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HOW TO COMPARE THE MATURITY OF INNOVATION ECOSYSTEMS?

COMO COMPARAR A MATURIDADE DOS ECOSSISTEMAS DE INOVAÇÃO?

¿CÓMO COMPARAR LA MADUREZ DE LOS ECOSISTEMAS DE INNOVACIÓN?

ABSTRACT

Purpose: To identify improvements to the model to enable comparisons of the evolution of the innovation ecosystem across regions within the same country.

Context: The Secretariat of Economic Development (SDE) of Santa Catarina encouraged mapping based on the Cukier, Kon, and Krueger (2015) model to monitor and compare different regions within and outside the state (SDS, 2017).

Diagnosis: The model proposed by Cukier, Kon, and Krueger (2015) suggests the comparison of multiple ecosystems, but encounters limitations when applied to ecosystems within the same country.

Originality: It enabled the comparison of different realities within the same country. Above all, it facilitated the self-analysis of each ecosystem to identify existing gaps.

Main Results: i) expansion of the sample size; ii) incorporation of additional data sources, such as interviews and secondary data; and iii) introduction of indicators that capture realities at the city level, rather than focusing solely on countries. These results allow comparisons of ecosystem evolution in different regions of the same country.

Practical, Theoretical, and Social Implications: It provided a consolidated information base and a reference point for measuring innovation ecosystems. It contributes to knowledge by proposing improvements to the model and presenting innovation results in the field of Administration and related fields. It aims to portray the current situation, enabling the design of improvement actions based on this panorama to contribute to the economic, social, and environmental development of the region. The practical results and the methodology applied in this project can serve as a basis for new studies that contribute to scientific advancement, knowledge dissemination, and relevant academic research.

Keywords: Innovation Ecosystem; Mapping; Startups.

Giovana Bueno
PhD.
Universidade de São Paulo – Brazil
giovanabueno@usp.br

Dinorá Eliete Floriani
PhD.
Universidade do Vale do Itajaí – Brazil
dinora@univali.br

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RESUMO

Objetivo: Apontar melhorias no modelo para permitir comparações da evolução do ecossistema de inovação entre regiões de um mesmo país.

Contexto: A Secretaria de Desenvolvimento Econômico (SDE) de Santa Catarina incentivou o mapeamento baseado no Modelo de Cukier, Kon e Krueger (2015) para monitorar e comparar diferentes regiões dentro e fora do estado (SDS, 2017).

Diagnóstico: O modelo proposto por Cukier, Kon e Krueger (2015) sugere a comparação de vários ecossistemas, mas encontra limitações quando aplicado a ecossistemas dentro do mesmo país.

Originalidade: Possibilitou a comparação de diferentes realidades dentro de um mesmo país. Principalmente, facilitou a auto-análise de cada ecossistema para identificar falhas existentes.

Principais Resultados: i) expansão do tamanho da amostra, ii) incorporação de fontes de dados adicionais, tais como entrevistas e dados secundários, e iii) introdução de indicadores que capturam realidades ao nível da cidade, em vez de se concentrarem apenas nos países. Esses resultados permitem comparações da evolução dos ecossistemas em diferentes regiões de um mesmo país.

Implicações práticas, teóricas e sociais: Forneceu uma base de informações consolidada e um ponto de referência para medir ecossistemas de inovação. Contribui para o conhecimento ao propor melhorias no modelo e apresentar resultados de inovação na área de Administração e áreas afins. Visa retratar a situação atual, possibilitando o desenho de ações de melhoria baseadas neste panorama para contribuir com o desenvolvimento econômico, social e ambiental da região. Os resultados práticos e a metodologia aplicada neste projeto podem servir de base para novos estudos que contribuam para o avanço científico, disseminação do conhecimento e pesquisas acadêmicas relevantes.

Palavras-chave: Ecossistema de Inovação; Mapeamento; Startups.

RESUMEN

Objetivo: Identificar mejoras al modelo para permitir comparaciones de la evolución del ecosistema de innovación entre regiones dentro de un mismo país.

Contexto: La Secretaría de Desarrollo Económico (SDE) de Santa Catarina fomentó el mapeo basado en el Modelo de Cukier, Kon y Krueger (2015) para monitorear y comparar diferentes regiones dentro y fuera del estado (SDS, 2017).

Diagnóstico: El modelo propuesto por Cukier, Kon y Krueger (2015) sugiere la comparación de varios ecosistemas, pero encuentra limitaciones cuando se aplica a ecosistemas dentro de un mismo país.

Originalidad: Permitió comparar diferentes realidades dentro de un mismo país. Principalmente, facilitó el autoanálisis de cada ecosistema para identificar fallas existentes.

Resultados principales: i) ampliación del tamaño de la muestra, ii) incorporación de fuentes de datos adicionales, como entrevistas y datos secundarios, y iii) introducción de indicadores que capturan realidades a nivel de ciudad, en lugar de centrarse sólo en países. Estos resultados permiten comparar la evolución de los ecosistemas en diferentes regiones de un mismo país.

Implicaciones prácticas, teóricas y sociales: Proporcionó una base de información consolidada y un punto de referencia para medir los ecosistemas de innovación. Contribuye al conocimiento proponiendo mejoras al modelo y presentando resultados de innovación en el área de Administración y campos afines. Se pretende retratar la situación actual, posibilitando el diseño de acciones de mejora con base en este panorama para contribuir al desarrollo económico, social y ambiental de la región. Los resultados prácticos y la metodología aplicada en este proyecto pueden servir de base para nuevos estudios que contribuyan al avance científico, la difusión del conocimiento y la investigación académica relevante.

Palabras clave: Ecosistema de Innovación; Mapeo; Startups.

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INTRODUTION

The concept of a startup refers to a company that emerges spontaneously under conditions of extreme uncertainty, with innovation at its core to develop products and services across diverse sectors (Ries, 2012). The startup ecosystem encompasses the environment related to startups, including institutions that foster innovation and entrepreneurship, such as educational institutions, incubators, and venture capital firms (Torres & Souza, 2016). Within this sphere, innovation ecosystems encompass not only startups but also other companies, both technological and non-technological, that introduce innovation into their business models. Aleisa (2013) defines the ecosystem as a network involving ideas, skills, entrepreneurs, startups, incubators, mentors, and capital, among other actors driving business dynamics.

