with stakeholders and incremental experimentation. Thus, Causation logic is grounded in structured analysis and decision planning, whereas Effectuation adopts a non-predictive approach, applying emergent strategies oriented towards opportunities that arise throughout the entrepreneurial process (Sarasvathy, 2001, 2008; Melo et al., 2019). Technology-based firms, particularly in their early stages, operate under significant scientific uncertainty. In such contexts, the gradual mobilization of resources, the formation of commitments, and continuous adaptation become central strategies for venture viability. Iglesias da Silva et al. (2025) indicate that startups with more developed digital capabilities and stronger performance tend to make fewer adaptations to their business models. Therefore, in contexts of uncertainty, startups need to carefully assess their business models and strategically determine their adaptation approaches.

Zhang et al. (2026) suggest that viewing resilience as a sufficient response to disruptions limits the understanding of entrepreneurial organizations, which are often reduced to reactive postures. In contrast, antifragility offers a more robust perspective by demonstrating how organizational capabilities can transform crises into opportunities for strengthening. The pre-disruption, disruption, and post-disruption phases show that digital technologies, social capital, and ambidexterity enable more proactive responses. Therefore, social capital supports resilience throughout a crisis, digital technologies enhance anticipation and collaboration, and ambidexterity facilitates positive responses to ongoing disruptions. Thus, rather

than merely surviving, entrepreneurial organizations need to develop capabilities that enable them to learn from instability and advance in turbulent contexts.

2.4 Beyond the dichotomy: dynamic articulation between Effectuation and Causation

Although initially presented as contrasting logics, subsequent research indicates that Effectuation and Causation should not be understood as mutually exclusive alternatives (Sarasvathy, 2008; Read et al., 2009). Instead, they can coexist and be dynamically mobilized throughout the entrepreneurial process. Recent studies suggest that entrepreneurs combine causal and effectual logics throughout the business life cycle (Kogut et al., 2023).

Recent reviews indicate that the articulation between Effectuation and Causation simultaneously depends on individual, organizational, and institutional factors (Kogut et al., 2023). Thus, the predominance of one logic or the other depends on the perceived degree of uncertainty, the stage of venture development, and the institutional demands of the context. In the early stages, characterized by ambiguity and limited resources, Effectuation tends to predominate. As the venture becomes more established and faces regulatory and competitive requirements, practices associated with Causation become more frequent. Melo et al. (2019) identified a positive association between Causation logic and female entrepreneurship, in line with established evidence in the literature. Regarding Effectuation logic, the findings indicate a positive association in contexts characterized by family influence, particularly when the father is an entrepreneur and when there is a greater number of children. In contrast, negative associations were observed with having an entrepreneurial mother and with the availability of initial resources, suggesting that these factors may influence how decision-making logics are mobilized.

Nevertheless, the literature remains an open field of inquiry, providing limited evidence on how this dynamic articulation manifests when decision-making processes are embedded in contexts shaped by gender inequalities (Mari et al., 2024; Fabrício & Vizeu, 2024), particularly within STEM fields. If women entrepreneurs in technological sectors face additional challenges related to legitimacy and access to resources, it is plausible to assume that the combination of strategic improvisation and structured planning may take on specific configurations.

However, the literature has questioned the limitations of predictive rationality in environments characterized by high levels of technological and market uncertainty. When the future cannot be adequately predicted, planning may prove insufficient as the sole mechanism for strategic guidance (Read et al., 2009). This issue leads to the analytical core of the present study: understanding how women founders of technology-based firms mobilize and articulate these logics in environments simultaneously characterized by technological uncertainty and institutional gender constraints.

3 METHODOLOGY

3.1 Research approach and study design

This research is characterized as qualitative and analytical-interpretive in nature and was conducted through a multiple-case study, following Yin (2014). Data were collected through semi-structured interviews with women entrepreneurs leading technology-based firms in Belo Horizonte, Minas Gerais, Brazil. The data were analyzed using content analysis to identify and interpret how Effectuation and Causation logics are articulated throughout the entrepreneurial process. From this perspective, qualitative research makes it possible to understand the meanings attributed by women entrepreneurs to their trajectories and to decisions related to Effectuation and Causation logics, considering that such decisions are constructed throughout the entrepreneurial process rather than representing isolated events (Peres, 2019). Furthermore, this approach requires interpretive rigor, since data production and analysis are mediated by the researcher's theoretical and methodological choices.

The adoption of the multiple-case study as a methodological strategy (Yin, 2014) enables an in-depth investigation of contemporary phenomena while preserving their embeddedness in the contexts in which they occur, particularly when the boundaries between phenomenon and context are not clearly defined.

The research design was grounded in the theoretical replication logic proposed by Yin (2014), according to which each case represents an opportunity to confirm, extend, or contrast evidence generated from the other cases analyzed. Accordingly, the four cases were treated as independent analytical units, making it possible to understand the specificities of each entrepreneurial trajectory and subsequently identify patterns of convergence and divergence across cases. This strategy strengthens the analytical robustness of the study by enabling interpretations supported by systematic cross-case comparison.

In accordance with the methodological protocol for multiple-case studies, the investigation was structured into successive stages comprising the definition of case selection criteria, evidence collection through semi-structured interviews and documentary research, organization of empirical corpus, thematic coding, and within-case and cross-case analyses. The interviews and organizational documents constituted the main sources of evidence for the study, enabling data triangulation and strengthening the chain of evidence proposed by Yin (2014).

