

Drivers and barriers for the formation of the cultivated meat innovation ecosystem in Brazil: a multi-stakeholder perspective

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1. INTRODUCTION

In the last decades, global food consumption has increased significantly, with the human population consuming twice as much meat as the previous generation (Morais-da-Silva et al., 2022). In this sense, emerging countries play a vital role in livestock production. In these regions, the sector represents relevant resources for local consumption, economic income, job generation, and technological upgrading, with more than 500 million people working in the industry (Reis, Heidemann, Borini & Molento, 2020). Brazil is one of the most prominent players in the livestock industry, being one of the world's largest exporters and having its economy strongly dependent on the agribusiness sector (FAO, 2021).

Notwithstanding an important activity for the Brazilian economy representing 25% of its GDP, it is relevant to note that animal production carries several environmental issues, such as soil depletion, intensive water usage, and gas emissions (Morais-da-Silva et al., 2022). In addition, there are many concerns about animal welfare, human health challenges, and food security (Rubio, Xiang & Kaplan, 2020), such as foodborne illnesses, infectious diseases, antibiotic resistance and others. Since raising and culling animals for food increase the greenhouse gas emission, there is growing evidence that reducing meat consumption is essential for mitigating climate change and preserving the environment (Santo et al., 2020).

Seeking for a cleaner and healthier food production, alternative meat emerges as relevant substitute for traditional meat production. Through the reconfiguration of the technologies, novel food production processes, and disruptive innovations (Newton and Blaustein-Rejto, 2021; Onwezen et al., 2021), alternative meat has the power to foster the agenda of more sustainable production and consumption. In addition to the well-known plant-based alternatives that do not use any animal ingredient (Cameron and O'Neill, 2019; Rubio et al., 2020).

Cultivated meat development has attracted researchers and investors, firms, governments, entrepreneurs, food industry experts, and other innovation ecosystem actors worldwide. Xie & Wang (2020) point out that innovation activities are never isolated; instead, they are part of changes in the economic environments and require innovation from several actors in an interdependent innovation ecosystem. Here, we take the perspective of Moore (1993) on what constitutes an innovation ecosystem. This author defines the concept as “a loosely interconnected network of companies and other entities that coevolve capabilities around a shared set of technologies, knowledge, or skills, and work cooperatively and competitively to develop new products and services” (p. 76). These other stakeholders may be suppliers, distributors, financial and research institutions, makers of complementary technologies, and regulatory bodies (Dedehayir, Ozgur, Makinen, Saku, & Ortt, Roland, 2018). Additionally, the way how partners act and react when facing changing ecosystem dynamics is a preoccupation risen in some studies. According to them, actors are required to manage technological, relational, commercial, and legal issues brought by ecosystems evolution. (Daymond et al, 2023).

In Brazil, this nascent industry requires advancing and consolidating an innovation ecosystem with highly-qualified people and a technological structure for its production (Morais-da-Silva,

2021). Also, it will demand partnerships between startups, traditional meat-processing firms, and other value chain actors (Reis et al., 2022).

Therefore, this study aims to investigate how the cultivated meat innovation ecosystem is being formed in Brazil, focusing on identifying the drivers, barriers, and characteristics perceived by the multiple stakeholders of this emergent industry. A qualitative study with different stakeholders, complemented by secondary sources, was conducted.

Regarding the expected contributions of the study, from the theoretical standpoint, we provide empirical evidence about the challenges brought by an emerging innovation ecosystem and how they are connected to the global value chain literature. Practitioners will find reflections on drivers and barriers a disruptive business is subject to and a better understanding of the current stage of cultivated meat industry in Brazil. We also suggest a future agenda based on insights that emerged in the study which raised questions still underexplored in the academy. These considerations may influence decisions that combine animal suffering relief, taking care of the planet while seeking for a quality alternative protein that meets nutritional and consumer requirements adequately.

The paper is structured as follows: first, in the theoretical background, we address innovation ecosystem concepts and perspectives. Next we present five conceptual variables identified as driving forces for innovative economies according to Yang and Yan framework (2019) and the connection between innovation ecosystems challenges and global value chains (GVC). Second, in the methodology session we contextualize the cultivated meat industry and explain the strategy used. Data analysis, results and discussion focus on four dimensions (technological, legal/institutional, environment/sustainable, and marketing-related), their main drivers and barriers. Finally, based on the identified challenges, we present insights on the cultivated meat ecosystem of Brazil perspectives and suggest a future agenda.

2. THEORETICAL BACKGROUND

2.1 Innovation Ecosystem

2.1.1 Ecosystem Concepts and Perspectives

There are many ways to approach an ecosystem. The perspectives vary according to the scholar's theoretical background and the main area of interest. It will determine the focus and key players. In addition, it could be observed that there is an evolution in the understanding of what composes an ecosystem based on the economic activities that are analyzed. Since manufacturing was the most relevant industry for decades, several studies focused on understanding the logics behind stakeholder's interaction. Later, studies were highlighting the role of external actors for increasing entrepreneurship at national level (Oliveira-Duarte et al, 2021). Moreover, it became important to understand the value of service and business models in changing the rationale on previous knowledge and competencies required to build a strong ecosystem.

This study will focus on innovation ecosystems from the innovation and business perspective. According to Gobble (2014), innovation ecosystems (IE) are dynamic purposive networks with complex relationships built on trust, co-creation of value, and complementary technologies or competencies. The IE construct offers a new lens for modeling the collective dimension of value creation (Gomes et al. 2018). Ecosystem strengthening involves helping multi-stakeholders in the system to see who is doing what and identifying the strengths of the system through mapping efforts. These efforts may also involve creating new platforms to enhance information sharing and facilitating activities to build collaborative working relationships (Tedesco & Serrano,

2019). Gomes et al. (2018) agree the IE is a key research area and requires investigation on decision management of collective impact to address innovation, new markets, and emerging industries.

Xie & Wang (2020) point out that innovation activities are never isolated; instead, they are part of changes in the firm's environments, also requiring innovation from several actors, in an interdependent innovation ecosystem. According to them, there are three defining characteristics of an innovation ecosystem: the dependencies settled among the members (members' performance and survival are intimately related to those of the ecosystem itself), a collaborative group of goals and objectives (defined by the ecosystem-level focus on a single customer value proposition), and a shared set of knowledge and abilities (complementary set of technologies and capabilities).

These dependencies, common goals, and shared capabilities establish the boundaries of an innovation ecosystem and help define it from the broader industry or sector or regional cluster. It is essential to leverage one another's knowledge and capabilities and coevolve to reach those objectives too. Prior studies have categorized innovation ecosystems into different types based on 4 criteria: the nature of governance, the extent of openness of the boundaries, the structure of the problem space and the nature of the innovation pursued (Nambisan & Sawhney, 2007; Pisano & Verganti, 2008).

It is important to note the role of suppliers, distributors, financial and research institutions, makers of complementary technologies and regulatory bodies (Dedehayir, Ozgur, Makinen, Saku, & Ortt, Roland, 2018) in designing an innovative ecosystem. Leading firms such as Google, Microsoft, P&G and Apple developed strong innovation ecosystems, based on their technological abilities and resource advantages, while other companies are not able to build their own and participate in existing ecosystems (Su, Zheng & Chen, 2018) to keep innovating.

Heaton (2019) argues that a good innovation ecosystem shall have an attractive living environment, large numbers of creative and competent engineers, building entrepreneurs, a supportive entrepreneurial milieu, easy property development approvals for structures suitable for new ventures, and easy access to major airports and other transportation arteries (Florida, 1999).

