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Sociotechnical Trajectory of Vitiviniculture in Pampa Gaúcho: analysis of the need for multilevel factors

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Abstract
Several ongoing agricultural transitions characterize the Pampa Gaúcho region. Beef cattle farming has always dominated this region. One of these transitions that has gained greater visibility is the production of grapes and wines, with the establishment of new wineries and producers of varying proportions. Despite the recent prominence, it is known that this process has been in transition for decades. Earlier studies have identified the phases of evolution and the factors associated with this trajectory. This study determines the factors that contribute the most to the sociotechnical trajectory of Pampa Gaúcho wines. For this purpose, 10 interviews with experts were conducted and analyzed. Drawing on the study of necessity proposed by the comparative qualitative analysis (QCA) method, we identified 13 essential factors along the trajectory. Furthermore, the factors and levels in the transition process work together. Finally, complexity has increased over time, as shown the numerous factors and levels required to analyze this trajectory. These findings suggest that three levels of sociotechnical trajectory (landscape, regime, and niche) are needed for this evolution, indicating that there is not just one decisive factor in this process.
Keywords: Transition, Multilevel Factors, Qualitative Comparative Analysis, Analysis of necessity, Vitiviniculture

Trajetória Sociotécnica da Vitivinicultura do Pampa Gaúcho: análise da necessidade dos fatores multiníveis

Resumo
A região do Pampa Gaúcho se caracteriza por várias transições agropecuárias em curso. Nessa região, historicamente, predominou a atividade de pecuária de corte. Um dos processos de transição que tem tido maior visibilidade, atualmente, é a produção de uvas e vinhos, com estabelecimento de novas vinícolas e áreas de produção de variados tamanhos. Apesar do destaque recente, sabe-se que este é um processo que está em transição há décadas. Pesquisas anteriores já identificaram as fases de evolução e os fatores associados à trajetória. Este estudo tem por objetivo identificar quais destes fatores foram os que mais contribuíram ao longo da trajetória sociotécnica dos vinhos do Pampa Gaúcho. Para isto, realizou-se um conjunto de dez entrevistas com *experts* e o exame de documentos através da análise de necessidade proposta pelo Método de Análise Qualitativa Comparativa–QCA.

Foi possível identificar treze fatores necessários ao longo da trajetória. Entretanto, há especificidades da necessidade dos níveis e fatores ao longo do processo de transição. A complexidade cresceu na última fase de evolução. Nesta fase, os fatores do nicho foram necessários, inclusive a formação de redes e atividades de gestão do nicho com vistas à identificação e ao aproveitamento de oportunidades e alinhamento dos esforços de aprimoramento do nicho. Estes resultados nos permitem concluir que os três níveis da trajetória sociotécnica (Paisagem, regime e nicho) são necessários no processo de evolução, indicando que não há um no qual sempre seja decisivo.
Palavras–chave: Transição. Fatores Multiníveis. Análise Qualitativa Comparativa. Análise de Necessidade. Vitivinicultura.

Trayectoria sociotécnica de la vitivinicultura en la Pampa Gaúcha: Análisis de la necesidad de factores multinivel

Resumen
La región de la Pampa Gaúcha se caracteriza por experimentar varias transiciones agrícolas en curso. En esta región, históricamente, predominó la ganadería bovina para la producción de carne. Uno de los procesos de transición que ha tenido mayor visibilidad en la actualidad es la elaboración vinos con el establecimiento de nuevas bodegas y áreas de producción de diversos tamaños. A pesar de su impulso reciente, es un proceso que se ha encontrado en transición durante décadas. Investigaciones previas han identificado las fases de su evolución y los factores asociados a dicha trayectoria. Este estudio tiene como objetivo identificar cuál de estos factores contribuyó más a lo largo de la trayectoria sociotécnica de la vitivinicultura en la Pampa Gaúcha. Para ello, se realizaron diez entrevistas a expertos y análisis de documentos, y a través del Método de Análisis Cualitativo-Comparativo - QCA fue posible identificar trece factores necesarios a lo largo de la trayectoria. Sin embargo, se observaron necesidades específicas de niveles y factores a lo largo del proceso de transición. La complejidad creció en la última fase de evolución. En esta etapa, se necesitaron factores de nicho, incluidas las actividades de gestión de nichos y redes para identificar y aprovechar oportunidades y alinear los esfuerzos de mejora de nichos. Estos resultados permiten concluir que los tres niveles de trayectoria sociotécnica son necesarios en el proceso evolutivo, no habiendo uno que sea siempre determinante.
Palabras clave: Transición. Factores multinivel. Análisis Cualitativo-Comparativo. Análisis de necesidades. Vitivinicultura.

1 Introduction

This study focuses on analyzing the sociotechnical transition of Winemaking in Pampa Gaúcho, specifically identifying the essential multilevel factors of the innovative trajectory of Winemaking production in Campanha Gaúcha.

Several ongoing agricultural transitions characterize the Pampa Gaúcho region. Historically, cattle farming has dominated this region. Since early land occupation, this sector has been identified as economically important to the region's primary sector. Rice production began in the 20th century, documenting the gradual expansion of the productive area. The ability to exploit the land's fertility has brought new challenges. Soy, which has recently been introduced, plays a prominent role, as do forestry and olive cultivation. After livestock and rice cultivation, the production of grapes and wines has been incentivized with the establishment of several wineries and producers of varying proportions, which expanded viticulture in the region (SANTOS; DIAS, 2019).