Data analysis was operationalized through the content analysis approach proposed by Bardin (2011), which was used as the analytical procedure for organizing, coding, and interpreting the empirical corpus. Thus, while the multiple-case study guided the methodological design of the research and the logic of comparison across cases, content analysis provided systematic procedures for identifying and interpreting categories related to Effectuation and Causation logics, as well as contextual elements associated with female entrepreneurship in technology-based firms.

To synthesize the methodological procedures adopted and facilitate an understanding of the analytical sequence of the research, Figure 1 presents the flow of the stages undertaken, from the definition of the methodological strategy to the interpretation of the findings.

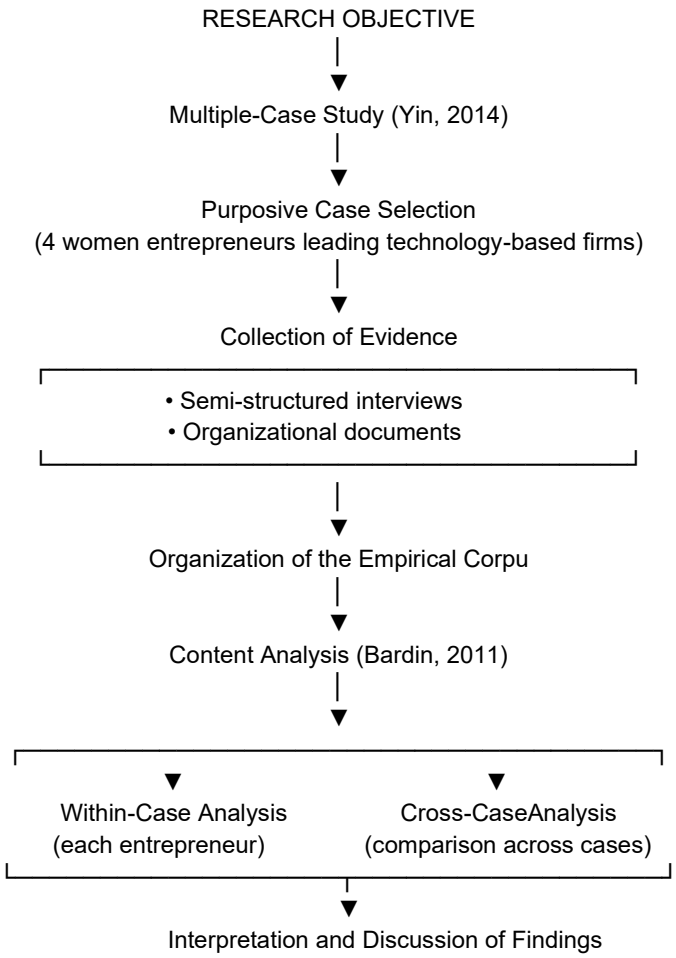

Figure 1. Flow of the research methodological procedures
Source: Developed by the authors.

3.2 Case selection criteria

The cases were purposively selected in accordance with the research objective and the multiple-case study strategy (Yin, 2014). Women entrepreneurs were included if they met the following criteria: (1) they had founded technology-based firms; (2) they operated in knowledge-intensive sectors; (3) they were located in Belo Horizonte, Minas Gerais, Brazil; and (4) they played an active role in the strategic decision-making processes of their ventures.

The choice of Belo Horizonte was justified by the presence of a well-established local innovation ecosystem, including technology parks, university incubators, and institutional networks that support the creation of technology-intensive firms.

The four cases encompass distinct sectors — technology-oriented library science, biotechnology, digital marketing, and forest engineering — thereby increasing analytical variability and making it possible to observe how decision-making logics manifest across different technological contexts.

Participants were recruited through the researcher's professional networks and referrals using the snowball sampling technique (Handcock & Gile, 2024). The sampling strategy was purposive, based on accessibility and referrals, with the inclusion criterion being women founders of technology-based firms located in Belo Horizonte, Minas Gerais, Brazil. This procedure is consistent with qualitative studies that prioritize analytical depth over statistical representativeness. Table 2 presents the profile of the research participants, highlighting their age and academic background, while aspects related to their professional experience and entrepreneurial trajectories are explored throughout the case analysis.

Table 2
Profile of the research participants

Case Code	Case Title	Case Synopsis	Entrepreneur	Age	Educational Level
Case 1 (C1)	Entrepreneurship in Library Science and Technology	Entrepreneurial trajectory involving the application of library science knowledge to technology-mediated solutions and services, developed through professional experience and specialized education.	Entrepreneur A	67	Bachelor's Degree in Library Science and Postgraduate Specialization
Case 2 (C2)	Entrepreneurship in Biotechnology	Technology-based firm in the biotechnology sector, originating from the entrepreneur's scientific and academic trajectory and developed in a context of high technical, regulatory, and market uncertainty.	Entrepreneur B	33	Bachelor's, Master's, and Doctoral Degrees in Biochemistry
Case 3 (C3)	Entrepreneurship and Digital Marketing	Entrepreneurial trajectory developed in the field of digital marketing, characterized by the mobilization of prior experience, continuous adaptation of the business model, and the progressive development of networks and market strategies.	Entrepreneur C	46	Incomplete Higher Education
Case 4 (C4)	Entrepreneurship in Forest Engineering and Technology	Technology-based firm related to Forest Engineering, developed from specialized technical knowledge and embedded in institutional environments and innovation networks.	Entrepreneur D	38	Bachelor's Degree in Forest Engineering, Master's Degree, Doctoral Degree, and Postdoctoral Training

Source: Developed by the authors.