Ecosystems are distinguished from clusters and networks through the following characteristics: they present results at a system level, there is the heterogeneity of participants, the nature of interdependencies and coordination mechanisms. Although none of these characteristics alone distinguish exclusively the ecosystems of other organizational collectives, the combination of the four characteristics is unique to ecosystems, and individual characteristics also help to distinguish between different types of ecosystems. (Autio & Thomas, 2021).

According to Matos and Teixeira (2022), the primary distinction between a Startup Ecosystem and an Innovation Ecosystem lies in their scope and infrastructure. A startup ecosystem operates within the confines of a specific region, establishing infrastructure to support the creation and growth of startups (Tripathi et al., 2019). Conversely, an Innovation Ecosystem serves as an integration mechanism between the exploration of new knowledge and its exploitation for co-creating value within business ecosystems (Dedehayir, Mäkinen, & Ortt, 2018; Valkokari, 2015). Despite their differences, both ecosystems share a common focus on innovation, with variations in actor types, context, and boundaries (Matos & Teixeira, 2022). Thus, an Innovation Ecosystem encompasses all elements contributing to the development of an environment conducive to innovation (Abstartup, 2022), functioning as an entity that evolves around innovation to foster relationships among various actors within this context (Gomes, Facin, Salerno, & Ikenami, 2018; Russo-Spena, Tregua, & Bifulco, 2017).

Significant innovation ecosystems include Silicon Valley in the United States, known for pioneering advancements in software, internet, and social networks, and housing numerous technology companies worldwide. In Europe, Sweden ranks as the second most innovative country globally, emphasizing research and development (R&D) and social well-being. The United Kingdom boasts 37% of unicorns across Europe, particularly excelling in Fintech, Blockchain, and Healthtech sectors. Israel, often referred to as the Startup Nation, features a unique ecosystem deeply ingrained in its culture, with cities like Tel Aviv, Jerusalem, and Haifa serving as innovation hubs housing globally recognized startups. Additionally, China emerges as a global leader in innovation, technologies, and trends (Amcham, 2021).

With the recent advancements in technology, there has been a notable proliferation of technology-based companies, startups, and innovative businesses worldwide (Stam & Van de Ven, 2021). However, what commonalities do these innovation ecosystems share? How can we gauge their level of development and identify opportunities for advancement? Measuring the development of innovation ecosystems on both global (inter-country) and regional (intra-country) scales is important for all ecosystem stakeholders, including universities, governments, companies, and society. This information is essential for guiding managers and governments in formulating effective policies that foster the growth of these ecosystems.

Hence, there is a growing interest in mapping innovation ecosystems to comprehend the innovation context, the factors facilitating its development, and those impeding it (La Rovere, Oliveira Santos, & Vasconcellos, 2021; Stam & Van de Ven, 2021). Seeking to address this need, the Secretariat of Economic Development (SDE) of Santa Catarina encouraged the application of a mapping exercise based on the Maturity Degree Measurement Model of Startup Ecosystems by Cukier, Kon, and Krueger (2015), as outlined

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in the Innovation Centers Implementation Guide (SDS, 2017). The SDE aimed to obtain results that could be monitored over time and compared between different regions within and beyond the state, providing insights to inform future actions toward innovation development (SDS, 2017).

However, challenges arose during the model application, particularly concerning the proposed indicators. For instance, the use of global indices limited comparisons to national levels, hindering the monitoring of ecosystem evolution and intra-regional comparisons. Therefore, this study's primary objective is to propose enhancements to the Model for Measuring the Degree of Maturity of Startup Ecosystems by Cukier, Kon, and Krueger (2015) to enable the monitoring and comparison of ecosystems within the same location. This technological article serves as the culmination of research into the innovation ecosystem involving eleven municipalities in the Foz do Rio Itajaí region, Santa Catarina.

Identifying differences in maturity between regions allows policymakers to gain a clearer understanding and thus create public policies that reduce disparities. For example, innovation initiatives such as research programs and accelerators, which work well in highly mature regions, may not work in regions in their early stages. In Brazil, with its marked regional inequalities, this is especially relevant. Furthermore, establishing regional maturity metrics allows for monitoring progress over time, assessing the impact of policies, and serving as a basis for regional benchmarks.

CONTEXT AND THE REALITY INVESTIGATED

Isenberg (2010) developed a model to measure ecosystem performance based on OECD (Organization for Economic Co-operation and Development) indicators across several areas: regulatory framework, market conditions, access to financing, creation and dissemination of knowledge, entrepreneurial capabilities, and entrepreneurial culture. However, a limitation of this model is its failure to consider the dynamic aspect and interconnectivity of ecosystems. Frenkel and Maital (2014) proposed a methodology for mapping innovation ecosystems based on factors deemed anchored by a team of ecosystem experts: Culture, Markets, Context (including infrastructure), and Institutions (including regulations). This methodology has been applied in numerous countries, leading to several subsequent studies.

Inspired by these studies, Cukier, Kon, and Krueger (2015) developed a model to measure startup ecosystem maturity. It presents indicators with metrics and scales that categorize ecosystems into four levels of evolution: Nascent, Evolving, Mature, and Self-sustainable. The model aims not only to highlight areas requiring greater attention within the ecosystem but also to facilitate comparison with other existing ecosystems. Subsequently, there have been other models such as those proposed by Arruda, Nogueira, Cozzi, and Costa (2015), Bell-Masterson and Stangler (2015), Solodilova, Malikov, and Grishin (2018), Zen, Santos, Faccin, & Gonçalves (2019), and Stam and Van de Ven (2021), among others. However, the model by Cukier, Kon, and Krueger (2015) is the focal point of this technological article, as it was the model chosen by the SDE to map the innovation ecosystems of the State of Santa Catarina. Consequently, all fifteen Innovation Centers located in the state are encouraged to utilize this methodology and apply it in their respective regions for subsequent ecosystem comparisons.