Multilevel perspective (MLP) focuses on the long-term transition processes and analyzes macro, meso, and micro factors associated with the technology's sociotechnical trajectory. Macro-level factors involve politics, culture and social values, demography,

macroeconomics, and natural environment; meso-level factors include the sociotechnical regime that involves shared practices, rules, and interests in collective, private, or public actions associated with technology. Micro-level factors include niches that refer to protected spaces where variations and deviations from new technology can emerge, be cultivated, and grown (GEELS, 2002; ZHANG, 2016).

The MLP has attracted worldwide scholarly attention. Policymaker observed MLP as a strategic tool. Several historical case studies on transitions have shown the utility of the MLP (GEELS, 2002; SMITH, 2007; GEELS, 2011). In Brazil, several studies have already focused on the use of MLP (BULHOES, 2011; OROSKI, 2013; MENDONÇA, 2015; and others).

However, the MLP has many gaps that need to be addressed. Genus and Coles (2008) and Zhang (2016) understand that quantifying the degree of contribution of each factor represents a gap in MLP research. According to Genus and Coles (2008) and Zhang (2016), it is still necessary to understand the essential factors involved in the process of technology transition, as well as the levels at which these factors operate in sociotechnical transitions. Besides, it is unclear whether landscape factors contribute to the sociotechnical niche (SCHOT; GEELS, 2008; BERGEK et al., 2015; KÖHLER et al., 2019)

Santos and Dias (2019) studied the evolution of Pampa Gaúcho wine-growing in Brazil, identifying factors present in each phase. Although this is a descriptive study, it does not focus on quantifying the degree of contribution of each factors nor on identifying the sociotechnical level that is most decisive for the technology evolution process. Additionally, this study does not check whether the factors are acting independently or complementarily.

After analyzing the factors that influence the innovative trajectory of wine production in Campanha Gaúcha, the following research questions arise. What factors were required during the Campanha Gaúcha wine industry's sociotechnical transition process? Which level is most crucial in this evolution process? Do the factors act independently or complementarily?

The qualitative comparative analysis (QCA) method can contribute to these theoretical questions using the necessity analysis technique to identify the contribution of these factors in the transition process. In the QCA method, the expected result cannot be derived if a necessary factor is absent. These factors cannot be offset by other factors in the phenomenon under analysis (DUL, 2016). Although there are only a few studies using the QCA method, it has already been used in the research on transition processes (HESS; MAI, 2014; OSUNMUYIWA; KALFAGIANNI, 2017). Specifically, sufficiency analyses were used to compare the possible different transition paths in multiple cases. In this regard, this study advances the use of the QCA method in transition processes using the QCA method to analyze the responses from multiple information and determine the necessary and most decisive factors and whether they are act independently or in conjunction with each other during the transition process.

Against this background, this study identifies the factors necessary for the sociotechnical trajectory of Pampa Gaúcho wines. The methodology involved a case study that relied on interviews with both closed and open-ended questions. The data from the interviews were analyzed using the QCA method. Additionally, documents were used to corroborate and justify the factors that were identified during the analysis of the closed interviews.

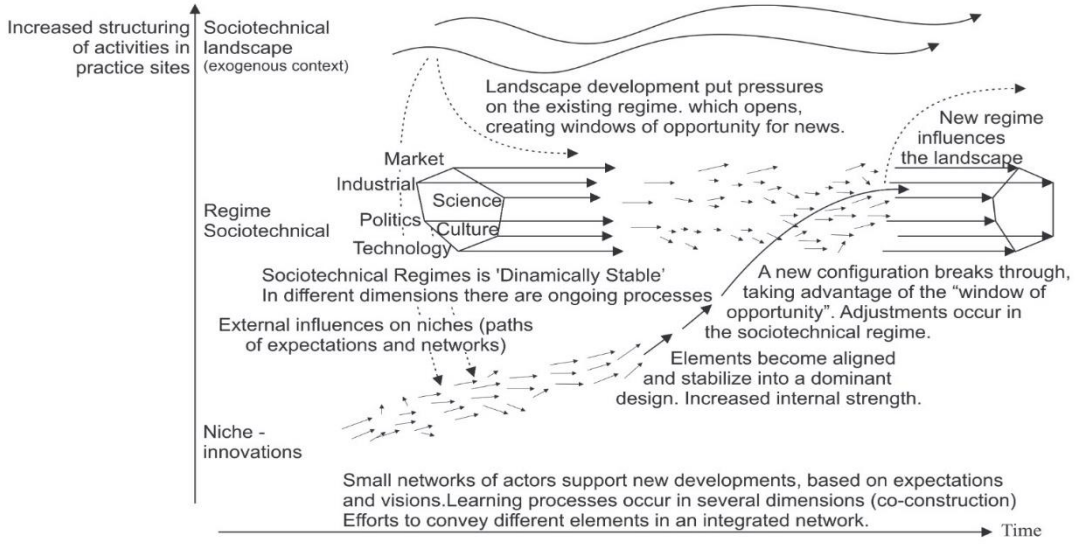
This study provides a theoretical review of the various multilevel factors that can affect the trajectory of socio-technological niches. It identifies the necessary factors for the sociotechnical trajectory of the Pampa Gaúcho wines and highlights the most prominent socio-technological levels in the transition process. This study contributes to transition studies using the QCA method and provides insight into future strategies for the sector.