3.3 Data collection

Data was collected through two main strategies: in-depth semi-structured interviews with the founders of the firms and the analysis of organizational documents shared by the participants and obtained from formal sources related to the ventures. The use of these different sources enabled the triangulation of evidence and contributed to strengthening the interpretation of the cases (Yin, 2014).

The participants were initially invited by email and received information about the objectives of the study, the voluntary nature of their participation, and their right to decline to answer any question. Following confirmation of their participation, the interviews were scheduled and conducted online via Google Meet. With the participants' consent, the interviews were recorded and subsequently transcribed in full, totaling approximately 6 hours and 48 minutes of recordings and resulting in approximately 95 pages of empirical material. The interviews were conducted in November 2023.

The research instrument consisted of a semi-structured interview guide (Appendix), developed based on the theoretical framework and comprising open-ended questions that allowed participants to freely discuss their entrepreneurial trajectories and experiences. The interviews sought to reconstruct the entrepreneurial trajectory from the initial conception of the business idea to the current stage of the venture, exploring aspects such as motivations for entrepreneurship; family and educational backgrounds; initial decision-making processes; interactions with networks and institutions; planning and formalization strategies; and responses to uncertainty and contingencies.

To preserve the participants' identities, their names were replaced with the designations Entrepreneur A, B, C, and D. The information collected was used exclusively for academic purposes, with data confidentiality maintained and the applicable procedures for the protection of personal data established under the Brazilian General Data Protection Law (Law No. 13,709/2018) duly observed. The study was not submitted for review by the Research Ethics Committee.

3.4 Data analysis procedures

The empirical corpus for data analysis consisted of the full transcripts of the semi-structured interviews and the organizational documents collected during the research, constituting a single body of evidence analyzed in an integrated manner. In accordance with the multiple-case study strategy (Yin, 2014), the analysis was conducted in four complementary phases, using content analysis (Bardin, 2011) as the procedure for organizing, coding, and interpreting the empirical corpus.

In the first phase, an initial exploratory reading of the interview transcripts and organizational documents was conducted to become familiar with the corpus and preliminarily identify recurring themes. The material was then organized by case, bringing together the different sources of evidence related to each venture.

In the second phase, content analysis was conducted (Bardin, 2011) through thematic coding of the empirical corpus, comprising the interviews and organizational documents. The coding was guided by categories derived from the theoretical framework and encompassed three analytical dimensions: (i) categories related to Effectuation logic, including bird-in-hand, affordable loss, crazy quilt, lemonade, and pilot-in-the-plane; (ii) categories related to Causation logic, such as formal planning, goal setting, predictive analysis, and process formalization; and (iii) contextual elements associated with gender, institutional legitimacy, and participation in the innovation ecosystem.

In the third phase, a within-case analysis was conducted to understand the decision-making trajectory of each entrepreneur individually. At this stage, the records coded during the content analysis provided the basis for the within-case analysis, making it possible to understand how Effectuation and Causation logics were mobilized throughout the entrepreneurial process.

In the fourth phase, a cross-case analysis was conducted through a systematic comparison of the four cases investigated, with the aim of identifying convergences, divergences, and patterns of hybridization across the trajectories analyzed. This stage made it possible to understand how decision-making logics are articulated across different contexts and how aspects related to gender, institutional legitimacy, and the innovation ecosystem influenced the entrepreneurial process.

3.5 Methodological rigor and validity

The methodological rigor of the research was ensured through different strategies aimed at enhancing the reliability and internal validity of the study. Triangulation of evidence sources was achieved through the combined use of semi-structured interviews and organizational documents, enabling the comparison and complementarity of the evidence produced. A systematic comparison across the cases investigated was also conducted, together with detailed documentation of the analytical process, thereby enhancing the transparency, traceability, and consistency of the interpretations. Whenever applicable, participants were consulted to validate the researchers' interpretations of the information.

The adoption of a multiple-case study design also contributed to the analytical robustness of the research by enabling theoretical replication (Yin, 2014), allowing patterns identified in one case to be confirmed, contrasted, or further explored in the other cases analyzed**.**

4 RESULTS

The comparative analysis of the four cases reveals that the use of Effectuation and Causation logics does not occur sequentially or in a mutually exclusive manner, but rather through a dynamic and contextual articulation. The mobilization of these logics is simultaneously influenced by individual factors, institutional networks, and the demands of the technological ecosystem, as evidenced by the interviews conducted with the women entrepreneurs.

The within-case analysis made it possible to understand the specificities of each entrepreneurial trajectory, while the cross-case analysis enabled the identification of recurring patterns, convergences, and distinctive features across the experiences investigated. Additionally, the analysis of institutional materials from the firms—such as organizational histories, areas of activity, content available through digital channels, and information related to their participation in innovation environments—contributed to contextualizing the ventures and corroborating objective aspects of the trajectories analyzed, thereby strengthening the interpretation of the findings.