The model by Cukier, Kon, and Krueger (2015) was developed based on literature review and qualitative research conducted in two ecosystems: Tel Aviv and São Paulo. To develop the methodology, they employed two different techniques: a multiple case study involving 80 semi-structured interviews with key actors (entrepreneurs, investors, educators, etc.) and a focus group conducted with experts in the city of São Paulo. Utilizing Grounded Theory, they identified the key factors contributing to the emergence of a successful ecosystem. After constructing each factor and generating the leaderboard, they input data from the Tel Aviv and São Paulo ecosystems and, with the assistance of experts in each ecosystem, applied the model.

The primary objective of the model, when measuring maturity, is to identify gaps and propose personalized actions leading to tangible improvements in existing ecosystems, thereby advancing them to the next level of development. The model presents indicators, as illustrated in

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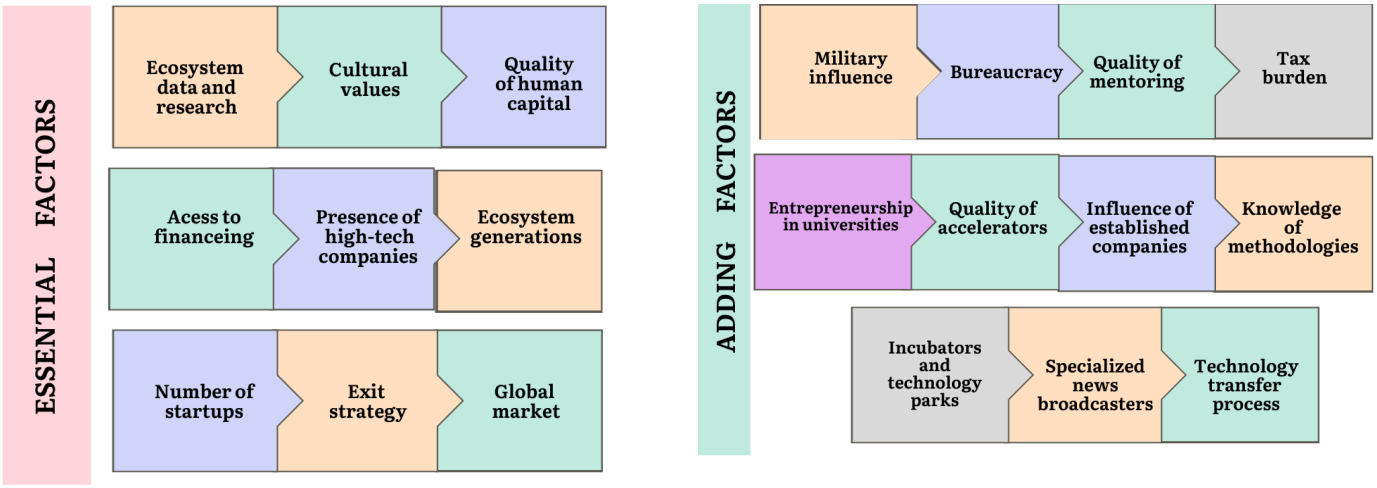
Figure 1, with metrics and scales divided into Essential Factors: number of startups, exit strategy, global market, access to financing, presence of high-tech companies, ecosystem generations, ecosystem data and research, cultural values, and quality of human capital.

Figure 1
Factors



Note. The model is composed of essential factors and summing factors. Source: adapted from Cukier, D., Kon, F., & Krueger, N. (2015). Towards a maturity model for software startup ecosystems. Department of Computer Science-University of São Paulo Technical Report RT-MAC. https://ccsl.ime.usp.br/startups/assets/profes2015short.pdf

Additionally, Adding Factors include military influence, entrepreneurship in universities, access to financing (business), bureaucracy, quality of mentoring, tax burden, incubators and technology parks, quality of accelerators, influence of established companies, technology transfer process, knowledge of methodologies, and specialized news broadcasters (Cukier, Kon, & Krueger, 2015). Each factor has a corresponding score so that, ultimately, it results in a classification distributed into four maturity levels divided into: Nascent, Evolving, Mature and Self - Sustainable.

This distinction is important because measuring maturity at the regional level allows to identify which regions are lagging behind or have potential to be explored, thus enabling more efficient public policy targeting. Examples of this are Silicon Valley and Detroit in the United States. While the first has become a benchmark for global innovation, the second has experienced decline with visible losses in both its innovative capacity and its ability to transform itself into a new innovation hub (Garcia, Serra, Mascarini, & Macedo, 2022).

DIAGNOSIS OF THE PROBLEM SITUATION

The proposal of the Cukier, Kon, and Krueger (2015) model is that essential factors and summing factors can gather information about the innovation ecosystem and classify it according to its maturity. However, the model has limitations. The problem situation identified in the model was that it does not allow monitoring the evolution of each ecosystem and does not allow comparison between ecosystem regions. Although it favors comparability between countries, it does not allow capturing the different realities that innovation ecosystems present within the same country.

The factors responsible for regions' innovation capabilities are the subject of studies in Regional Innovation Systems. This approach derives from National Innovation Systems of Lundvall (1992). Regional Innovation Systems recognizes that innovation dynamics are influenced by regional factors such as geographic proximity, local institutions, culture and networks, formal and informal institutions, knowledge flows, interactive learning capacity, regional incentive policies, among others (Asheim & Gertler, 2005).

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There are significant differences between regions in terms of productive structure, innovation capacity, competitiveness, and economic growth which significantly impacts both the standard of living of their populations and social cohesion. Therefore, regional innovation policies must take into account the specific conditions of each region so that the mechanisms created by policies to promote the development of their knowledge generation and exploitation capacity are truly effective (Garcia, Serra, Mascarini, & Macedo, 2022).

A diagnosis was carried out to better understand the problem situation. First, the description of each factor was presented in Table 1.