2 Transitions in the Multilevel Perspective (MLP)

Geels (2002, 2005) and Geels and Schot (2007) describe transitions through the interaction of MLP's three levels: landscape, regime, and niche (Figure 1). From this perspective, the innovation trajectory depends on several factors; it combines several evolution concepts (trajectory, regimes, niches, dependent path, social networks, technology, rules, institutions, etc.) (GEELS; SCHOT 2007, GEELS 2011).

Geels (2005) distinguishes four phases of the niche transition process: experimentation, stabilization, resistance, and substitution.

Figure 1- Relationship between niche, regime, and landscape levels



Fonte: Adaptado de Geels (2011).

During the experimentation phase, innovation niches begin to emerge. Niches are characterized by unstable networks consisting of several competing technologies. Niche actors still need to learn the needs of potential users. At this stage, competing technologies pose no threat to the existing regime (Geels 2005).

In the stabilization phase, competing technologies and users have better understanding and knowledge. However, these technologies still pose a threat to the existing regime and can remain so for decades (GEELS, 2005).

In the resistance phase, there is a stronger definition of the technological standard, greater acceptance of technology by users, and increased competition with the existing regime. This phase of niche evolution needs coordination among niche actors. The existing regime and landscape are also part of this process, creating windows of opportunity that arise due to the presence of a problem that challenges the existing regime and disrupts the previously stable elements. This creates an opportunity for competition between the niche and the existing regime (GEELS, 2005).

The replacement phase, which is considered the final phase, involves significant changes during the transition. This phase occurs gradually and takes longer to observe. At this stage, the existing technology is gradually replaced by the new niche technology (Geels 2005).

2.1 Multilevel conditioning factors of the transition trajectory

From the literature review, this study identifies the following factors at each level: landscape, regime, and niche. At the landscape level, factors such as demographic trends, political ideologies, deep cultural patterns, social values, and macroeconomic patterns are cited as sudden events with significant impact (Figure 2).

Demographic trends refer to an aging population and rural exodus (GEELS; SCHOT 2007, GEELS 2011). Santos and Dias (2019) found that the immigration factor in the Vitiviniculture of the Pampa Gaúcho, mainly from Europeans affected the trajectory of this activity. Deep cultural patterns refer to patterns that emerge in the interaction between users, media, and groups in society (GEELS; SCHOT, 2007). Santos and Dias (2019) also found that eating habits, particularly the habit of rural producers of producing and drinking and their own wine, affected this trajectory (SANTOS; DIAS, 2019).

Political ideologies refer to partisan changes, economic systems, and forms of government (VAN DRIEL; SCHOT 2005, GEELS 2011) and political interests (SANTOS; DIAS, 2019). They are influenced by the actions of influential politicians who are involved in productive activity. This often leads to politicians favoring their regions where their productive activity were prevalent, either because they were born there or belonged to that region (SANTOS; DIAS, 2019). Social values refer to the environmental concerns that affect them at the time (VAN DRIEL; SCHOT 2005, GEELS 2011).

Macroeconomic patterns relate to oil price fluctuations, economic recession, privatization, and investment cuts (VAN DRIEL; SCHOT 2005, GEELS 2011). Besides economic aspects, trade policies, such as import barriers, trade liberalization policy, and price control policy, are associated with the trajectory of viticulture in the Pampa Gaúcho (SANTOS; DIAS, 2019).

Sudden events with high impact are defined as inclement weather, windstorms, hurricanes, droughts, and wars (VAN DRIEL; SCHOT 2005, GEELS 2011). The appearance of diseases and pests in crops was also considered a sudden event (SANTOS; DIAS, 2019).

The following factors are mentioned at the regime level: industry and infrastructure, science and technology, market, politics and natural resources (Figure 3). Industry is the production of goods and services that requires equipment, machinery and tools, and the associated infrastructure, such as roads and ports (GEELS 2002, SANTOS; DIAS, 2019).

Figure 2 - Identified factors associated with the landscape level

Level	Factors	Subfactors	Authors	Code
Landscape	Demographic trends	Aging population.	(GEELS; SCHOT 2007, GEELS, 2011).	PTDP
		Rural exodus.		
		European immigration.	(SANTOS; DIAS 2019).	
	Political ideologies	Political party changes.	(VAN DRIEL; SCHOT 2005)	PIPP
		Economic system.		
		Forms of government.		
		Self-interests of influential politicians.	(SANTOS; DIAS 2019).	
	Social values	Environmental concerns.	(VAN DRIEL; SCHOT 2005,GEELS 2011).	PVSP
	Cultural patterns	Patterns are produced in the interaction between users, media, and groups in society.	(GEELS; SCHOT 2007).	PPCPP
		Eating habits.	(SANTOS; DIAS 2019).	
	Macro Patterns	Economic, such as oil price fluctuations, economic recession, privatizations, and investment cut-offs.	(VAN DRIEL; SCHOT 2005,GEELS 2011, SANTOS; DIAS, 2019).	PPMFP
		Commercial: import barriers, trade liberalization policy, and price control policy.	(SANTOS; DIAS 2019).	PPMCP
	Suddenn Events	Inclement weather.	GEELS, 2011; VAN DRIEL;SCHOT, 2005).	PERP
		Wars.		
		Occurrence of diseases and pests in crops.	(SANTOS; DIAS 2019).	