The results are organized into four analytical dimensions:

1.Initial conditions and mobilization of means;

2.Legitimacy building and strategic networks;

3. Management of uncertainty and contingencies;

4. Formalization and transition toward structured rationality.

4.1 Initial conditions: identity, technical expertise, and mobilization of means

The within-case analysis revealed that, although each entrepreneur followed a unique trajectory, all of them mobilized previously available resources, knowledge, and networks to structure the initial stages of their ventures. Across the four cases analyzed, the entrepreneurial process began strongly anchored in Effectuation logic, particularly in the bird-in-hand principle. The entrepreneurs drew on their professional backgrounds, academic training, and existing networks to structure the initial steps of their ventures.

In Cases A and C, although their educational backgrounds were not originally linked to sectors traditionally classified as technological, their professional experience was creatively reinterpreted, enabling a transition toward digital or innovative solutions. In the case of Entrepreneur C, this mobilization of means is explicitly reflected in her trajectory, as she stated: "I have always been very curious about technology; I started when no one was talking about it," demonstrating how the knowledge and experience accumulated over time were converted into strategic resources for building the venture. Furthermore, her ability to reframe adverse experiences reinforces the Effectuation logic, as reflected in her statement: "I had to turn many bad experiences into fuel to keep moving forward." In Entrepreneur C's case, this rationality is also manifested in the adoption of structured practices throughout the process, as indicated by her statement: "I used lean startup methodologies because I needed to validate quickly and with data," demonstrating the emerging coexistence of elements of causal logic.

In Cases B and D, the well-established scientific foundation resulting from their trajectories in academic research and technical specialization constituted their main initial asset. Accumulated knowledge served as the primary means for constructing the opportunity. In the case of Entrepreneur B, this dynamic is evidenced by the direct mobilization of her scientific background and academic networks, which enabled the transformation of knowledge into market-oriented solutions, particularly in the biotechnology sector. In this context, her approach to uncertainty also reflects a typical Effectuation orientation, as illustrated by her statement: “If you wait until everything is perfect, nothing ever gets off the ground,” demonstrating action based on available means rather than on the predictability of the environment. Entrepreneur D’s statement, “We kept doing what we could, and opportunities began to emerge,” similarly demonstrates an orientation toward taking advantage of opportunities as they arose to sustain the venture.

The cross-case analysis shows that this initial mobilization was not driven by clearly defined goals, but rather by the progressive exploration of possibilities based on available resources. The process was characterized by experimentation, incremental testing, and continuous adjustments, indicating the predominance of Effectuation logic in the early stages. At the same time, this stage was not devoid of rationality. Even within exploratory contexts, decisions were informed by assessments of minimum viability and preliminary market analysis.

4.2 Networks, ecosystems, and legitimacy building

The cross-case analysis confirms the central role of networks and the regional innovation ecosystem in the consolidation of the ventures. The analysis demonstrates that legitimacy building resulted not only from the entrepreneurs’ technical capabilities but also from the mobilization of strategic relationships and their participation in institutional environments capable of enhancing business credibility. The information obtained from the interviews was contextualized using the firms’ institutional materials and records related to their participation in innovation environments.

The within-case analysis revealed that, although each trajectory mobilized different types of connections, networks played a decisive role in the creation and strengthening of the ventures. In Cases A and C, legitimacy was built predominantly through informal networks and strategic relationships. In the case of Entrepreneur C, her trajectory was strongly supported by connections developed over time through events, communities, and professional interactions involving mentors, entrepreneurs, and clients. This relational dynamic is reflected in her statement: “I had to turn many bad experiences into fuel to keep moving forward,” indicating not only resilience but also the ability to mobilize relationships and adverse contexts as sources of strength for the venture. Furthermore, the creation of an entrepreneurial community focused on mutual support among women reinforces the role of networks as mechanisms for legitimacy building and expansion.

In Entrepreneur C’s case, legitimacy building through networks is also explicitly reflected in the development of progressive partnerships and the strengthening of relationships based on trust and collaboration, a characteristic associated with the crazy quilt principle. These networks functioned as mechanisms for accessing symbolic resources, knowledge, and business opportunities, enabling the gradual expansion of the venture in environments characterized by uncertainty. In Entrepreneur C’s case, for example, this movement is evidenced by the adoption of more systematic management and market validation practices, as indicated in her statement: “I used lean startup methodologies because I needed to validate quickly and with data,” demonstrating the progressive incorporation of elements characteristic of Causation logic.

In Cases B and D, participation in formal institutional environments, such as incubators and technology parks, operated as a mechanism of symbolic and technical legitimation. These environments provided infrastructure, mentoring, and access to funding calls, but, above all, they contributed to reducing credibility barriers associated with gender in highly technical environments.

In the case of Entrepreneur B, this dynamic is evidenced by her engagement with institutional and scientific actors, including academic advisors, laboratories, and innovation programs, as well as her participation in initiatives such as TecnoPARQ and other innovation-support environments. Partnership building also emerges as a central element of her trajectory, as the firm was founded together with members of her academic network, reinforcing the role of these connections in the initial legitimation of the venture. Her relational and proactive approach to these institutional interactions is summarized in her statement: “If you wait until everything is perfect, nothing ever gets off the ground,” indicating an active role in constructing opportunities under conditions of uncertainty.

The cross-case analysis therefore demonstrates the strong presence of the crazy quilt principle, as partnerships and progressively established commitments were crucial to venture expansion. Opportunities emerged through interactions with stakeholders rather than exclusively from prior planning. However, as networks expanded and institutional demands intensified, the need for process formalization and the definition of more structured strategies also increased.