Table 1

Factors

Factors	Description
Global Market	Percentage of companies operating in markets outside the country, with existing consumers or at least one official representative office.
Entrepreneurship in universities	Percentage of students who founded a startup within 5 years of graduation.
Number of startups	Number of startups founded.
Access to financing	Total investment volume and number of trades.
Quality of mentoring	Percentage of mentors who had a successful startup in the past or founded and worked for more than 10 years in one or more startups.
Bureaucracy	Based on the government bureaucracy inefficiency index from the Global competitiveness report, it represents the percentage of respondents who consider bureaucracy to be a problematic factor in doing business.
Tax Burden	Position in the country's total tax rate ranking presented in the Global Competitiveness Report.
Incubators /Technology Parks	Number of incubators, innovation centers and technology parks active in the Ecosystem.
Quality of accelerators	Percentage of startups in accelerators that have reached the stage of receiving "next level investment" or reached the global market at a sustainable profitable stage.
Presence of High Technology companies	Number of high-technology companies with R&D centers (Technology Teams – Tech Team) located in the Ecosystem region.
Influence of established companies	Number of large companies with activities in which they collaborate with the activation, evolution and maturation of the Ecosystem (organizing events, local community mentors and ambassadors, acceleration programs or local investment in startups).
Quality of human capital	Ecosystem position in the talent index of the Global Startup Ecosystem Report.
Cultural values for entrepreneurship	Position of the "cultural support" index of the Global Entrepreneurship and Development Index.
Technology transfer process	Based on the innovation and sophistication factors of the Global Competitiveness Report.
Knowledge of methodologies	Percentage of startups that have knowledge or are trained in recognized methodologies (Learn Startup, Business Model, Design Thinking).
Specialized news providers	Local media specializing in the startup industry.
Ecosystem research and data	Existence of Ecosystem databases
Generations of Ecosystem Entrepreneurs	Generations of ecosystem entrepreneurs are reinvesting in it.
Exit Strategy	Startup exit strategy
Military influence	Existence of military participation

Note. The model is composed of essential factors and summing factors. Source: adapted from Cukier, D., Kon, F., & Krueger, N. (2015). Towards a maturity model for software startup ecosystems. Department of Computer Science-University of São Paulo Technical Report RT-MAC. https://ccsl.ime.usp.br/startups/assets/profes-2015short.pdf

At the same time, an analysis of its applicability was conducted to assess its ability to generate results aligned with the objective proposed by the model. It was analyzed that factors such as Bureaucracy, Tax Burden, Quality of Human Capital, Cultural Values, and Technology Transfer have metrics based on global indicators, as illustrated in Figure 2. This limitation restricts the perception regarding the evolution and comparison between ecosystems in the same country since they share the same indicators, and their evolution depends on the progress of the country rather than self-adjustment or alignment at the regional or state level.

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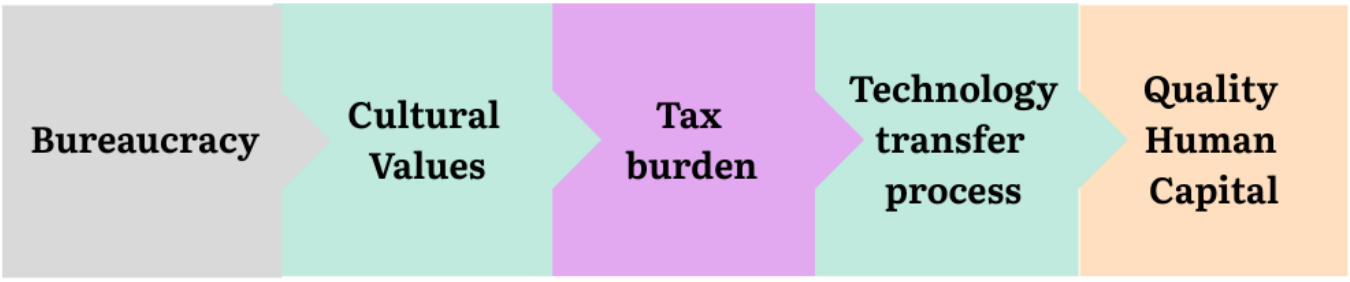
Figure 2
Metrics based on global indicators



Other points analyzed, such as the sample selected to apply the model considering only startups, the data collection technique using only questionnaires, and the metric used to classify the number of startups, contribute to the limitation of the model, as detailed below:

Factors indexed by global indicators: When analyzing these factors, two problems stood out. The first concerns comparability between regions or cities. Since there is uniformity for locations within the same country, there will be no differentiation (or weighting) of these factors when comparing regions or cities. The second issue relates to the classification itself. Due to the scoring of these global indicators, ecosystems located in the same country, such as Brazil, will always correspond to the Nascent and Evolving levels, regardless of the efforts and initiatives of each region. In other words, these ecosystems will only have a chance of being classified as Mature or Sustainable if there is any change in the global indicator.

Sample: The sample proposed by the model consists only of startups and does not consider the analysis of the ecosystem as a whole (companies, academia, government, society), potentially introducing interpretation biases by focusing only on one actor in the innovation ecosystem. It is worth noting that Innovation Ecosystems are characterized by the collaborative creation of value, comprising interconnected and interdependent network actors who collectively drive innovation, including companies, educational institutions, government, and society.

Data collection: The model presents specific questions for startups and cannot be applied to other actors in the ecosystem. Consequently, the collected data will only partially capture the issues surrounding an innovation ecosystem.

Number of startups factor: The metric for the number of startups differs from the national reality. The model classifies as the first level Nascent those ecosystems that have up to 500 startups (Nascent < 500 > In evolution). These numbers represent very high values when considering the reality of many places, especially in Brazil. For instance, Florianópolis, the capital with the highest density of startups per inhabitant in Brazil, according to Fonseca (2021), does not reach the mark of 500 startups. It has 404 registered startups (Abstartup, 2022). Moreover, using absolute numbers does not provide a parameter for comparison with other ecosystems and does not contextualize what this number represents for the region in terms of demographic density, for example.

ANALYSIS OF THE PROBLEM SITUATION AND RECOMMENDATION PROPOSALS

As a result of diagnosing the problem situation and analyzing the Cukier, Kon, and Krueger Model (2015), it is apparent that although it can be applied to compare countries, it does not meet the objective of monitoring the evolution of each ecosystem and does not allow for comparison between ecosystems located within the same country. The proposed improvements are summarized in Table 2 which includes adaptations to the model to address the critical points identified in the problem situation.