Source: prepared by the authors based on the cited authors (2020).
Remark: The last column refers to the codes used in the method.

Science and Technology refer to the role of universities and research centers (GEELS, 2002), specifically, in the dynamism of knowledge production through new information flows, which enables the development of new technologies. However, the empirical use of technologies in daily work can also be a source of knowledge acquisition (MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014; SANTOS; DIAS, 2019).

Market refers to the demand for new technology (GEELS, 2002). The market could necessitate products and services with complex applications (large firms or governments that use products in complex applications) (MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014) or products and services that are not critical to customers (common consumers and the products are not critical) (MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019).

Politics and culture refer to legal regulations and social norms and stakeholder demands (GEELS, 2002; MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014; SANTOS; DIAS,2019) and a dominant group's technology that contributes to the trajectory (MILLER; FLORICEL, 2007).

A group has technological dominance when companies have a disproportionate market share compared to their competitors and thus can introduce their technology (MILLER; FLORICEL, 2007). In the case of Pampa Gaúcho viticulture, technological dominance refers to the standard that multinational wine companies impose on grape producers for technology adoption, indicating the use of recommended wine varieties and more intensive use of fertilizers and pesticides (SANTOS; DIAS, 2019).

Figure 3 - Factors identified associated with the regime

Level	Factors	Subfactors	Authors	Code
Regime	Industry	Equipment, machinery, and tools.	(GEELS, 2002, SANTOS; DIAS, 2019).	RAMER
		Associated infrastructure.		RILR
	Science and technology	Origin of knowledge from universities and research centers.	(GEELS, 2002, MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019).	RDCR
		Origin of learning through the empirical use oftechnologies in daily work.		RDEER
	Market	Demand specifics of large firms or governments for use in critical applications.	(GEELS, 2002, MILLER; FLORICEL, 2007, DIAS; PEDROZO; SILVA, 2014).	RECR
		Specifics of demand originating from consumers, and thus can judge the product quality compared to other products.	(GEELS, 2002, MILLER; PETROZO; DIAS; ABREU, 2014, SANTOS; DIAS, 2019).	
	Politics and Culture	Legal regulations and social and stakeholder norms.	(GEELS, 2002, MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019).	RPERR
		Technological Dominance.		RPEDTR
	Natural resources	Soil and Climate Resources.	(SANTOS; DIAS, 2019).	RRECP

Source: prepared by the authors based on the cited authors (2020).
Remark: The last column refers to the codes used in the method.

Finally, Santos and Dias (2019) added that the availability of natural resources such as soil or climate in a region affected the wine-growing trajectory (SANTOS and DIAS, 2019).

At the niche level, the following factors are mentioned: identification of opportunities and threats, seizing opportunities, reconfiguration, and barriers. These levels include individual, organizational, external factors (Figure 4).

Identifying opportunities and threats refers to discovering, interacting, and evaluating information about customer expectations, science and technology production centers, suppliers, companies' internal environment, R&D sectors, and participation in networks (MILLER; FLORICEL, 2007; TEECE, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019).

Figure 4 - Factors related to the niche level

Level	Factors	Subfactors	Authors	Code
Niche	Identification of opportunities and threats	Customer expectations.	(MILLER; FLORICEL 2007; DIAS, PEDROZO, 2014; SANTOS; DIAS 2019).	NIOAC
		Science and technology production centers.		NIOAP
		Suppliers.		NIOAF
		Participation in networks.		NIOAR
		Internal environment of companies and R&Dsectors.		
	Seizing opportunities	Development of new products and services, managing the architecture of existing products.	(MILLER; FLORICEL 2007; DIAS, PEDROZO, 2014;).	NAOCA
		Knowledge of the positioning of the most innovativeorganizations.	(TEECE, 2007, DIAS, PEDROZO, 2014).	
		Development of new markets.	(MILLER; FLORICEL 2007; DIAS, PEDROZO, 2014;).	
		Asset complementarity management.	(TEECE, 2007, DIAS, PEDROZO, 2014; SANTOS; DIAS 2019).	
	Reconfiguration	Formation of networks: network governance, incentive mechanisms, opportunism control, learning, such as knowledge transfer, know-howprotection, evaluation of activities, etc.	(TEECE, 2007, DIAS, PEDROZO, 2014; SANTOS; DIAS 2019).	NRTC
		Fostering creativity and learning.		NAOCR
		Co-specialization (Joint studies with universitiesand research centers).	(MILLER; FLORICEL 2007; TEECE, 2007; DIAS, PEDROZO, 2014; SANTOS; DIAS 2019).	NRTCC
	Individual	Barriers	(NONAKA; TAKEUCHI 1995; DIAS, PEDROZO, 2014; SANTOS; DIAS 2019)	NBIN
		Organizational		NBOR
		External		NBEX

Source: prepared by the authors based on the cited authors (2020).
Remark: The last column refers to the codes used in the method.