4.3 Managing uncertainty: affordable loss and leveraging contingencies

The cross-case analysis shows that managing uncertainty was a central element in the entrepreneurial trajectories investigated. The interviews and organizational documents analyzed reveal that the entrepreneurs dealt with scientific, market, and regulatory uncertainties through adaptive strategies characterized using available resources and the progressive incorporation of accumulated experience.

The within-case analysis revealed that, although the context in which the entrepreneurs operated had their own specificities, a strong presence of the affordable loss principle was identified across all four cases. Rather than making decisions based on projections of maximum returns, the entrepreneurs adopted an incremental approach, investing resources in a controlled manner and adjusting their strategies according to accumulated learning.

In Cases A and C, uncertainty management was manifested through gradual and adaptive decisions. In the case of Entrepreneur C, this approach is explicitly reflected in the management of the venture, particularly when dealing with adverse situations such as conflicts among business partners and market challenges. Her statement, “I had to turn many bad experiences into fuel to keep moving forward,” illustrates the adoption of an affordable-loss logic, in which negative experiences are incorporated as learning opportunities rather than regarded as definitive barriers.

Furthermore, unexpected events, such as regulatory changes, market shifts, or opportunities arising through referrals, were adaptively incorporated into the decision-making process, reflecting the lemonade principle. Contingencies were not treated as negative deviations but rather as elements integrated into the venture’s trajectory.

In Cases A and C, the incorporation of contingencies was also particularly evident. In the case of Entrepreneur C, in addition to the previously mentioned reframing of negative experiences, the continuous adaptation of the business model in response to crises and contextual changes reinforces this logic. Her statement, “I had to turn many bad experiences into fuel to keep moving forward,” also directly illustrates this process of transforming adversity into an impetus for venture development. In Entrepreneur C’s case, this movement is also evidenced by the adoption of structured validation and planning practices, as indicated in her statement: “I used lean startup methodologies because I needed to validate quickly and with data,” demonstrating the gradual incorporation of elements of Causation logic.

In Cases B and D, this logic is evidenced by their willingness to take calculated risks and launch their ventures with limited resources. In the case of Entrepreneur B, the formalization of the business occurred while she was still pursuing her doctoral degree, based on minimal investment and an acceptance of the uncertainties inherent in the biotechnology sector. Her approach to risk and uncertainty is summarized in her statement: “If you wait until everything is perfect, nothing ever gets off the ground,” demonstrating decision-making oriented toward feasible action rather than ideal predictions.

In Cases B and D, this dynamic is particularly evident in scientific and regulatory contexts. In the case of Entrepreneur B, for example, the absence of Brazilian firms capable of meeting the initial demands of her project was reinterpreted as an opportunity to create her own venture, leading to new areas of activity and the expansion of the firm. This movement demonstrates the ability to transform structural limitations into strategic opportunities, a central characteristic of the lemonade principle.

The cross-case analysis demonstrates that this adaptive approach was particularly relevant in regulated sectors such as biotechnology, where technical and regulatory uncertainties are structural features. However, as the ventures progressed toward consolidation, managing uncertainty increasingly required formal control mechanisms.

4.4 Transition and hybridization: from experimentation to structuring

The cross-case analysis shows that the consolidation of the firms involved a partial transition toward practices associated with Causation logic. Strategic planning, the establishment of business goals, contract formalization, the structuring of internal processes, and the professionalization of management became part of the entrepreneurs’ decision-making repertoire.

The within-case analysis revealed that this transition occurred at different paces and levels of intensity, preserving the characteristics of each entrepreneurial trajectory. In Cases A and C, the transition toward more structured practices is more explicit. In the case of Entrepreneur C, the adoption of management and planning tools is evidenced in her statement: “I used lean startup methodologies because I needed to validate quickly and with data,” demonstrating the incorporation of strategic rationality oriented toward market validation and business growth. This movement indicates a shift from a predominantly exploratory logic toward one that combines experimentation with structured planning.

However, this transition did not represent the replacement of Effectuation logic. Instead, a process of hybridization was observed, in which planning practices coexist with continuous experimentation. In the case of Entrepreneur C, for example, even with the adoption of formal management tools, openness to adjustments and business reconfigurations in response to contingencies remains, as evidenced in her statement: “I had to turn many bad experiences into fuel to keep moving forward,” indicating the persistence of an adaptive logic. Furthermore, Entrepreneur C’s trajectory demonstrates that Effectuation practices, such as network building, adaptation to change, and the exploration of emerging opportunities, remain present even at more advanced stages of the venture, characterizing a hybrid process between Effectuation and Causation.

In Cases B and D, this transition is particularly evident as the ventures advance within highly technical and regulated sectors. In the case of Entrepreneur B, although the initial stages were strongly characterized by Effectuation logic, the development of the venture was accompanied by greater organizational structuring and strategic direction, particularly in response to the requirements of the biotechnology sector and the need to expand operations. Nevertheless, her approach continues to reflect an action-oriented logic, as expressed in the statement: “If you wait until everything is perfect, nothing

ever gets off the ground," indicating that greater structuring does not eliminate the need to act under conditions of uncertainty.