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Table 2
Analysis of the problem situation

Critical points	Improvements/Solutions
Sample	Expansion of the sample to other actors in the innovation ecosystem (academia, government, companies and society)
Data collect	Use of other data collection techniques such as interviews and access to secondary data.
Factor Number of startups	Consider the percentage of startups per number of inhabitants of the ecosystem under analysis.
Factors indexed by global indicators – Bureaucracy	Consider the number of facilitating programs for opening companies present in the ecosystem.
Factors indexed by global indicators - Tax burden	Observe Innovation Laws with incentives to reduce taxes for companies with innovative projects implemented in the ecosystem.
Factors indexed by global indicators - Quality of human capital	Describe the number of research programs such as master's and doctoral programs present in the ecosystem.
Factors indexed by global indicators - Cultural values for entrepreneurship	Analyze the presence of programs aimed at entrepreneurship and innovation implemented in the ecosystem.
Factors indexed by global indicators - Technology transfer process	Describe the number of ecosystem patent applications

Note. Analysis of the problem situation with the inclusion of improvement proposals in the identified critical points.

Regarding the sample, it is essential to recognize that an innovation ecosystem comprises interdependent actors and entities that foster entrepreneurship and innovation. According to Stam and Van de Ven (2021), much research on ecosystems overlooks aspects related to the connections between different actors and the significance of each in the ecosystem. Hence, it is crucial to expand the sample to include other actors in the innovation ecosystem, such as educational institutions, government bodies, companies, and society. This expansion will enable a more comprehensive understanding of the ecosystem as a whole. Additionally, it is important to diversify data collection techniques by including secondary data obtained from government websites, educational institutions, and other associations focused on innovation. Employing other data collection methods, such as interviews with ecosystem actors, can further enhance the analysis by capturing points that may not be adequately addressed in questionnaires targeting startups.

When considering the number of startups, it is vital to understand what this figure signifies for the ecosystem. One approach to contextualize this information is to calculate the percentage of startups per capita. This indicator facilitates comparisons with benchmarks and allows for comparisons among the municipalities comprising the ecosystem. Such data, when analyzed alongside other metrics, can serve as a foundation for seeking incentives and improvements in the realms of entrepreneurship and regional innovation.

Analyzing additional data not indexed by global indicators can provide a more accurate portrayal of the ecosystem's reality. While global indices offer insights into the overall context, they do not reflect values subject to change through initiatives originating within the ecosystem itself.

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For instance, when assessing bureaucracy, which is often a hindrance to business operations, particularly for new ventures, it is essential to consider the number of programs developed by public policies aimed at streamlining the business registration process. This information can be sourced from municipal government websites within the ecosystem under examination.

The tax burden, representing the tax rates levied, plays a crucial role in analyzing the flow of financial resources from society to the state. High tax burdens can deter company growth, and the absence of incentive policies supporting businesses, particularly during the transition from small to medium-sized enterprises, can stifle growth prospects (CRCGO, 2020). One method of gauging the tax burden of a region would be to evaluate innovation laws designed to incentivize tax reductions for companies undertaking innovative projects, as implemented within the ecosystem.

The quality of human capital serves as an indicator of the ecosystem's current or potential talent pool. One approach is to assess the number of research programs available in the ecosystem, such as master's and doctoral programs, which can indicate the region's intellectual capital. According to Peres, Bencke, and Lazarotti (2021), educational institutions, through their research and extension programs, play a pivotal role in fostering collaboration and driving local community initiatives. Additionally, innovation spaces and companies contribute to scientific and technological curiosity within the region, thereby supporting local development.

Cultural values for entrepreneurship evaluate innovative potential and mechanisms aimed at fostering policies and practices to encourage entrepreneurs and other innovators. One method to analyze this factor is to examine the presence of programs dedicated to promoting entrepreneurship and innovation implemented within the ecosystem. This information can be sourced from government websites or gathered through interviews with government representatives.

The technology transfer process facilitates the conversion of knowledge into products and services, with the protection of intellectual property serving as the initial step. Therefore, measuring this factor would entail describing the annual number of patent applications, which provides insights into the region's innovation capacity and the potential for fostering a culture of innovation. This data can be accessed through the country's patent website, filtered by the desired city or region.

Many governments adopt a mistaken approach to building the innovation ecosystem by pursuing unattainable goals as a consequence of looking at environments that are completely different from their own (Isenberg, 2011). Applying global indices to specific territorial contexts without understanding the particularities of the innovation process leads to misunderstandings that impede progress in implementing policies that encompass the challenges and opportunities currently facing Brazilian society and the economy. Universal innovation models often reflect paradigms of advanced economies and prioritize dimensions poorly representative of peripheral, informal, or culturally and socially based ecosystems (Cassiolato & Lastres, 2014).

Recognizing that ecosystems in general, especially nascent ones, require a clear vision of how to develop their community in order to plan actionable steps aimed at evolving into a fruitful and sustainable ecosystem (Cukier, Kon, & Krueger, 2015). Figure 3 highlights the new model proposed "Model for Measuring Regional and Global Maturity of Innovation Ecosystems" with the recommended improvements and their corresponding measurement methods.