Seizing opportunities extends to knowing the adequacy of the desired knowledge and positioning the most innovative organizations (TEECE, 2007; DIAS, PEDROZO; DIAS; ABREU, 2014), development of new products and services, managing the existing products' architecture (MILLER; FLORICEL, 2007; TEECE, 2007; DIAS; PEDROZO; SILVA, 2014), asset complementarity management (TEECE, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019), and development of new markets (MILLER; FLORICEL, 2007; DIAS; PEDROZO; SILVA, 2014).

Reconfiguration is the creation of more flexible organizational structures, such as organizational networks, where it is possible to implement the governance of actors, including knowledge transfer practices, protecting know-how, and encouraging creative action (TEECE, 2007; DIAS; PEDROZO; SILVA, 2014, SANTOS; DIAS, 2019), and co-specializing (strategic management of assets adding value, studies in conjunction with universities and research centers (MILLER; FLORICEL, 2007; TEECE, 2007; DIAS; PEDROZO; SILVA, 2014; SANTOS; DIAS, 2019).

All three identified factors can be promoted by introducing the four phases of knowledge creation (DIAS; PEDROZO; SILVA, 2014). Nonaka and Takeuchi (1995) described these four phases as socialization, externalization, combination situations, and internalization. Socialization means sharing and creating tacit knowledge through direct experience. Externalization is about tacitly articulating knowledge through dialogue and reflection. Combined situations involve the systematization and application of explicit knowledge, while internalization represents the learning and acquisition of new tacit knowledge through practice (NONAKA; TAKEUCHI, 1995). In addition to the four phases, it is necessary to consider the conditions that promote the learning phases, including autonomy, fluctuation and creativity, chaos, redundancy, and variety (NONAKA; TAKEUCHI, 1995).

Individual barriers include accommodation (the more difficult it is to acquire knowledge, the easier it is to lose interest) and threats to self-image (resistance to change, as it seems risky to break away from familiar habits (NONAKA; TAKEUCHI, 1995; DIAS, PEDROZO, 2014; SANTOS, DIAS, 2019).

Organizational barriers refer to contexts such as the lack of exposure to diverse and complementary knowledge (from external sources that can provide the organization with greater opportunities), the search for past experiences (seeking information where success has already been achieved), and the lack of social integration mechanisms (those that reduce information barriers and increase the ability to assimilate and transform) (NONAKA; TAKEUCHI, 1995; DIAS, PEDROZO, 2014; SANTOS, DIAS, 2019)

Finally, external barriers refer to the appropriation regime (industrial and institutional dynamics affecting the company's ability to protect innovations or adopted innovation protection dynamics affecting winemakers' capabilities) (ZAHRA; GEORGE, 2002; DIAS, PEDROZO, 2014; SANTOS, DIAS, 2019).

3 Method

The case study method was used in the study as it was found to be effective strategy for understanding the factors associated with the innovative trajectory of viticulture in the Campanha Gaúcha. The case study approach stems from the desire to understand complex social phenomena. This approach allows for preservation of the integral and expressive characteristics of real-life scenarios in the studies, thus requiring an accurate presentation of the collected data (YIN, 2017).

In transition research, the subject of the study is linked to the organizational field (GEELS; SCHOT, 2007). The chosen subject of this study pertains to actors involved in viticulture in Pampa Gaúcha (Figure 5) and their interactions.

Figure 5 - Campanha Gaúcha wine route

Source: Made available by the Associação Vinhos da Campanha (2020).

3.1 Data collection

In this study, 10 interviews were conducted to quantify the influence of multilevel conditioning factors on the trajectory of viticulture in the Pampa Gaúcho. Respondents (Figure 6) were classified based on their level of knowledge and involvement with the wine production process in Campanha Gaúcha. This classification also considered whether they were natives of the region or had lived there for a longer time. Appointments were made in advance with the respondents to use the questionnaires. All interviews were conducted on site.

Figure 6 – Respondents' profile chart

Interviewee	**Profile** (background, occupation)	**City**	**Relationship time with viticulture**
1	Administrator and Winemaker	Livramento	32 years old
2	Agronomy Engineer and WineryCoordinator	Livramento	19 years old
3	Agronomy Engineer	Candiota	15 years old
4	Agronomy Engineer	Candiota	30 years old
5	Agronomy Engineer, University Professor and Researcher	Bagé	5 years old
6	Winery Manager	Itaqui	18 years old
7	Rural Producer	Candiota	64 years old
8	Winery Manager Graduated in History	Bagé	18 years old
9	Agronomy Engineer and Winemaker	Dom Pedrito	18 years old
10	Winery Manager and Partner	Dom Pedrito	16 years old

Source: prepared by the authors (2020).

Each respondent was asked the following question in the survey. To what extent did factor X contribute to the success of the Pampa Gaúcho winery in phase Y? The respondent had the option to answer on a scale of 1 to 5 as follows: did not

contribute at all (1), contributed very little (2), contributed little (3), contributed a lot (4), fully contributed (5).

The multilevel factors evaluated were those previously identified in Section 2.1. (Figures 2, 3 and 4). These factors were assessed for each phase of the evolution identified by Santos (2019) as follows: experimentation (1887–1969), stabilization (1970–1999), and resistance (2000–present day). For more details on the phases of evolution, see the article by Santos and Dias (2019).