During its initial stage, an innovation ecosystem can be typified by low density, a limited identity, and few linkages (Heaton et al, 2019) Firms and other actors begin to cooperate on key activities. To be successful, the ecosystem must build a critical mass of companies, entrepreneurs, talent, and investment—a process that can take years and involve a certain risk, in the early stage; a common language and culture may emerge. The ecosystem may have a few firms and other actors that begin to cooperate around a central activity and realize common opportunities across their linkages. Linkages (informal forms of inter-organizational networking and cooperation) are part of the social context in which new knowledge is generated in the ecosystem. Formal and informal systems and norms of collaboration will become established. In this early stage, universities can contribute to both producing and attracting the human capital necessary for innovation. By having talented faculty and students, universities can help to generate new knowledge within the innovation ecosystem (Heaton et al, 2019)

2.1.2 Strategic Drivers for Innovation Ecosystems

According to Yang and Yan (2019), four conceptual variables are identified as driving forces for innovative economies: (1) technological innovation; (2) development of new business; (3) market performance; (4) competitiveness of industrial clusters. These authors state that firstly, the concept of technological innovation includes investment in different technologies, and so

do the relative costs of alternative technologies; secondly, the concept of the development of new business describes the connection among technological innovation, the market, and business models; thirdly, market performance includes several concepts, such as market size, market potential, and economies of scale; fourthly, the competitiveness of industrial clusters includes the technological innovation and new business boosted by the competitive advantages of industrial clusters. Yang and Yan (2019) incorporate a fifth conceptual variable: strategic orientation which encompasses three new drivers: interaction, market and entrepreneurial orientation.

Interaction orientation (IO) represents the effectiveness of the interaction between organizations and individual customers, as well as the useful customer information obtained through such successful interactions. Based on IO, the successful innovation of an organization is supported by its positive relationship with customers. Organizations can improve corporate performance by accumulating the knowledge of customers' preferences and needs; therefore, the interactive model offers opportunities for companies to create value with individual customers, and thus, increase the mutual benefits (Yang and Yin, 2019)

According to these authors, Marketing orientation (MO) is associated with implementing market concepts, including market intelligence development, generation dissemination, and responsiveness. Intelligence generation involves collecting and analyzing information regarding customer behavior; generation dissemination is a sharing mechanism that allows the different departments of an organization to receive market intelligence; finally, responsiveness involves the use of available information to produce products that meet customer needs.

Finally, entrepreneurship orientation (EO) enables a company to be constantly ahead of its competitors and seize opportunities for innovation in an uncertain environment. EO includes innovativeness, proactiveness, and risk-taking. Innovativeness refers to the application of new technologies to new products; proactiveness indicates the quest for new opportunities that meet future customer needs; risk-taking shows the managers' view regarding investment in volatile industries. (Yang and Yin, 2019). The complete framework and all its interactions are stated in figure 1:

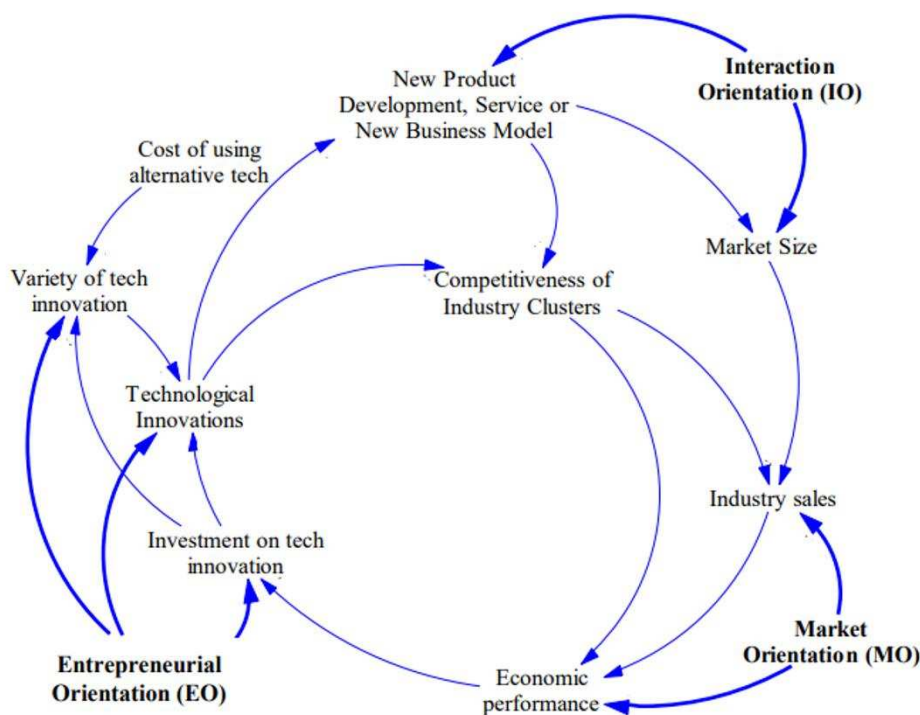


Figure 1. Yang and Yan (2019) Strategic Orientation for Technology-driven Business Innovation Ecosystems

In summary, the framework presented by Yang and Yan (2019) identifies five conceptual drivers (technological innovation; development of new business; market performance; competitiveness of industrial clusters and strategic orientation) that interact to promote the necessary conditions to an innovative economy. The connections of these drivers and the research findings will be addressed later, along the discussion session. In the next topic we will deepen the interactions between the challenges of a nascent innovation ecosystem and the global value chain literature.

2.1.3 Global Value Chains (GVC) and Innovation Ecosystems

Based on Gereffi and Fernandez-Stark (2016), the value chain concept encompasses the complete range of activities that firms and workers perform to bring a product from its conception to end use and beyond. It encompasses research and development (R&D), design, production, marketing, distribution and support to the final consumer, which can be conducted within a single firm or divided among different firms.

In the context of globalization, the activities that constitute a value chain often have been held in inter-firm networks on a worldwide scale. According to Reis et al. (2022) the GVC literature portrays how value is generated along internationally spread inter-firm relationships and activities. A GVC is “a governance arrangement that utilizes multiple governance modes within a single structure for distinct, geographically dispersed and finely sliced parts of the value chain” (Kano et al, 2020). Reis et al (2022) recall that the GVC framework evolves key dimensions that should be considered to understand how chains are organized, operate, and develop: input-output structures, geographic scope, governance dynamics and upgrading.

Regarding the sequences of tangible and intangible value-adding activities, from conception and production to end use, Gereffi and Fernandez-Stark (2016) state that the GVC assessment offers a holistic overview of worldwide industries – from the top-down (for example, examining how lead enterprises “govern” their global-scale affiliate and supplier networks) and from the bottom-up (for example, asking how these business decisions impact the trajectory of economic and social “upgrading” or “downgrading” in determined countries and regions). Participants are also susceptible to be spread among different firms geographically dispersed; they tend to occur in the context of intricate inter-firm relationships and transactions.

In terms of socio-economic relevance, The World Bank (2017) estimated that GVCs account for 60% of international trade and employ 17 million people (Lee, Gaspar and Du, 2021).

While the term GVC is increasingly applied in the International Business literature, there is a field dedicated its analyses, mostly focused on externalization and inter-firm relationships through the lenses of governance and upgrading (Lee and Gereffi, 2015). It provides a very useful gateway for the investigation of knowledge flows and innovation dynamics that take place outside of the hierarchical boundaries of multinational enterprises (De Marchi et al., 2014).

Innovation ecosystem research emphasizes breakthrough technologies and new value propositions related to them, along with the constellation of actors involved in value creation (Daymond et al, 2022)

Upgrading the technological production refinement or offering knowledge-intensive activities within a value chain requires a propitious innovation ecosystem. For a GVC, this should “shape

the ability of actors to master and use existing technologies to carry out routine tasks and to create new products and processes” (Sampath and Vallejo 2018, 486).

According to Smorodinskaya and Katukov (2019) , a systemic approach to innovation suggests their cognitive proximity and closeness of their activities in both industrial sectors (a network of firms from related industries) and institutional entities (a network of industrial firms, research centers, universities, and government agencies).

Gereffi and Fernandez-Stark (2016) draw attention to globalization’s benefits, which continue to be not equally distributed, with its gains directed to those with more education, skills, wealth, and power, historically detained by developed countries. However, the inclusion of large emerging economies like China, India, Brazil and Mexico among those who are benefitting, at least in part, is a qualitative shift in the process.

The more intricate the technology involved, more challenging the innovation ecosystem tend to be. Next session will explore these challenges and their linkage with the GVC analysis literature.