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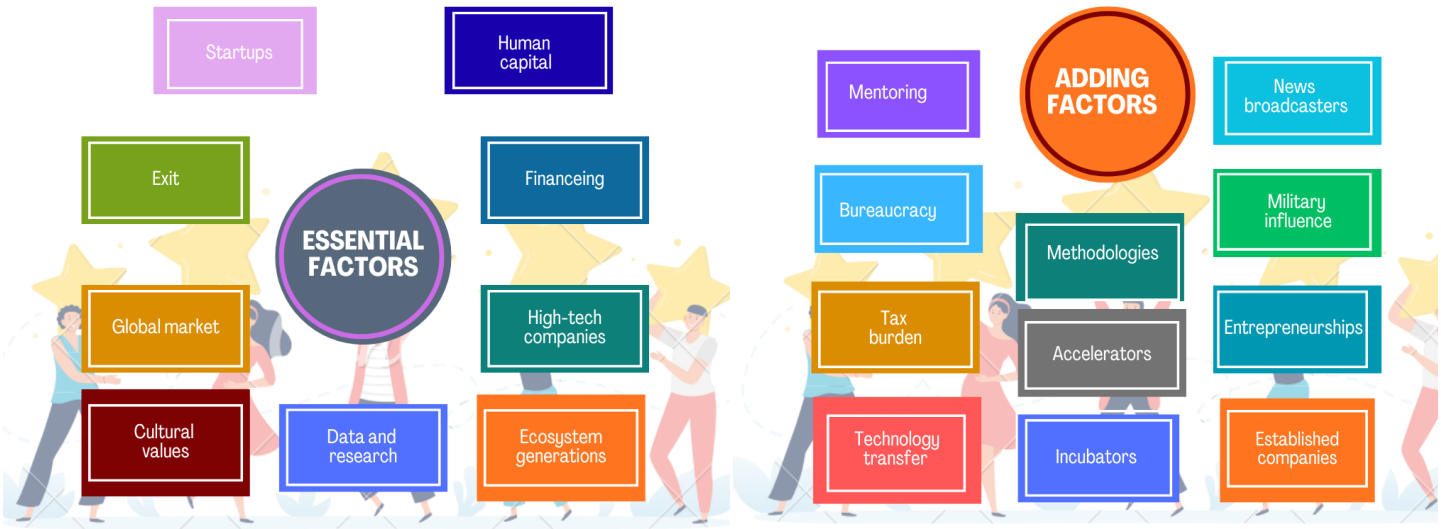
Figure 3

Model for Measuring Regional and Global Maturity of Innovation Ecosystems



Model for Measuring Regional and Global Maturity of Innovation Ecosystems

Essentials	**Factors**			
Factor	**Description for Regional Maturity**	**Score**	**Description for Global Maturity**	**Score**
Global Market	Percentage of companies operating in markets outside the country, with existing consumers or at least one official representative office	**L1** < 10% **L2** 10 - 50% **L3** > 50%	Percentage of companies operating in markets outside the country, with existing consumers or at least one official representative office	**L1** < 10% **L2** 10 - 50% **L3** > 50%
Startup	Density of startups per number of inhabitants = number of startups per 100K inhabitants (n°startups/n°hab *100.000)	**L1** < 20 **L2**= 20-50 **L3** > 50	Number of startups founded.	**L1** >500 **L2** = 500 -3k **L3** >3K
Financing	Total investment volume and number of trades (USD/year)	**L1** = 200M **L2** = 200M - 1B **L3** >1B	Total investment volume and number of trades (USD/year)	**L1** = 200M **L2** = 200M - 1B **L3** >1B
High Technology companies	Number of high-technology companies with R&D centers (Technology Teams – Tech Team) located in the Ecosystem region.	**L1** <10 **L2** = 10-50 **L3** >50	Number of high-technology companies with R&D centers (Technology Teams – Tech Team) located in the Ecosystem region.	**L1** <10 **L2** = 10-50 **L3** >50
Human capital	Number of research programs such as master's and doctoral programs present in the ecosystem	**L1** <10 **L2** = 10-50 **L3** >50	Ecosystem position in the talent index of the Global Startup Ecosystem Report.	**L1**>20 **L2**=15-20 **L3**<15
Cultural values	Presence of programs aimed at entrepreneurship and innovation implemented in the ecosystem.	**L1** <10 **L2** = 10-50 **L3** >50	Position of the "cultural support" index of the Global Entrepreneurship and Development Index.	**L1**<0,5 **L2**=0,5-0,75 **L3**>0,75
Research and data	Existence of Ecosystem databases	**L1**=available **L2**=partially available **L3**>=unavailable	Existence of Ecosystem databases	**L1**=available **L2**=partially available **L3**>=unavailable
Ecosystem Entrepreneurs	Generations of ecosystem entrepreneurs are reinvesting in it.	**L1**=0 **L2**=1 **L3**>=2	Generations of ecosystem entrepreneurs are reinvesting in it.	**L1**=0 **L2**=1 **L3**>=2
Exit	Startup exit strategy	**L1**=0 **L2**=1 **L3**>=2	Startup exit strategy	**L1**=0 **L2**=1 **L3**>=2