The questionnaire was pre-tested before its administration to adapt the questions to the respondents' understanding. The pre-test was conducted in August 2018 with the manager of a winery in the city of Seival. He was chosen because of his familiarity with the trajectory of viticulture in the Campanha Gaúcha. His qualifications include a background in agronomy, a postgraduate degree in oenology at the Federal University of Pampa (UNIPAMPA), and past experience as president of the Associação de Vinhos da Campanha Gaúcha. After adapting the questionnaire based on the respondent's feedback, it was distributed to the other respondents.

3.2 Analysis

The questionnaires were analyzed using the "analysis of necessity" technique. This technique is part of the QCA method conducted using the fsQCA software (RAGIN; DAVEY, 2008). The QCA method is ideal for analyzing a limited number of cases (or respondents). Originally used in political science, it has recently been adopted in applied social science (PEDROZO; DIAS; ABREU, 2012; DIAS; PEDROZO, 2015). This method proposes a detailed approach to case comparison (in this survey, e.g., the responses of different respondents were compared). This method uses formal processes to systematically organize information, ensuring transparency and replicability of the analysis (RIHOUX; RAGIN, 2009).

Necessary conditions are important for theory and practice because if these causal conditions are absent, the expected result is not achieved. In addition, other causal conditions cannot compensate for their absence (DUL, 2016). In analysis of necessity, a factor is required if the causal condition (x) is present regardless of the outcome condition (y).

In this study, the outcome conditions were defined as the phases of evolution of the identified trajectory: experimentation (1887–1969), stabilization (1970–1999), and resistance (2000–present day). Causal conditions were defined as the factors that influence the transition process and were defined in the previous section.

To perform the analysis of necessity, all factors were calibrated. A value of 1 was assigned to indicate that the factor contributes fully to the phase of the trajectory analyzed (corresponding to value 5 on the response scale), 0.5 was assigned to indicate that the factor contributed little (corresponding to value 3 on the response scale), and 0 was assigned to indicate that the condition does not contribute at all (corresponding to value 1 on the response scale).

Two indicators were used to assess the degree of necessity of each factors at each of the three stages of evolution of the viticultural trajectory: consistency and coverage.

Necessary factors are those with high consistency indicators (X> = 80%). This is a key indicator for analyzing the necessity of a factor. The consistency of a factor

is calculated as follows: the sum of the minimum value assigned to each of the factor(X) or the value attributed to the performance variable (Y) is divided by the sum of the performance variable (Y) (Figure 7) (SCHNEIDER; WAGEMANN, 2012).

Figure 7 - Formula of consistency of a given factor

$$Consistency\ (necessary\ conditions)(Xi \geq Yi) = \frac{\sum_{i=1}^{I} \min(Xi, Yi)}{\sum_{i=I}^{I} Yi}$$

Source: Schneider and Wagemann (2012, p. 141).

Coverage should be calculated only if consistency is satisfactory. The coverage of a factor is given by the sum of the minimum value attributed to either factor (X) or the performance variable (Y) divided by the sum of the factor (X) (Figure 8) (SCHNEIDER; WAGEMANN, 2012). In other words, if the size of X exceeds that of Y, then the coverage of X as a necessary condition decreases. This is an indicator of the relevance of the need for a given factor (SCHNEIDER; WAGEMANN, 2012).

Figure 8 - Formula for coverage of a given factor

$$Coverage\ of\ X\ as\ a\ necessary\ condition\ for\ Y = \frac{\sum_{i=1}^{I} \min(Xi, Yi)}{\sum_{i=I}^{I} Xi}$$

Source: Schneider & Wagemann (2012, p. 141).

The coverage indices (X > 50%) are considered representative and the necessary conditions under analysis are significant (SCHNEIDER; WAGEMANN, 2012) as it is often not possible to achieve high values for the measures of consistency and coverage simultaneously.

4 Results

Figure 9 shows the results of the analysis of necessity for multilevel factors.

An analysis of Figure 9 shows that the factor "European immigration" from the landscape level was considered necessary during the experimentation phase. This factor achieved a consistency of 0.835, indicating a strong consensus among respondents regarding the contribution of "European immigration" to the first phase of the wine-producing trajectory of the Pampa Gaúcho. A coverage value of 0.632 (Figure 9) for this factor indicates the factor's relevance and nontriviality. (SCHNEIDER; WAGEMANN, 2012).

During the stabilization phase of the technology evolution, the factor "natural resources—climate, soil, topography" at the level of the regime was identified. This factor achieved 0.937 consistency and 0.663 coverage, indicating its necessity and significance.

While one factor was considered necessary in each of the first two phases, twelve factors were considered necessary in the technology resistance phase, five at the regime level, and seven at the niche level.