2.1.4 Innovation Ecosystem Challenges and their relation to GVCs

The challenges related to the five strategic driving forces for innovative ecosystems (Yang and Yan, 2019) were used to conduct the discussion regarding their active involvement in the GVCs.

Regarding technological innovation, the authors refer to the investment in different technologies and relative costs of alternative ones. Lee, Gaspar and Du (2021) add that innovation efficiency should be the focus to benefit from being in a GVC and move into the higher end of the chain. Specialized research, testing, training centers and labs are important preconditions to build productive capacity. They can provide resources on technical issues, specialized machinery, training in quality control or safety management, and certification services. Such institutes often exist in developing countries but are underfinanced and do not provide the right mix of services needed by the industry (UNIDO & UIBE, 2018).

Additionally, the authors recommend that leading innovation ecosystem for GVCs should involve improvements in education and supportive policies that foster technological capabilities, e.g., sustained public R&D and building domestic knowledge and technological absorptive capacity (Lee, Gaspar and Du, 2021). Sinkovics, Hoque and Sinkovics (2018) comprise partnerships with local and foreign universities, research institutes, consultancy firms, and suppliers of machines and raw materials, to foster knowledge improvement, capability acquisition and development.

Path, speed and direction of learning and innovation are influenced by the properties of knowledge (e.g.complexity, cumulateness, appropriability), the channels of technology transmission (e.g. technical assistance, labour mobility, licences, turn-key plants) and the firms’ different stages in absorptive capacity (Cohen & Levinthal, 1990; Breschi et al., 2000; Nelson & Winter, 1982). Generally speaking, developed countries usually have a presence in high value added activities, while developing countries concentrate in lower value added ones (Gereffi and Fernandez-Stark, 2016).

Finally, some studies note the importance of learning within domestic markets, especially for functional upgrading, and stimulate a strategy based on “prior apprenticeship in the national market and ... operating in several chains simultaneously” (Bazan & Navas-Aleman, 2004, p. 136).

Concerning the development of new business, Yang and Yin (2019) focus the relationship between new business and new market opportunities, rather than competition. The development of new business is complex. According to the authors, it results from the investment in technological innovation which leads to new products development and marketing orientation (a concept also related to strategic orientation) which encompasses the ability to collect and analyze information regarding customer behavior, share this information within the firm and translate it into products that fulfill what the customer needs, wherever he is.

On the other hand, there are other challenges involved concerning a new business development. Identifying what the value chain looks like and how different countries and firms participate helps identify prospects for entering and upgrading, and policies to help achieve feasible goals that consider the limitations of participating in distinct phases of chains, for diverse sort of buyers (Frederick, 2019).

According to Lee, Gaspar and Du (2021), empirical results suggest that moving up a GVC heavily depends on economy-specific endowments that can be enhanced by supportive policies in infrastructure, institutions, and innovation. The authors defend that governments should facilitate an enabling innovation ecosystem by implementing effective innovation policies.

In this sense, institutional coordination is essential to provide a coherent business environment. It includes stakeholders across multiple institutions, establishing institutional arrangements for coordination, developing an accurate, shared understanding of the industry's chain and opportunities, and aligning policies with objectives.

The local institutional framework identifies how local, national and international conditions and policies shape a country's participation in each stage of the value chain (Gereffi, 1995). GVCs are embedded within local economic, social, and institutional dynamics. Insertion in GVCs depends significantly on these local conditions.

The third variable identified by Yang and Yan (2019) as a driving force for innovative economies, market performance, encompasses several concepts, such as market size, market potential, and economies of scale. It is also closely connected to the market orientation – as long as it understands customers' wants and potential needs better than its competitors do, and consequently, show better competitiveness and strategies. The firm's superior response will deliver superior customer value and more two-way communication, which will have positive reinforcing effect on the development of new products and new businesses in a virtuous cycle (Yang and Yan, 2019).

Regarding the fourth parameter, competitiveness of industrial clusters, technological innovation and new business driven by the competitive advantages of industrial clusters are, according to the authors, strictly related. Their model suggests that technological innovation will push the competitiveness of industrial clusters, and such increasing competitiveness will lead to better economic performance and produce more investment in technological innovation, thus, generating a reinforcing feedback loop. This rising competitiveness promotes economic performance and attracts more investment in technological innovation to create reinforcing feedback.

Smorodinskaya and Katukov (2019) remind us that global firm organizing a GVC neither participates in every node, nor seeks to control the key nodes nowadays. Rather it plays a role as an effective project coordinator, or just a project leader through its branch-offices in one of the regional clusters, and furthermore, as an ordinary supplier of certain intermediaries. During co-production, lead firm locates and regroups value chain nodes in such arrangement that enable costs reduction and create new products with the highest value added. Lead firm usually selects

specialized contractors on terms of smart-sourcing: it picks up a supplier for each narrow business task from that very local cluster, where this task can be performed most effectively as compared to all other clusters across the world. As a result, most innovative clusters with a smart specialization become highly specialized local nodes in GVCs.

Additionally, global lead firms are increasingly facing public pressure to make their supply chains socially and environmentally sustainable. Any corporate wrongdoings in their supply chains could eventually inflict reputational damage on lead firms even if the factory is not owned by them.

The last conceptual variable introduced by Yang and Yin (2019), strategic orientation, aims to include customer demand, innovation, risk-taking, and organizational learning in their model. Different strategic orientations are possible, linking all elements of the innovation ecosystem while others might be university-based, where universities are regarded as a source of innovation and the university-enterprise relationship plays an important role in technological success. Another possibility is that the government integrates resources to build an innovation ecosystem powered by national technological policies and boosts the close collaboration between industry and university through investments in education, R&D, corporate technology innovation, entrepreneurship, and corporate export capability enhancement as observed in Finland and Taiwan.

Conceptually, technological innovation is the leading force to strengthen technological development, new business development, and economic benefits; however, such a feedback system will not automatically sustain itself, as it is the organizational strategy guided by managers' strategic thinking that holds the key to the sustainable development of an ecosystem. The more specialized the firm, the higher its position within the GVC.

The complex alternative proteins industry reinforces this statement, counting on partners which contribute to the business value creation according to their expertise, despite of their location. According to Reis et al (2021), radical innovation can substantially modify global value chain's activities and reframe its geographic scope; it may also embody a change from natural resource-intensive to technology-intensive activities.

Cultivated meat (CM) industry can be recognized in this scenario. This aspect and others relevant for the industry will be explained in depth in the following session.

3. METHODOLOGY

3.1 The cultivated meat context and industry

Alternative proteins represent a viable solution to some of the most important challenges caused by meat and its dairy production and consumption, such as increasing population, environmental issues, and animal welfare. Therefore, companies have been looking for new products to replace conventional sources of protein which are becoming very popular depending on the production process. Alternative proteins can be classified into four categories: plant-based, cell-based (also known as cultured meat, cell-based meat, and clean meat), fermentation-based (Microorganism) and other types for instance, insect-based (PWC, 2022).

According to Reis et al (2022), CM is an alternative meat production process that does not require the raising and slaughtering of animals. This is an exceptional case since the innovation may dramatically modify the traditional meat production chain for the better and is claimed to refine the situation regarding serious sustainability and animal ethics issues addressed to traditional meat production. Such alternative meat production systems are also likely to enhance food security and other critical social issues, in a complex and positive relationship with the

United Nations Sustainable Development Goals (UNSDGs), allowing for a virtuous cycle which has just started to be explored in scientific literature. Moreover, several CM enterprises bloomed worldwide. According to the authors, there are over 82 publicly known startups so far, spread in several countries. Since the CM industry is developing in a very dynamic way with key actors continuously entering the scene, interacting into a global value chain with products and markets still gaining track, exploring the development of a nascent ecosystem has become incredibly challenging.

3.2 Research strategy

A qualitative study was conducted to investigate how the cultivated meat innovation ecosystem is being formed, focusing on identifying the drivers, barriers and characteristics perceived by the multiple stakeholders of this emergent industry. For the data collection, we relied on in-depth interviews with the cultivated meat industry experts from multiple areas (academia, enterprises, startups, and NGOs) from May to October 2022 and also gathered data from several secondary data, such as consultancy reports, academic reports, national and international conferences and events.