The cross-case analysis demonstrates that this articulation between strategic improvisation and rational planning was particularly relevant in technological contexts, where regulatory requirements coexist with market dynamism. Thus, venture consolidation does not imply the abandonment of Effectuation logic, but rather its integration with structured practices, resulting in a hybrid, dynamic, and adaptive decision-making model.

4.5 Synthesis of findings

The cross-case analysis indicates that:

- The entrepreneurial process begins predominantly under Effectuation logic, based on the entrepreneurs' available resources, prior experiences, and relationship networks;
- Networks and ecosystems function as central mechanisms for legitimacy building and expansion, whether through formal institutional environments or informal and strategic relationships;
- Uncertainty management is guided by affordable loss and continuous adaptation, involving incremental decisions and the ongoing reconfiguration of strategies;
- Venture consolidation requires the progressive incorporation of practices associated with Causation logic, such as planning, goal setting, and organizational structuring;
- Decision-making dynamics are hybrid, relational, and adaptive, combining elements of Effectuation and Causation logics throughout the entrepreneurial trajectory.

These findings suggest that, in the context investigated, the articulation between Effectuation and Causation does not occur as a dichotomous choice, but rather as a dynamic process of alternation and complementarity, shaped by the venture's stage of development, the networks mobilized, and the institutional, technological, and market requirements identified throughout the trajectories analyzed.

4.6 Discussion

4.6.1 Hybridization of logics as a situated and relational process

The literature on the entrepreneurial process emphasizes opportunity identification and strategic rationality as relevant elements in the creation and development of new ventures (Shane, 2003). From this perspective, entrepreneurs organize resources and capabilities to respond to environmental demands and construct market opportunities.

However, the findings of this study indicate that, among women founders of technology-based firms, the decision-making process is not organized exclusively around this predictive rationality. Consistent with Sarasvathy (2001, 2008), a strong initial predominance of Effectuation logic was observed, particularly through the bird-in-hand, affordable loss, and crazy quilt principles. The entrepreneurs drew on their technical expertise, accumulated experience, and available networks to progressively construct opportunities rather than implement predefined plans.

These findings reinforce the understanding that, in technology-based firms, non-predictive logic tends to play a central role during the early stages of the venture, corroborating and extending the evidence presented by Melo et al. (2019). Similarly, Read et al. (2009) argue that Effectuation tends to be more prevalent in contexts of high uncertainty. In the cases analyzed, this uncertainty was not limited to market conditions but also encompassed scientific and regulatory dimensions, which are common characteristics of technology-intensive ventures, thereby reinforcing the relevance of effectual logic as a mechanism of non-predictive control.

However, unlike part of the literature that relates Effectuation and Causation primarily to the venture's stage of development, the findings suggest that the articulation between these logics also responds to institutional conditions and the demands of the context in which the ventures operate. The incorporation of practices associated with Causation, such as strategic planning, process formalization, and goal setting occurred not only as a function of organizational maturity but also as a mechanism for responding to the technical, regulatory, and legitimacy requirements present in the technological field. This finding is consistent with the literature on planning and structuring of the entrepreneurial process (Gartner, 1985; Hisrich et al., 2014). Thus, the hybridization observed is not limited to a functional dynamic between uncertainty and stability but also incorporates relational and contextual dimensions, broadening the theoretical debate on the simultaneous use of Effectuation and Causation logics.

4.6.2 Gender, legitimacy, and institutional conformity

The literature on female entrepreneurship demonstrates that women face structural challenges associated with legitimacy building, particularly in knowledge-intensive environments (Ahl, 2006; Jennings & Brush, 2013; Brush et al., 2018). The figure of the entrepreneur, historically associated with masculinized attributes such as risk-taking, technical authority, and aggressive growth, contributes to symbolic asymmetries in access to recognition and capital.

The cases analyzed demonstrate that such challenges influence how decisions are structured. Participation in incubators and technology parks, as highlighted by Brush et al. (2018), not only provides infrastructure but also operates

as a mechanism of institutional legitimation. This external endorsement helps reduce uncertainty perceived by stakeholders and enhances the entrepreneurs' technical credibility. In this context, the adoption of causal practices can be interpreted not only as a requirement for scalability but also as a strategy of institutional conformity. Formal planning and clearly defined goals function as signals of professionalization aligned with the dominant norms of the technological field.

On the other hand, the persistence of effectual practices demonstrates that incremental adaptation remains essential to innovation. This coexistence reinforces the argument of Jennings and Brush (2013) that female entrepreneurship needs to be analyzed through multiple structural and relational dimensions rather than solely from an individual perspective. Thus, the articulation between Causation and Effectuation in the cases analyzed assumes a strategic character: while enabling entrepreneurs to navigate uncertain environments, it also facilitates alignment with the institutional expectations that regulate the technological field.

4.6.3 The entrepreneurial process in technology-based firms: between innovation and control

Technology-based firms operate in contexts characterized by high levels of scientific, technological, and market uncertainty, requiring continuous processes of experimentation, adaptation, and formalization (Sarasvathy, 2001, 2008; Read et al., 2009). In this context, entrepreneurial decision-making involves the articulation between opportunity construction and the requirements associated with venture consolidation.

The findings indicate that this structural duality—innovation under uncertainty and the simultaneous need for formalization requires continuous articulation between strategic improvisation and rational planning. Consistent with Sarasvathy (2008), control of the future through action (pilot-in-the-plane) remains active even when causal practices are incorporated.