Figure 9 - Consistent factors (x ≥ 80%) in the three phases of the wine trajectory

Phases				Experimentation(1887–1969)		Stabilization (1970–1999)		Resistance (2000–present day)	
Level	Factors		Code	Consistency	Coverage	Consistency	Coverage	Consistency	Coverage
Landscape	Demographic trends	European Immigration	PTDP	0.83*	0.632	0.436		0.378	
Regime	Industry	Infrastructure,artifacts, machinery and Equipment	RAMER	0.314		0.718		0.860*	0.544
	Science and technology	Knowledge of universities and research centers	RDCR	0.207		0.757		0.950*	0.556
	Market	Demand specificsfrom consumers	RECR	0.414		0.744		0.937*	0.557
	Politics and Culture	Technological Dominance	RPEDTR	0.293		0.622		0.821*	0.568
	Natural Resources	Soil and Climate Resources	RRECP	0.528		0.937*	0.663	0.950*	0.503
Niche	Identification of opportunities and threats	Customer expectations	NIOAC	0.378		0.545		0.873*	0.615
		Science and technology production centers	NIOAP	0.228		0.616		0.898*	0.593
		Participation in networks	NIOAR	0.178		0.417		0.898*	0.682
	Seizing opportunities	Asset complementarity management	NAOCA	0.107		0.609		0.924*	0.602
	Reconfiguration	Networking	NRTC	0.233		0.641		0.892*	0.584
		Fostering creativity and learning	NAOCR	0.107		0.519		0.892*	0.632
		Co-specialization	NRTCC	0.178		0.635		0.860*	0.572

Source: prepared by the authors (2020).
*Indicates that the respondents' responses regarding the need for the factor are consistent.

The following factors were considered necessary at the regime level: "infrastructure, artifacts, machinery and equipment," "knowledge of universities

and research centers," "demand specifics originating from consumers," "technological dominance," and "soil and climate resources." Consistency values ranged from 0.821 to 0.950 and coverage values ranged from 0.503 to 0.568, indicating their necessity and significance.

The following factors, associated with the identification of opportunities and threats, were considered necessary at the niche level: "customer expectations," "science and technology production centers," and "participation in networks." In addition, the factor "asset complementarity management," associated with seizing opportunities, was considered a necessary factor. Fin associated with the reconfiguration of the niche ally, the following factors associated with the reconfiguration of the niche were considered necessary: "networking," "fostering creativity and learning," and "co-specialization." Their consistency values ranged from 0.86 to 0.924 and coverage values ranged from 0.527 to 0.682, indicating their necessity and significance.

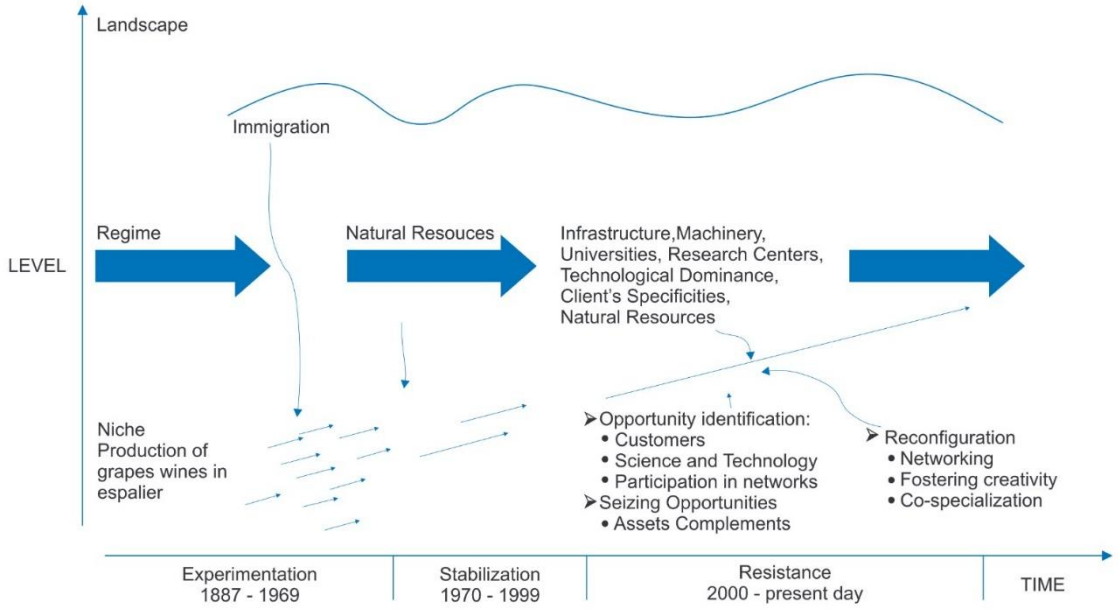
4 Discussion

Figure 10 summarizes the results discussed in Section 4, indicating the necessary factors and the level of origin. On analyzing the entire trajectory, it was observed that factors from all three levels, landscape, regime, and niche, were necessary throughout the transition process, which confirms the relationships proposed in the MLP Framework (GEELS, 2011).

However, when analyzing the sequence of phases, in this case, it is particularly noted that there are specific needs for the factors at each level throughout the transition process. In the experimentation phase (1887–1969), a landscape factor "immigration" was necessary; that is, the experimentation phase would not have occurred in the absence of this condition and could not have been compensated by another condition to initiate the analyzed trajectory (DUL, 2016). This finding shows that a factor related to the landscape is crucial for initiating a transition process. The same conclusion can be drawn about the regime factor "natural resources" in the stabilization phase of technology (1970–1999). The resistance phase (2000–present day) is also characterized by being dependent on the outside; however, it involved 12 necessary factors related to two levels of the transition process, 5 to the regime phase, and 7 to the niche phase.