Concerning the organizations chosen to integrate the research, Alpha is a Brazilian multinational founded in 1930, recognized as being one of the biggest players in the food industry with over 90.000 labors in 130 countries. It represents the MNEs with consolidated knowledge in the traditional meat segment, which is, through alliances and partnerships with foreign startups, and institutional NGOs, helping to rewrite the meat global value chain.

Beta is a federal university located in the southern part of Brazil, pioneer in CM interdisciplinary studies focusing on sustainability, innovation, and animal welfare. It also promotes partnerships with startups, NGOs, firms, and governmental institutions to foster knowledge exchange through research.

Delta is a non-profit, philanthropic-funded organization that works internationally to accelerate innovation in the alternative protein sector. With donor support, it is developing the strategy to create a fair, safe and sustainable food production system. To do this, they identify the most effective solutions, advance open access research, stimulating partnerships and helping advance in legal/ regulation matters.

Finally, Gamma is a Brazilian startup which first developed CM in Brazil. It was responsible for researching and expanding ingredients related to the industry such as animal fat.

In the interviews and secondary data, based on Yang & Yan model (2019), we looked for 4 dimensions for our analysis: (technological, legal/institutional, environmental/ sustainable, and marketing-related (from the consumer-behavior perspective). These dimensions were chosen due to its relation to the main investments, research and efforts taken by the ecosystem participants to boost the industry so far and the challenges encompassed. This variety of dimensions provided a comprehensive view of the characteristics, barriers and drivers for the development of the cultivated meat industry in Brazil.

Table 1 below provides a brief description of the interviewees and contains more information about the interviews:

Table 1 – Detailed information about the interviews.

| Organization | Type of the organization | Profile of the interviewees | Duration (minutes) |
|--------------|---|---|--------------------|
| Alpha | Multinational Enterprise of the Food Industry | Manager in the New Business Development / Open Innovation area | 50 |
| Beta | Research center - Cultivated Meat Food Lab | PhD Professor. Coordinator of the research center | 46 |
| Delta | Non-governmental organization (NGO) | (1) Corporate Engagement Director (2) Public Policies Director | 55 |
| Gamma | Cultivated meat startup | Scientific director of the startup | 65 |

Source: Own elaboration based on the research.

We relied on secondary data to have a deeper understanding of the phenomenon and to expand the possibilities of analysis in each of the selected dimensions of the study. The majority of our secondary data came from business reports and research from consultancy groups (such as McKinsey & Company, Accenture, KPMG, etc.). Table 2 provides a description of the documents that were used in our analysis.

Table 2 – Detailed information about the secondary data.

| Name | Abbreviation | Authors | Type of document analyzed | Year | # Pages |
|---|--------------|---|--------------------------------|------|---------|
| Cultivated meat: out of the lab, into the frying pan | R1 | McKinsey & Company | Industry report | 2021 | 10 |
| The Future of Food | R2 | Deloitte | Industry report | 2021 | 24 |
| The Novel Food Market | R3 | PWC | Industry report | 2022 | 20 |
| Sustainably securing the future of agriculture | R4 | BCG | Industry report | 2019 | 64 |
| Reality check | R5 | Accenture | Industry report | 2021 | 33 |
| The Swiss FoodTech Ecosystem | R6 | Accenture | Industry report | 2021 | 58 |
| The future of Food - Meatless? | R7 | McKinsey & Company | Industry report | 2020 | 22 |
| The taste of things to come | R8 | KPMG | Industry report | 2019 | 17 |
| 2021 State of the Industry Report - Cultivated Meat and Seafood | R9 | Good Food Institute (GFI) | Industry report | 2021 | 65 |
| Cultivated meat – Perspectives and Opportunities for Brazil | R10 | Good Food Institute (GFI) | Industry report | 2022 | 70 |
| Food for Thought | R11 | BCG | Industry Report | 2021 | 48 |
| Sci-Business Seminars – Cultivated Meat | R12 | Panel with specialists on cultivated meat Corporate Engagement Specialist on GFI and Researchers | Transcription of the interview | 2022 | - |
| Seminar on Cultivated Meat | R13 | R&D Director of a Brazilian Multinational Enterprise in the Food Industry | Transcription of the seminar | 2022 | - |

Source: Own elaboration based on the research.

In total, we analyzed more than 430 pages of business reports, research, panels and seminars and more than 3.5 hours of interviews.

3.3 Data Analysis

First, we triangulated the data from the interviews and secondary data, creating an Excel matrix for each of the four dimensions (technological, legal/institutional, environment/sustainable, and marketing-related). For each dimension, we categorized the drivers and enablers for the development of the ecosystem and industry and also the barriers faced in Brazil. For this categorization, we used the software Microsoft Excel.

We used the thematic categorization technique, and a descriptive study was conducted. For each dimension, we carried out the processes of (1) pre-analysis; (2) exploration of the materials; and (3) treatment of the results, with posterior inferences, interpretations, and connections with theoretical background. Pieces of information collected from the interviews were codified from the transcriptions. Afterward, codification was revised to improve the codes, merge those that address similar issues, or exclude unrepresentative codes with few mentions in the entire set of interviews.

4. RESULTS AND DISCUSSION

This section contains the results and analysis related to following dimensions: technological, legal/institutional, environment/sustainable, and marketing-related (from the customer-behavior perspective). It was possible to identify, for each of them, the main factors which are seeing as advantages or positive initiatives that help boost the industry (Drives) and also the barriers still in place to be superseded.

It is divided into two parts: the first discusses the main drivers and barriers framework based on the qualitative data analysis framework proposed by Gioia et al. (2013). Next, we address the challenges and insights captured along the research and discuss their relation to the global value chain literature.

4.1 Dimensions, Drivers and Barriers

4.1.1 Technological dimension

Brazil is dealing with the technological dimension in diverse and complementary ways. Figure 2 shows the drivers and barriers related to this dimension.

The country has been very successful concerning the technical development of the cultivated meat technology since the isolation of cells until their growth in labs, as stated by Gamma scientist director. Her startup has already advanced dealing with tissue engineering matters and developed a hamburger prototype. Partnerships with universities such as UFRS and Unisinos were essential to exchange and combine lab capacities and knowledge about the process itself. In the same direction, UFPR multi-campi cellular agriculture and cultivated meat research group (an initiative of three universities led by UFPR that includes Biotechnology, Animal Sciences, Veterinary and Business Administration courses) jointly with the Araucaria Foundation (State of Parana's Research Funding Agency) have just inaugurated the first pilot cultivated meat facility/lab, for research purposes (the first in Brazilian universities) as disclosed by Beta PhD Professor.

Likewise, the development of cultivated meat has been strengthened by the association conducted by two Brazilian multinational enterprises, both leaders in the production of conventional meat, BRF and JBS, with two foreign startups, respectively Aleph Farms (located in Israel - it has a strategic alliance with BRF) and BioTech Foods (based in Spain – BioTech was acquired by JBS in 2021).