However, this study advances the discussion by demonstrating that this articulation takes on specific characteristics when shaped by gender-related issues. The need to signal technical competence may accelerate the incorporation of causal practices, particularly in sectors where scientific authority is central. Thus, hybridization is not merely a response to technological uncertainty but also a mechanism for building legitimacy within an institutionally structured field. This evidence broadens the scope of entrepreneurial process theory by integrating cognitive, institutional, and symbolic dimensions.

4.6.4 Theoretical advancement: beyond the functional dichotomy

The literature has advanced by recognizing that Effectuation and Causation coexist (Read et al., 2009). However, much of the analysis remains centered on "uncertainty" as the primary variable explaining the choice between these logics.

The findings indicate that the articulation between these logics is also shaped by:

- Institutional expectations within the technological field;
- Gender-related legitimacy challenges;
- Participation in regional innovation ecosystems;
- Specific regulatory requirements.

By integrating these dimensions, the study contributes to shifting the debate from a functional dichotomy toward a contextualized understanding of hybridization. Female entrepreneurship in technology-based firms emerges as a relational process in which decisions are continuously reconstructed in dialogue with institutional structures, support and relationship networks, and the demands of the environment in which the ventures operate. In this sense, the findings suggest that the articulation between Effectuation and Causation should be understood not only as a functional response to uncertainty but also as a socially situated process. The trajectories analyzed demonstrate that the mobilization of these logics involves continuous negotiations among institutional expectations, legitimacy building, and strategic adaptation to the environment.

By demonstrating this process through the trajectories of women founders of technology-based firms, the study broadens the entrepreneurship debate by incorporating gender and institutional context into the analysis of decision-making logics. These findings are consistent with the literature that understands entrepreneurship as a socially constructed practice in which identity, gender, and institutional context influence not only the opportunities available but also the ways in which decisions are formulated and legitimized.

5 CONCLUSIONS

This study aimed to analyze the articulation between Effectuation and Causation logics in the process of creating and developing women-led technology-based firms in Belo Horizonte, Minas Gerais, Brazil. Through a within-case analysis followed by a cross-case analysis, the study sought to gain an in-depth understanding of the individual trajectories and subsequently identify patterns, convergences, and divergences across the cases.

The analysis revealed four interdependent analytical dimensions: (i) initial conditions, anchored in the mobilization of identity, technical expertise, and networks; (ii) networks and ecosystems as mechanisms for legitimacy building and expansion; (iii) uncertainty management guided by affordable loss and continuous adaptation; and (iv) transition and hybridization between experimentation and structuring. Regarding the first dimension, the early stages were predominantly

characterized by the mobilization of available means, professional identity, technical expertise, and relationship networks, which are characteristic of effectual logic. As the ventures progressed and began to face regulatory, institutional, and market requirements, there was a progressive incorporation of practices associated with causal logic, such as strategic planning, process formalization, and goal setting.

However, this transition did not represent the replacement of one logic by another, but rather a dynamic process of articulation between different decision-making rationalities. What emerged was a dynamic hybridization in which strategic improvisation and predictive rationality coexist and are continuously adjusted to contextual demands. This articulation proved particularly relevant in technologically complex and institutionally structured environments, where innovation and control need to operate simultaneously.

The interrelationship among these dimensions permeates the entrepreneurial process, which begins predominantly under effectual logic; networks and ecosystems operate as mechanisms for legitimacy building and expansion; uncertainty management is guided by affordable loss and continuous adaptation; venture consolidation requires the incorporation of causal practices; and decision-making dynamics are hybrid, relational, and adaptive.

The main contribution of this study lies in demonstrating that the mobilization of Effectuation and Causation logics occurs in a hybrid, dynamic, and relational manner, influenced not only by the level of uncertainty but also by processes of institutional legitimation, relationship networks, and the specific characteristics of female entrepreneurship in technology-based firms. The findings indicate that female entrepreneurship in technology-based firms constitutes a decision-making process characterized by the integration of different logics of action, strongly influenced by relationships and the entrepreneurs' adaptive capabilities. The dynamic articulation between strategic improvisation and rational planning reveals that entrepreneurship in technologically complex environments simultaneously requires control and flexibility.

The findings reinforce that Effectuation and Causation should not be understood as mutually exclusive approaches, but rather as complementary logics that are dynamically mobilized throughout the entrepreneurial trajectory according to contextual characteristics, established relationships, and the demands associated with each stage of venture development.

By integrating gender, decision-making processes, and the regional innovation ecosystem, this study contributes to a deeper understanding of how women build, sustain, and expand businesses in contexts characterized by uncertainty and substantial institutional demands. Beyond demonstrating the coexistence of Effectuation and Causation, the research shows that their articulation performs a strategic function in navigating technologically intensive and symbolically structured environments, thereby broadening the contemporary debate on entrepreneurship, innovation, and diversity.

Theoretical contributions: The main theoretical contribution of this study lies in advancing the understanding of the articulation between Effectuation and Causation by demonstrating that the hybridization of these logics is not determined exclusively by the level of uncertainty or the stage of venture development, but also by institutional factors, legitimacy challenges, and gender-related conditions that shape entrepreneurial action.

By integrating gender, technology, and decision-making processes within the same analytical framework, the study broadens the debate on female entrepreneurship, shifting the analysis from structural barriers toward an understanding of the adaptive strategies developed by women entrepreneurs. In this context, causal logic emerges not only as a planning mechanism but also as an instrument for signaling competence and institutional alignment.