Therefore, in the first two phases of transition, the niche depended on the necessary presence of an external factor (landscape and regime), which corroborates the proposition of (BERGEK et al., 2015) about the existence of more distant external links (landscape) to development of niche, the "landscape forces" and the less distant (regime) type, the "structural couplings" type. As examples of landscape level forces, Bergek (2015) cites steep rises in prices and shifts in society's priorities. Structural coupling implies the existence of factors that are consistent with the trajectories existing in the regime (BERGEK et al., 2015). The resistance phase (2000–present day) was characterized by a "structural couplings" type of relationship. Finally, the evolution from the more distant connections (landscape) in the experimentation phase to less distant connections in the stabilization and resistance phases of technology also confirms the general rule of approximation of the connections throughout the transition process (BERGEK et al., 2015).

Figure 10 - Synthesis of necessary factors, transition phase, level of origin



Source: prepared by the authors (2020).

The presence of complementarity of niche and regime factors supports the findings of BERGEK et al. (2015) and ZHANG (2016) on the complementarity of levels and factors (OSUNMUYIWA; KALFAGIANNI, 2017). It was found that the resistance phase (2000–present day) was characterized by higher complexity, due to the need for two-level factors (niche and regime) and a larger number of these factors (12). When analyzing the regime's factors, such as "knowledge of universities and research centers," "market–demand specifics originating from consumers," and "soil and climate resources," these acted as complementary to the analyzed niche, as they were all

assessed as necessary. In the niche, the necessary factors associated with the identification of opportunities and threats were "customer expectations," "science and technology production centers," "participation in networks," in addition to the factor associated with seizing opportunities "asset complementarity management." The factors "networking," "fostering creativity and learning" and "co-specialization" were all considered necessary at this stage.

The cooperation of the regime with the niche can be inferred from the type of transition that represents viticulture in the Pampa Gaúcho, considering the type of transition that can be characterized as "Reconfiguration" (GEELS; SCHOT, 2007). Geels and Shot (2007) explained that in such a transition, the innovation in development of the niche is related to the regime because this technology represents a replacement component for another. In the Pampa Gaúcho region, where agricultural production mainly consists of soybeans, rice, wine grapes are also produced. This involves common machinery and equipment, such as tractors, and knowledge, such as fertilization and use of pesticides. Certainly, wine production has its specificities; however, agricultural practices are not radically different, thus allowing better adaptation of the regime's actors to the new niche, such as machine industries, organizational support corporations, universities, and even the practices associated with soil and climate resources.

Finally, it is important to highlight the need for factors related to the niche in the resistance phase, the phase of greater adoption of the technology. Networking can contribute to niche management, thereby aligning all niche improvement efforts. The construction system involves many actors, each with their own agenda and strategic plan. These actors can provide resources to other participating actors. This benefits the system as a whole, resources are pooled, and efforts are aligned. Without coordination, individual efforts can be futile, given the many demands that larger numbers of technology adopters can generate (MUSIOLIK; MARKARD; HEKKERT, 2012).

5 Final Considerations

First, it is important to note the contribution of the theoretical review of the factors associated witheach level of socio-technological trajectories (Section 2.1 and Figures, 2, 3, and 4). This will aid future studies in other transition processes. Finally, it is important to emphasize the importance of the QCA method for the study of transitions, especially in case studies with fewer experts, while still providing tools to synthesize data and draw conclusions from systematized and accepted procedures in the scientific field (FISS, 2009; PEDROZO; DIAS; ABREU, 2012, DIAS; PEDROZO, 2015).

One of the limitations of this study is that it only analyzed a single case, indicating that theresults cannot be generalized. Another important limitation is that the study was conducted long ago, making it difficult to access information, especially during the first phase of experimentation. Finally, as a limitation, it should be noted that even if the necessary conditions are present, the expected result of the analyzed phenomenon will be achieved.This is because all necessary factors must be included in the configuration that includes complementary factors to achieve the result of the analyzed phenomenon. A sufficiency analysis can help identify these factors (DUL, 2016).

As future research, it is suggested to analyze the multilevel factors identified in the theoretical review (Section 2.1) in the process of transition from other socio-technological niches. Multiple case studies would also make it possible to perform sufficiency analysis and thus identify different transition paths of socio-technological niches as well. Performing sufficiency analysis through multiple case studies could identify various transition paths of socio-technological niches.

Finally, this study aimed to identify the necessary factors for the sociotechnical trajectoryof the Pampa Gaúcho wines. These findings suggest that there are specific levels of needs and factors that work together in the transition process. The landscape level was necessary for the experimentation phase, while the regime level for the stabilization phase. In the resistance phase, the levels of the niche and regime necessarily interact, indicating that theniche is exposed to more distant external influences (landscape forces) in its initial phase and to closer ones (structural couplings) in more advanced phases. The complexity of the factors grew in the resistance phase. Niche factors were necessary in this phase, including network formation and niche management activities aimed at identifying and seizing opportunities and aligning nicheimprovement efforts. In the end, the three levels of the sociotechnical trajectory are necessary in the evolution process, indicating no one is always decisive.

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