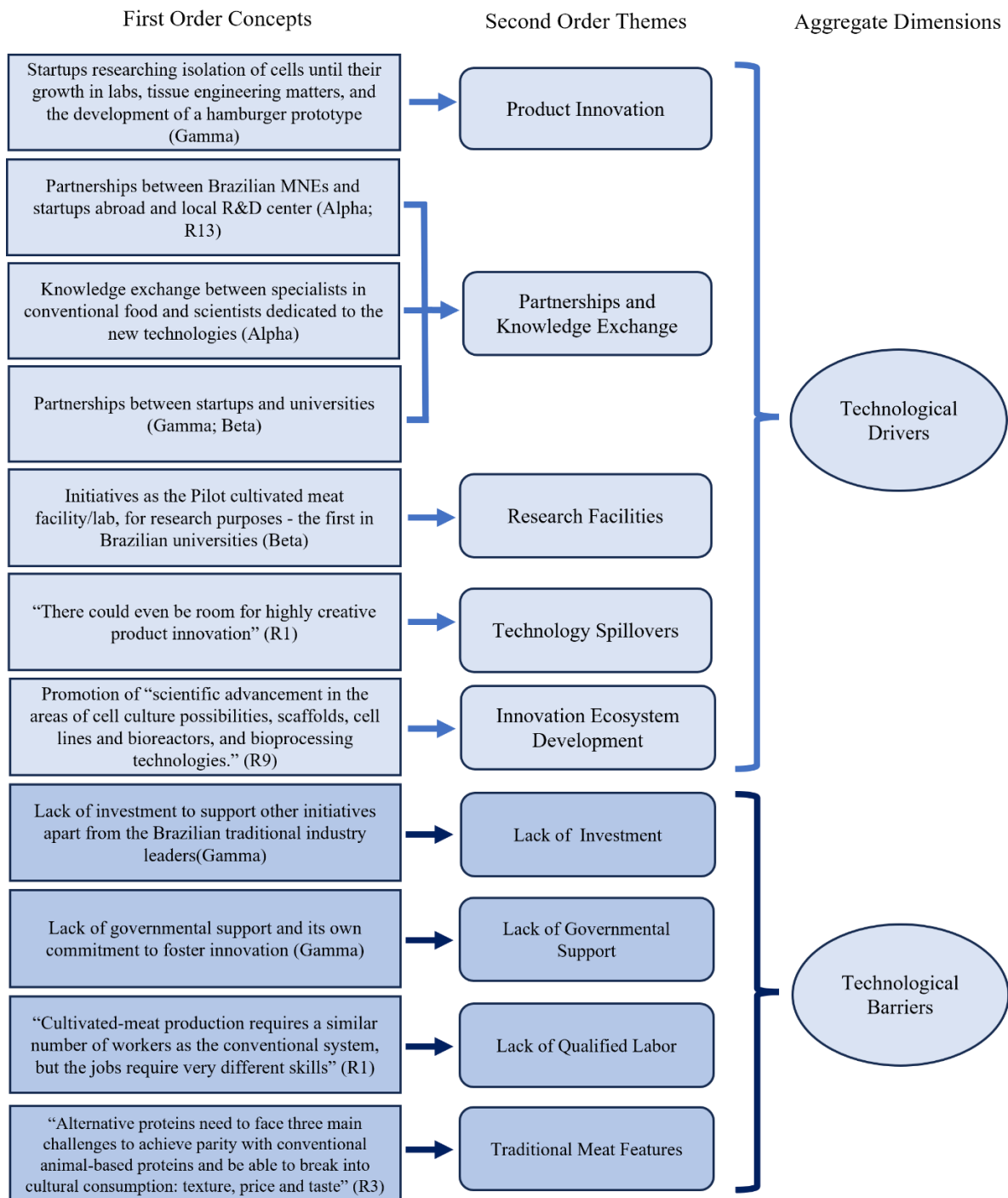


Fig. 2. Data analysis structure, based on Gioia et al. (2013), showing technological drivers in light blue and barriers in dark blue.

Source: prepared by the authors

In global terms, start-ups are leading the research and technological development of Cell Based Meat (Stephens et al., 2018) while the largest meat-processing firms (e.g., Tyson and Cargill) are also investing in the cell-based technology (Froggatt & Wellesley, 2019). We found evidence that it also includes the Brazilian context. Furthermore, JBS is currently building a Research and Development Center focused on food biotechnology and cultivated protein, located in the south region of Brazil. Their expertise in conventional meat business is a relevant competitive advantage and massive investments state that they are also interested in leading the

cultivated meat segment. Therefore, to control technological aspects of cultivated meat production is crucial to reach this goal. JBS has an extensive experienced and high-skilled food researchers, specialized in meat. They not only understand its nutritional aspects, but also familiar with Brazilian preferences regarding taste and appearance. Thus, they are able to exchange previous experience with scientists that are developing the new technology and it can be considered a differential as reminded by the Alpha manager in the new business development / open innovation area:

“We have a team of over 100 researchers who are able to make a formulation with their eyes closed.(...) Many times we need immediate knowledge and then we hire people in the market, we go to the best institutions that train people with the knowledge we need, and we put them to work here and make this integration, of those who are already in the company. (...) Let's suppose we can transform this new technology into a steak analogous to a chicken breast, the company has known for 86 years how Brazilians like their chicken breasts when they are made from real chicken, so my researcher here for chicken breasts has to talk to the new researcher for cultivated meat and explain where he needs to get to.” (Alpha)

Facing limited financial resources and having to compete with giants from the meat market, that explains why Brazilian startups are moving their research interest from the final product to ingredients that may be interesting to the industry all over the world. This move has already started and was addressed by Gamma scientific director, who has been working on cultured fat and have recently joined forces with another conventional meat experienced executive to explore brand-new ingredients opportunities. According to the GFI Corporate Engagement Specialist (R12), achieve ingredient production independence is essential to become a worldwide reference, which requires having lower costs to compete internationally. Additionally, specific machinery is being demanded by this technology, required by this branch-new ecosystem, so there is room also for this front. This statement can be found in the GFI - 2021 State of the Industry Report - Cultivated Meat and Seafood (R9) as follows:

“The brand-new industry is dealing with multiple independent analyses that use different assumptions and process models to evaluate an emerging industry for which commercial-scale facilities do not yet exist.

Challenge: pursue scientific advancement in the areas of cell culture facilities, scaffolds, cell lines and bioreactors, and bioprocessing technologies.” (R9)

GFI also has Science and Technology Program, which takes care of scientific advancement, developing themes for R&D with a global impact by funding scholarships to researchers, for instance.

On the other hand, the main barriers faced by the technological aspects are related to the lack of investment to support other initiatives apart from the Brazilian traditional industry leaders, mostly motivated by the lack of foreseeability regarding a deadline to share research results. Nowadays there is only one country (Singapore) which has been successful in completing all phases of the production process, having cultivated meat available on the market shelves for consumption. This result was possible, partially due to the governmental support and its own commitment to fostering innovation. Brazil is also behind in research, having to compete with international startups who have been working on this theme since 2015. As Gamma scientific director states:

“One of the biggest startups, Aleph Farms was founded in 2018 and we have to offset this delay. And to keep Brasil's position as a leader (not as a leader, but as a relevant player) in this market, it is crucial to invest in research. We need to start developing technology today because in a few years, the main American, Israeli, European and Australian companies will have

developed their own technology, ready to export and implement it in other countries (...).” (Gamma)

Thus, there is a clear need (from interviewee’s perspective) of improving public and private investments in the area if we are looking to have an influence in the technological development. In addition, boost government support is essential to retrieve Brazil’s role as a key global player in the CM industry. Despite the governmental financial underpinning, other aspects as regulation and surveillance integrate the scope of legal and institutional dimension which will be addressed in the next session.

4.1.2 Legal and Institutional dimension

Regulation is one of the main challenges regarding the CM industry. Figure 3 shows the drivers and barriers related to this dimension.

As a key catalyst of the development of the area of alternative proteins in the world, the Good Food Institute (2022) point out that regulatory agents will play a fundamental role in the consolidation of the cultivated meat industry in Brazil. Regarding the formation of the ecosystem, the proactivity of ANVISA in dealing with the emergence of this area is extremely relevant for the strengthening of such structures (R10).

The main driver identified for the formation of the cultivated meat industry is the existence of a GFI office in Brazil, dedicated to work and engage with large food producers, the Brazilian government and scientists across the country (GFI, 2022), acting proactively to form and maintain the cultivated meat ecosystem:

“It is important also to have these independent views and other types of institutions, such as the Good Food Institute. I think they have a lot to add. The GFI is one of the main voices, not only at the Brazilian level, but in a global level. They make a great articulation between the Government and firms. There are specific people working on this. And now they are leading the first study on the safety and security of cultivated meat (...)” (Gamma)

Additionally, the scientific director of Gamma points out that there is an emergence of fundings for research and innovative projects on novel foods, specifically on cultivated meat, such as public fundings from FINEP. On the other side, the manager of the New Business Development area of Alpha sees that there is difficult for the regulatory institutions in Brazil to cope with the speed of the development of this new area of cultivated meat. This vision is also shared by the Public Policies Director of Delta:

“To create a new chain is ‘dryer’ on many aspects than to ‘stir’ with an older chain. The regulatory has complications with its interfaces and these interfaces have complications with other chains and incumbent regulations.” (Delta)

In this sense, Delta states that the implementation of a unified and global regulatory mark would be beneficial for the strengthening and development of the cultivated meat industry. After this global landmark, the adaptations and internalizations would be set by each country. Delta points out the need for a higher integration of the international actors – such as FAO (Food and Agriculture Organization of the United Nations) and the WHO (World Health Organization).