Furthermore, by investigating firms situated in an emerging economy, the study contributes to broadening the empirical base of a literature predominantly concentrated in North American and European contexts. The analysis highlights the active role of regional innovation ecosystems in shaping entrepreneurial trajectories and decision-making dynamics.

Practical contributions: From a practical perspective, the findings indicate that policies and programs supporting female entrepreneurship in technological sectors should consider the hybrid nature of the decision-making process. Initiatives focused exclusively on strengthening formal planning or, alternatively, solely on encouraging creativity and experimentation may prove insufficient.

Incubators, technology parks, and funding institutions can play a strategic role by providing not only infrastructure and technical training but also mechanisms that enhance legitimacy and visibility for women in knowledge-intensive environments. Strengthening both formal and informal networks proved central to the expansion of the ventures analyzed, as knowledge alone is insufficient. Pre-existing networks were important for structuring the initial stages of the ventures, while informal networks and strategic relationships—including events, professional communities, and interpersonal connections—functioned as mechanisms for the gradual expansion of the businesses.

Furthermore, the findings suggest that entrepreneurial education should encompass the simultaneous development of critical and adaptive competencies without neglecting motivation. In Cases B and D, academic knowledge and technical specialization played a central role, whereas in Cases A and C, prior experience was particularly relevant. This points to the recognition that success in technological environments depends both on the ability to plan and on the capacity to navigate contingencies.

Social and institutional contributions: From a social perspective, the study contributes to the debate on diversity and innovation by demonstrating that women's participation in technological sectors depends not only on technical qualifications but also on institutional structures that foster recognition and strategic inclusion.

By bringing visibility to the decision-making dynamics of women founders in technological environments, the research reinforces the importance of policies that expand access to capital, networks, and mechanisms of institutional endorsement. In this sense, understanding female entrepreneurship in technological contexts requires recognizing not only structural barriers but, above all, the adaptive and relational strategies that enable women entrepreneurs to navigate and transform complex and uncertain environments.

Study limitations: This study presents limitations related to its empirical and contextual scope. The investigation focused on four cases of women founders of technology-based firms located in Belo Horizonte, Minas Gerais, Brazil, purposively selected based on accessibility and referrals. This scope enabled an in-depth understanding of the entrepreneurial trajectories and decision-making logics analyzed while taking into account the specific characteristics of the context investigated. At the same time, the findings should be understood in light of the characteristics of the cases and Belo Horizonte's innovation ecosystem and cannot be automatically extended to other regional contexts or different venture configurations.

This delimitation, however, is aligned with the research objective and the multiple-case study design adopted. In this regard, future research may broaden the empirical scope to include different regions and innovation ecosystems, as well as investigate other sectors and organizational configurations, making it possible to examine the persistence, variation, or emergence of new patterns related to the articulation between Effectuation, Causation, gender, and institutional context.

Future research agenda: Future research may extend this investigation to other innovation ecosystems, geographical regions, and organizational configurations, making it possible to examine the extent to which the patterns identified in this study persist or take on new configurations across different contexts. Comparative studies may also investigate, as an extension of the present research, differences related to gender, sectors of activity, stages of firm development, and characteristics of innovation environments. Longitudinal approaches would also be relevant for understanding how the combination of Effectuation and Causation evolves throughout the different stages of the entrepreneurial trajectory.

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APPENDIX – Semi-Structured Interview Guide

The interview guide was developed based on the study's theoretical framework and structured into thematic sections, comprising open-ended questions that enabled the participants to describe their trajectories, decision-making processes, and experiences in the context of female entrepreneurship in technology-based firms, as presented in Table 3 below:

Table 3
Interview Guide

1. Participant Profile	**2.Entrepreneurial Process**
Age	Previous Exposure to Entrepreneurship within the Family or Social Circle
Educational Background/Institution	Family Influence on Career Choice
Previous Occupation	Approach to Entrepreneurship in Educational Training
Age at the Time of Founding the Company	
3. Company Characteristics	**4.Desenvolvimento do negócio**
Industry/Sector of Activity	Company Formation and Origin of the Idea
Product/Service Offered	Definition of Initial Objectives
Geographic Scope of the Business	Definition of Products/Services and Target Markets
Year Founded	Choice of Business Location
Number of Managing Partners	Conducting Market Research
Number of Employees	Development and Use of a Business Plan
Average Annual Revenue	Sources of Initial Resources and Financing for Growth
Motivations for Creating a Technology-Based Firm	Establishment and Role of Partnerships

	Occurrence of Unexpected Events and Ways of Coping with Them
5.Decision-Making and Strategies	**6. Female Entrepreneurship**
Initial Commercialization and Contact with Customers	Barriers and Difficulties Encountered
Market Entry Strategies	Influence of Gender on the Entrepreneurial Trajectory
Changes in Strategies over Time	Experiences of Prejudice or Discrimination
Decision-Making Approach at the Beginning and at Present	Perceived Benefits Associated with Gender
Reassessment of Objectives in Light of New Resources	Impacts on Personal and Family Life
Recruitment Processes and Their Evolution	Relationships with Male and Female Entrepreneurs
Investment Decisions and Use of Market Forecasts	
Planning for the Company's Future	

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