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Adding	**Factors**			
Factor	**Description for Regional Maturity**	**Score**	**Description for Global Maturity**	**Score**
Entrepreneurship in universities	Percentage of students who founded a startup within 5 years of graduation.	**L1**<2% **L2**=2-10% **L3**>10%	Percentage of students who founded a startup within 5 years of graduation.	**L1**<2% **L2**=2-10% **L3**>10%
Mentoring	Percentage of mentors who had a successful startup in the past or founded and worked for more than 10 years in one or more startups.	**L1**<10% **L2**=10-50% **L3**>50%	Percentage of mentors who had a successful startup in the past or founded and worked for more than 10 years in one or more startups.	**L1**<10% **L2**=10-50% **L3**>50%
Bureaucracy	Number of facilitating programs for opening companies present in the ecosystem	**L1** <1 **L2** = 1-5 **L3** >5	Based on the government bureaucracy inefficiency index from the Global competitiveness report, it represents the percentage of respondents who consider bureaucracy to be a problematic factor in doing business.	**L1**<40% **L2**=10-40% **L3**>10%
Tax Burden	Innovation Laws with incentives to reduce taxes for companies with innovative projects implemented in the ecosystem	**L1** <0 **L2** = 1 **L3** >2	Position in the country's total tax rate ranking presented in the Global Competitiveness Report.	**L1**>50% **L2**=30-50% **L3**<30%
Incubators /Technology Parks	Number of incubators, innovation centers and technology parks active in the Ecosystem.	**L1**=2 **L2**=2-10 **L3**>10	Number of incubators, innovation centers and technology parks active in the Ecosystem.	**L1**=2 **L2**=2-10 **L3**>10
Accelerators	Percentage of startups in accelerators that have reached the stage of receiving "next level investment" or reached the global market at a sustainable profitable stage.	**L1** <10% **L2**=10-50% **L3**>50%	Percentage of startups in accelerators that have reached the stage of receiving "next level investment" or reached the global market at a sustainable profitable stage.	**L1** <10% **L2**=10-50% **L3**>50%
Established companies	Number of large companies with activities in which they collaborate with the activation, evolution and maturation of the Ecosystem. Activities such as organizing events, local community mentors and ambassadors, acceleration programs or local investment in startups.	**L1** <20 **L2**=20-80 **L3**>80	Number of large companies with activities in which they collaborate with the activation, evolution and maturation of the Ecosystem. Activities such as organizing events, local community mentors and ambassadors, acceleration programs or local investment in startups.	**L1** <20 **L2**=20-80 **L3**>80
Technology transfer	Number of ecosystem patent applications per number of inhabitants = = number patent applications per 100K inhabitants (n°patent/n°hab *100.000)	**L1** <20 **L2**=20-40 **L3**>50	Based on the innovation and sophistication factors of the Global Competitiveness Report.	**L1** <4,0 **L2**=4,0-5,0 **L3**>5,0
Methodologies	Percentage of startups that have knowledge or are trained in recognized methodologies (Learn Startup, Business Model, Design Thinking).	**L1** <20% **L2**=20-60% **L3**>60%	Percentage of startups that have knowledge or are trained in recognized methodologies (Learn Startup, Business Model, Design Thinking).	**L1** <20% **L2**=20-60% **L3**>60%
Specialized news providers	Local media specializing in the startup industry. Specialty publishers must be recognized by the local community as a reference to be considered for this list.	**L1** <3 **L2**=3-5 **L3**>5	Local media specializing in the startup industry. Specialty publishers must be recognized by the local community as a reference to be considered for this list.	**L1** <3 **L2**=3-5 **L3**>5
Military influence	Existence of military participation	**L1**<10% **L2**=10-50% **L3**>50%	Existence of military participation	**L1**<10% **L2**=10-50% **L3**>50%
Level 1 - Nascent: factors must have ratings less than or equal to the Level 1 indicators.				
Level 2 - Evolving: all essential factors must be rated at least Level 2 and 30% of the summing factors must be at Level 2.				
Level 3 - Mature: all essential factors must be rated at least Level 2, 50% of the summing factors must be at Level 2, and at least 30% of all factors must be at Level 3.				
Level 4 - Self-sustaining: all essential factors must be rated at Level 3 and 80% of the summing factors must also be at Level 3				

Maturity	**Levels**
Nascent	Ecosystem is already recognized as a startup hub, with some existing startups, some investment agreements, and perhaps government initiatives to stimulate or accelerate the development of the ecosystem, but without significant results in terms of job creation or global penetration."
Evolving	When the ecosystem has few successful companies, some regional impact, job creation with low local economic impact
Mature	Ecosystems with hundreds of startups with a considerable number of investment deals, successful startups with global impact, and a first generation of successful entrepreneurs who have begun to help the ecosystem grow and become self-sustainable.
Self-Sustaining	Ecosystems with thousands of startups and investment agreements, at least a second generation of entrepreneurial mentors, especially angel investors, a strong network of successful entrepreneurs committed to long-term ecosystem maintenance, an inclusive environment with many events, startups, and the presence of high-quality technical talent.

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After analyzing the critical points of the Cukier, Kon, and Krueger Model (2015) and incorporating the proposed improvements/solutions along with new steps to address these adjustment recommendations, the model was reapplied to assess its practicality. The chosen region was Foz do Rio Itajaí, located in the state of Santa Catarina and comprised of eleven municipalities: Camboriú, Balneário Camboriú, Itajaí, Porto Belo, Bombinhas, Itapema, Luiz Alves, Ilhota, Penha, Balneário Piçarras, and Navegantes. The selection of the Foz do Rio Itajaí region is justified due to its diversified economy, particularly its emphasis on tourism, civil construction, nautical, and naval sectors, all of which contribute to fostering innovation in the state of Santa Catarina.

The methodology used to verify the model was documentary analysis based on secondary data (bibliographic research, searches on official websites, and indicators). The model was applied using a mixed approach. Qualitative data were collected through 28 interviews with managers of startups, traditional companies, educational institutions, and government representatives. This information was coded, categorized, and analyzed using content analysis. This technique was important for understanding how the data fit into the model's indicators.

In the quantitative phase, the questionnaires (appendix) were developed based on the literature on entrepreneurship and innovation, combined with the model by Cukier, Kon, and Krueger (2015). Initially, the questionnaires were administered to experts in the field of innovation and entrepreneurship, where the questions were evaluated, analyzed, and appropriate modifications were made for validation. Subsequently, they were administered to a small number of startups for pre-testing, and if no modifications were found, the questionnaire was applied to the initial sample of 55 startups managers. To select the sample, a search was conducted in the databases available in the ecosystem (universities and city halls) and on the Abstartup website. The total number of questionnaires analyzed was 29, after screening the responses received and excluding deactivated startups. The remaining data were secondary data collected from government websites, educational institutions, and other innovation-focused associations. After collection, the data were entered into the model to identify the maturity level.

The results confirmed the applicability of the new model. The table with the scores of the model application before and after the adaptations were made was included in the appendix. Although the maturity level remains at 1 (nascent), the structured model allows for a more accurate understanding of each of the analyzed items. In the case of the Foz do Rio Itajaí region, it is not only possible to compare these results with other regions, but also to compare the indicators for each municipality and thus direct public policies more assertively. Expanding the sample to include other actors in the innovation ecosystem (academia, government, companies, and society) was important because it enabled a deeper understanding of the reality of the region under investigation. Likewise, the model can be applied to any other city, region, or state.

Indexing the number of startups per municipality's inhabitants, it was possible to not only obtain density data but also compare it with benchmarks and other municipalities within the ecosystem. It was observed that two cities, Balneário Camboriú and Itajaí, stood out in terms of the number of startups. These findings, when analyzed alongside other data points, can serve as a foundation for seeking incentives and improvements in the areas of entrepreneurship and innovation within these municipalities. The startup density indicator per 100,000 inhabitants was 45, resulting in Level 2, instead of Level 1 (<500 startups) in the previous model. Having an indicator closer to the reality of each location facilitates a more equitable comparison.