With all these characteristics and challenges ahead, the orchestration of the relevant producers of the meat industry has a fundamental role in the institutional aspects. The coordinator of Beta points out that the interactions of the MNEs and the technologies that they are developing have the power to push the regulations forward. This orchestration of CEOs and directors of relevant MNEs is also highlighted by Delta:

"[The director] is personally involved in agendas and is creating a 'group' of executives of the sector that are interested in these advancements in order to form a unity and have a louder voice" (Delta)

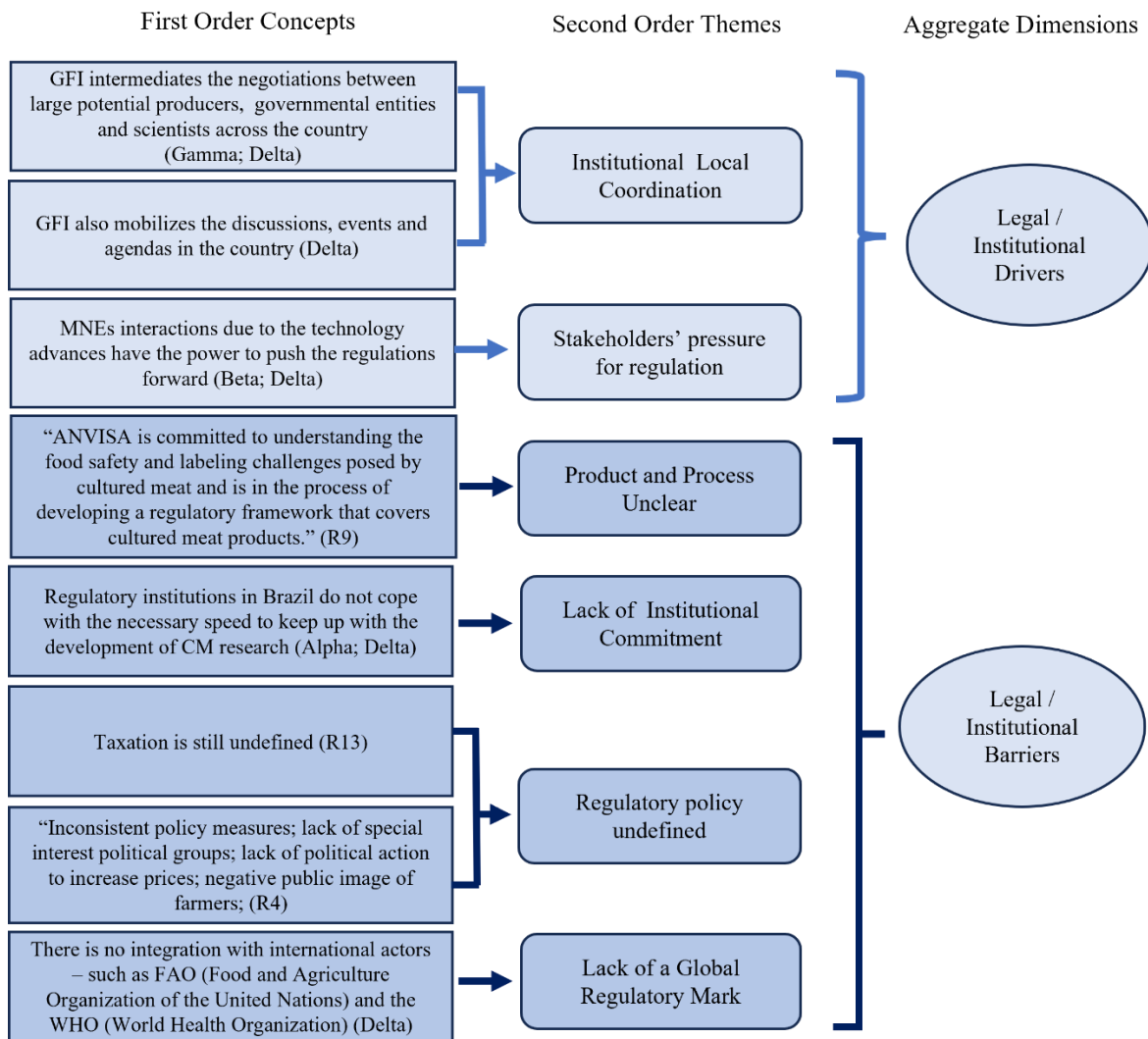


Fig. 3. Data analysis structure, based on Gioia et al. (2013), showing legal/ institutional drivers in light blue and barriers in dark blue.

Source: prepared by the authors

These answers and data highlight the orchestration and close communication that different actors have to overcome Brazil's institutional barriers. The presence of important catalyzers such as GFI mobilizes the agendas in the country.

As stated by Goes et al (2022), civic justifications, that is, justifications regarding how CM favours the collectivity and also the ones related to the regulation of the technology, were mainly manifested by start-ups and expressed to be one of the main challenges to be overcome in the next years worldwide. According to their research findings, the regulatory process takes approximately 1.5 years in Europe. In the United States, obtaining Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) approval is also challenging, which means that regulatory issues are intricate not only in Brazil. Concerns regarding reliability and product security are limitations to be overcome before CM products get to the market. On the other hand, environmental, health and societal benefits associated with

innovation are relevant positive aspects of the CM industry, which encourage it to move forward. Next session we will focus on the environmental dimension.

4.1.3 Environmental dimension

There is a consensus that the cultivated meat industry is strongly related to positive environmental impacts. Figure 4 shows the drivers and barriers related to this dimension. Compared to traditional meat, the CM environmental footprint (reduction of greenhouse gas emissions and protection of biodiversity) is significantly smaller and even enhanced if combined with sustainable energy, directly impacting the climate change issue, which is one of the main drivers of this dimension (R4).

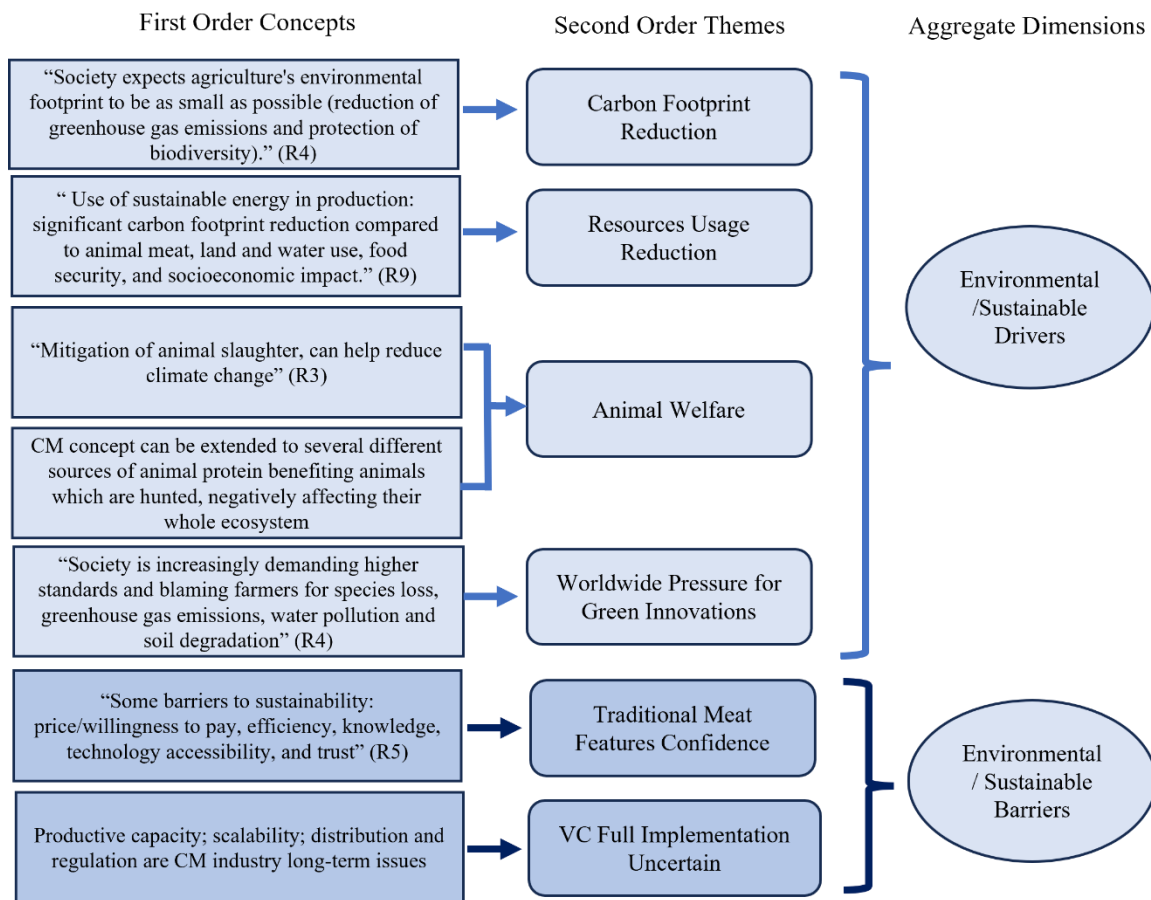


Fig. 4. Data analysis structure, based on Gioia et al. (2013), showing environmental/ sustainable drivers in light blue and barriers in dark blue.

Source: prepared by the authors

Diverse ecosystem’ partners as national and supranational regulatory structures, global governance institutions and private sector organizations (e.g. multinationals, industry groups and associations), along with actors from civil society (e.g. consumers, social movements, activists and NGOs) are all increasingly involved in regulating environmental impacts in global value chains. Companies have adopted labels, sustainability, and corporate social responsibility patterns, which aim to certify that their products derive from environmentally and socially responsible activities (Reis et al, 2021).

Farms in the future will demand much smaller pieces of land and water, and their production capacity without harming the environment is one of the most significant arguments for pro-new

industry. Another relevant aspect is concerning the mitigation of animal slaughter, which can also help reduce climate change” (R3)

This close relationship between sustainability and CM was the first attractive aspect that motivated the Beta coordinator to start dealing with alternative proteins:

“(...) in this meat process, there are some things about social responsibility and there was an animal welfare component there that caught my attention a lot. So, the whole story begins with an important motivation, linked to a concern about the environmental impacts of meat production and also with animal welfare, you know? So it started there, working together with the animal welfare laboratory.” (Beta)

Another advantage of the CM concept is that it can be extended to several different sources of animal protein: there are on-going studies involving tuna, fish, animals which are hunted, negatively affecting their whole ecosystem. On the other hand, the fear of meat lack or shortage would stop haunting people, particularly in poor countries.

Benefits brought by this technology are being used to justify startups' and investors green positions all over the world and help boost the industry (Góes et al., 2022). According to these authors,

“Most of the arguments emphasized animal welfare and environmental benefits of CB meat (the green world) and its potential to mitigate the lack or shortage of meat, and health-related issues related to the civic world. Thus, the consistency and similarities in the arguments of startups and investors have been positively influencing the industry development”.

Moreover, technology accessibility, production in a scale that allow affordable price, trust and safety are some of the barriers that sustainability has got to face, still (R5). By contrast, from the consumer's standpoint, the environmental appeal that follows CM is one of the arguments that impact positively the demand and the product positioning related to its competitors in the market. These aspects among others will be discussed in the next section.

4.1.4 Marketing-related dimension

In the latest years, there has been a growing consumer demand for sustainable products, given that consumers are more aware of the climate change issues and the impacts of the food on the environment (R6; R9). In the Brazilian context, the situation is not different. Figure 5 shows the drivers and barriers related to this dimension.

The coordinator of Beta explains that this demand is formed by multiple actors, such as vegans, vegetarians and, more recently, the “flexitarians”. The flexitarianism is defined as “as a food consumption pattern in which meat is eaten occasionally without avoiding it completely” (Degevos, 2021, p. 531). The coordinator also points out that there is relevant research being developed on the intention to consume cultivated meat:

“There is market research that shows that 60% or 70% of the interviewees are interested in consuming cultivated meat... trying it [...] So we have a consumer market that is interested.” (Beta)

The director of Gamma argues that younger people are more open to try and consume cultivated meat. This response is in line with the report R3. This report shows that “generation Z” and millennials are a strong profile of the consumption of the novel foods (such as plant-based and cultivated-meat). These new types of consumption are not specifically a substitution of previous

patterns, instead they are seen by the stakeholders as additional patterns, as highlighted by Delta:

"We do not believe in a full substitution on the table of the consumers. There will be the plant-based, you are also having the animal meat, the cultivated-meat. They will all co-exist. The consumers are going to understand, when they are making their choices, depending on the product that is being delivered, the sensorial experience, the price and many other factors [to make the decision]" (Beta)

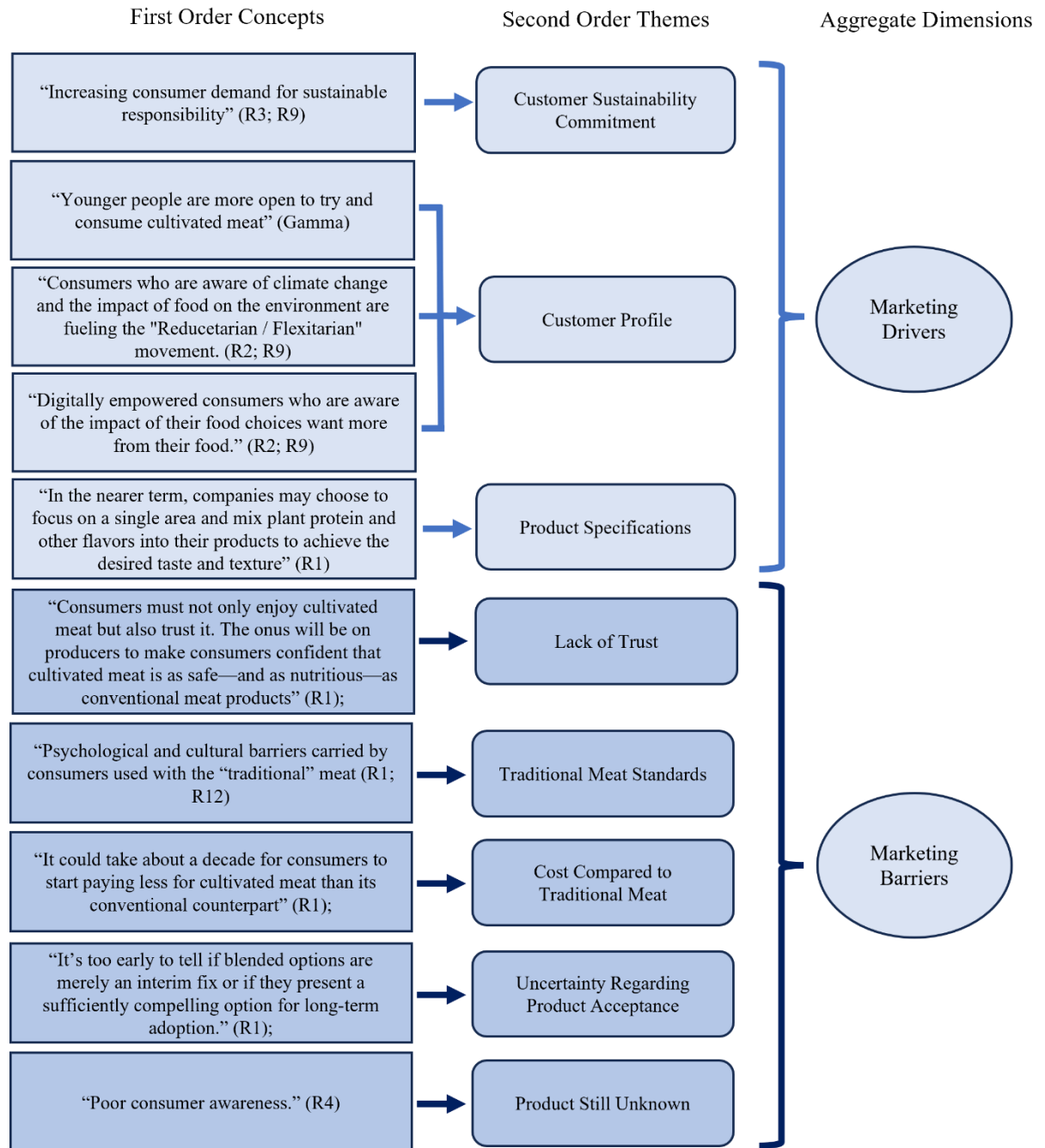


Fig. 5. Data analysis structure, based on Gioia et al. (2013), showing marketing-related (from the customer perspective) drivers in light blue and barriers in dark blue.

Source: prepared by the authors

On the other side, there are challenges and barriers that Brazilian cultivated meat ecosystem will face in the upcoming years regarding the consumption aspects. In addition to the many psychological and cultural ties that consumers have with the “traditional” meat (R1; R12), there is a matter of the perception of safety and security of this type of protein. The communication of the producers will have to be precise and clear in order to make consumers confident that cultivated meat is a safe option (R1), increasing consumer awareness (R4). This can be a shared responsibility, where the multiple actors in this ecosystem should reinforce the beneficial aspects of CM.

Another crucial aspect that must be discussed in the ecosystem level is the extent to which the CM consumption is affordable and available for consumers, especially in emerging economies. It could take a long time to the prices of CM to be on par with the traditional meat (R1). In this context, the orchestration of the top food producers with their value chains, aligned with the legal and political actions (such as fiscal incentives) will play a role in the speed of the change.

4.2 The cultivated meat ecosystem of Brazil – perspectives

It is important to note the role of suppliers, distributors, financial and research institutions, makers of complementary technologies and regulatory bodies (Dedehayir, Ozgur, Makinen, Saku, & Ortt, Roland, 2018) in designing an innovative ecosystem. During its initial stage, an innovation ecosystem can be typified by low density, a limited identity, and few linkages (Heaton et al, 2019) Firms and other actors begin to cooperate on key activities. To be successful, the ecosystem must build a critical mass of companies, entrepreneurs, talent, and investment—a process that can take years and involve a certain risk, in the early stage; a common language and culture may emerge.

Formal and informal systems and norms of collaboration will become established. In this early stage, universities can contribute to both producing and attracting the human capital necessary for innovation. By having talented faculty and students, universities can help to generate new knowledge within the innovation ecosystem (Heaton et al, 2019)

The challenges are mostly related to the dimensions analyzed in the previous section and were summarized in Table 3:

Table 3 – Challenges and insights

| Challenges | Insights |
|--|--|
| Industry production growth forecast | <ul style="list-style-type: none"> • “Production growth in Brazil in: Brazil, China, the European Union and the United States United States should produce almost 60% of global meat production by 2029. Production growth in Brazil in Brazil will continue to benefit from an abundant supply of natural resources, animal feed availability of pasture, productivity and, to some extent, the devaluation of the Real. Source: OECD and FAO (2020).” (R10); • “Challenges: increased production capacity at scale that achieves greater economies of scale and a resilient supply of alternative proteins (R9); |
| Industry Development Forecast and Technological and Customer-related Challenges | <ul style="list-style-type: none"> • “Most types of Novel Foods are still in the "development phase", in terms of (i) technological stage; and (ii) consumer awareness; • “Technology will lead to the creation of new purchasing experiences, digitalization of the supply chain.” (R6); • “Food and technology are becoming increasingly interdependent, and cutting-edge technology offers more possibilities in product offerings and distribution channels to meet consumer needs.” (R8) • “In 20 years, 35% of global meat consumption will come from cultured meat products; Plant-based alternatives are expected to continue to dominate the market but will show the lowest growth rates over the next decade; Animal cell-based alternatives are expected to accelerate growth with a '30-'35 CAGR of 116%.” (R3) |
| Government Support And Regulatory Recommendations | <ul style="list-style-type: none"> • “Incredible power to help the industry grow exponentially by investing in open access R&D, supporting the private sector, and creating a clear regulatory path for the cultured meat market.” (R9) |

Table 3 (cont.) – Challenges and insights

| Challenges | Insights |
|--|--|
| Environmental Challenges | <ul style="list-style-type: none"> • “Foodtrends (2020 report): precision farming, recycling and upcycling, sustainable protein, transparency and traceability = current global trends; climate change and plastic pollution influence consumer demand; simple and recognizable ingredient lists have become a consumer focus; accessibility and home delivery become a unique aspect.” (R6) |
| Change in the Consumer Mindset - a challenge to producers | <ul style="list-style-type: none"> • “Companies need to remove sacrifice from the equation and be innovative in how they make sustainability a benefit to people -> three levers brands can use to create realistic sustainable consumption = influence, offer, and engagement” (R5) • “Develop new ways to meet delivery challenges and demand in the food industry and to decrease food waste in the different areas of the food industry.” (R6) |
| Healthy-related impacts | <ul style="list-style-type: none"> • “Nutrition aspects related to novel foods will be an extension of the health chain, traditionally limited to curative, clinical and hospital interventions ex post, by invading an area that ranges from nutrition to the set of lifestyles.” (R3); • Demographic changes and greater diversity in diets -> low meat consumption and increase in flexitarianism; increase in sustainable and purpose-driven alternatives -> expect more responsible brands; high demand for price agreements and healthier, premium products; need for convenience and time saving --> delivery apps; importance of food safety and traceability --> transparency” (R3) |
| Additional issues | <ul style="list-style-type: none"> • “Financial challenges: maintain profitability; Sustainable operational management; Improved understanding of functions as an ecosystem service provider.” (R4) |

Source: Prepared by the authors

The table’s main limitation is that it is fully based on secondary sources. On the other hand, it provides a starting point to allow deeper investigation. Financial challenges such as scalability, food safety and regulation constitutes relevant aspects to be studied in future research. Scalability impacts cost reduction and pricing, allowing access to the lower income layers of consumers, possible only when safety is incorporated into the process and regulation is clearly defined. Still there are many challenges ahead.

5. FINAL COMMENTS

The focus of this study was to analyze the formation of the cultivated-meat ecosystem in the Brazilian context. Drawing from the theoretical developments on the innovation ecosystem, we defined a set of dimensions and collected data from multiple actors of this nascent sector. Secondary data was also collected from business reports, industry reports, seminars, and conferences. This study identified the main drivers and barriers that multiple stakeholders perceive from technological, legal/institutional, environmental, and marketing-related dimensions.

Based on this data, this study discussed the implications of these dynamics and presented a set of challenges and insights to the development of the cultivated-meat industry and ecosystem in Brazil, precisely on: industry production and development forecasts, government support and regulatory recommendations, environmental challenges, changes in consumer mindsets, health-related aspects and other additional issues. It has practical implications, providing a multiple-stakeholder view on the orchestration needed for the ecosystem's development.

On the other side, this research has limitations that need to be discussed. Only actors and stakeholders that were highly active (in public media, events, and conferences) in the discussions and development of the cultivated-meat ecosystem were chosen. In this sense, we did not cover potential actors (such as other firms, research centers, political actors, NGOs, etc.) that are not involved in this ecosystem yet but can be of great importance in the future developments of the field.

Future studies could analyze the formation of the cultivated-meat industry and ecosystem in other emerging countries and compare it with the developed economies. Such investigations could help in the cooperation of different countries in strengthening the theme and advancing the topic of sustainable development. Going to an organizational level, longitudinal studies with MNEs that are developing their business and industrial structure to launch cultivated-meat products would be of great value to explore the phenomenon since these processes usually involve orchestrations and partnerships with multiple stakeholders. And other theoretical lenses of business strategy (such as the resources and dynamic capabilities approaches) could have a significant impact, exploring different perspectives on developing this nascent industry.

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