Previously classified as Level 2 when measured by the Government Bureaucracy Inefficiency Index from the Global Competitiveness Report (Brazil = 11.9). Since this indicator applies equally to all Brazilian states, regional comparisons are not possible.Bureaucracy indicator measuring the number of facilitating programs for opening companies present in the ecosystem shows that the region is classified at level 3. It was observed that 82% of municipalities have incentive programs that facilitate the opening of new businesses for micro-entrepreneurs, and 73% of municipalities have programs to encourage innovation

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and entrepreneurship. While this is a positive result for the ecosystem, the analysis of this factor enabled the mapping of municipalities that are still slow in opening new businesses.

Regarding the tax burden in the Global Startup Ecosystem Report's Talent Index, Brazil is ranked at Level 2 (model). Because it's a general indicator, it doesn't reflect the specificities of each region. With the revised indicator, the region shows few laws to encourage innovation with only 9% of its municipalities having innovation laws. This indicates a weakness in the ecosystem, as the absence of tax incentives may lead many startups and technology-based companies to choose to establish themselves in other locations that offer tax reduction incentives for innovative companies.

Finally, the application of the new model allowed for a deeper understanding of the ecosystem of the Foz do Rio Itajaí region and, importantly, the mapping of the particularities that constitute the ecosystem as a whole. Although the final result remains at the Nascent level, in this new format, it is easier to understand existing gaps and provide insights to plan initiatives and actions that must be implemented to reach the next level. Based on the results presented here, it is possible to highlight the benefits generated by the alternatives suggested for resolving the problem scenario and that could result from the application of the new model, such as:

- Developing policies to encourage entrepreneurship and innovation (Innovation Law) in all municipalities;
- Implementing a training program for public leaders on entrepreneurship policies to streamline business start-up processes;
- Engage communication channels and news outlets with innovation and entrepreneurship topics;
- Develop human capital through training initiatives and;
- Involve municipalities, business associations, companies, and universities in fostering an innovation-friendly environment through programs and events focused on innovation and entrepreneurship.

The results of this research, adapting a model for regional innovation measurement, align with the structure of important international indicators such as the European Commission's Regional Innovation Scoreboard (RIS). RIS is the regional extension of the European Innovation Scoreboard (EIS), which provides national-level insights across 241 European regions. Regions are crucial drivers of economic development, and measuring innovation performance at the regional level has become increasingly important. RIS uses EIS indicators or their proxy indicators, for which regional data are available, and provides a comparative assessment of the performance of innovation systems across regions (Regional Innovation Scoreboard, 2025).

The use of regional innovation indicators is confirmed for Silva, Pires, and Teles (2021), who investigated the models that best explain innovative employment and the emergence of new markets in European regions. For this purpose, the 2019 Regional Innovation Scoreboard dataset was used. The results reveal the "dual role" that some variables play in regional innovation, highlighting the difficulties of managing different trade-offs and developing a self-contained innovation policy strategy.

Also using data from the Regional Innovation Scoreboard 2021 (RIS 2021), Lima (2024) investigated the innovation processes and R&D investment of European companies, exploring their regional innovation systems. Their results suggest that R&D investment by both companies and universities and research institutes is crucial for the growth and development of regional innovation systems. Furthermore, moderate interaction between local producers and users of knowledge proves most appropriate for optimizing the creation of regional innovation systems.

Brazil has very significant regional inequalities in income, infrastructure, education, connectivity, and technological capacity. These differences are also reflected in the development of innovation ecosystems. Although there are well-developed ecosystems, such as those in São Paulo, Minas Gerais, Santa Catarina, Paraná, and Pernambuco, a large portion of regions still have little or no innovation development. The results of this study favor the measurement of these di-

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fferences, allowing public policies to be targeted more assertively. Identifying differences in maturity between regions allows policymakers to gain a clearer understanding and thus create public policies that reduce disparities. For example, innovation initiatives such as research programs and accelerators, which work well in highly mature regions, may not work in regions in their early stages.

CONCLUSIONS AND TECHNOLOGICAL/SOCIAL CONTRIBUTION

The objective of this study was to propose improvements to the Startup Ecosystem Maturity Measurement Model by Cukier, Kon, and Krueger (2015) to allow for the comparison of ecosystem developments within regions of the same country. As a result, the model, with the proposed improvements, filled the gap identified in the problem scenario. First, it allowed for the comparison of different realities within the same country. Second, it facilitated the self-analysis of each ecosystem to identify existing gaps that could be addressed collaboratively with ecosystem stakeholders to achieve improvements and advance to the next level of maturity.

As a practical and social contribution, the application of the model and its adjustments provided a consolidated information base and a reference point for measuring innovation ecosystems. In terms of economic, environmental, and public policy impacts, the results of this research aim to portray the current situation, enabling the design of improvement actions based on this panorama, in order to contribute to the economic, social, and environmental development of the region. Thus, the article contributes to knowledge by proposing improvements to the model and presenting results related to innovation in the field of Administration and related fields. The practical results and the methodology applied in this project can serve as a basis for further studies and generate new insights that contribute to scientific advancement, knowledge dissemination, and relevant academic research. Furthermore, a future research agenda is proposed:

- Develop maturity indices or models that allow for hierarchical ranking of scales to capture local dynamics and make consistent aggregations.

- Conduct national and international comparative studies to calibrate dimension weights in the model, observing which factors explain the greatest portion of the performance variation between regions.

- Include analyses of historical evolution to understand maturity not as a fixed state, but as a dynamic process.

- Examine how external networks (e.g., international connectivity, global value chains) bring regional advances, especially in developing countries, where such integrations can offset local weaknesses.

Measuring the maturity of innovation systems or ecosystems at different territorial scales is not only an analytical issue, but also a political one, as it serves as a basis for defining where resources will be invested, how balanced development will be articulated, and which regions are considered strategic. In Brazil, given its regional heterogeneity, this type of measurement is particularly relevant for formulating specific regional policies, preventing the worsening of inequalities, and promoting innovation.

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APÊNDICE

Mapping Form for Startups in the Regional Innovation Ecosystem

1. Registration Information

Name: Website: Contact Email: Source of Information:

2. Characteristics

Select the area of operation (industry, commerce, service):

( ) Aeronautical/Aerospace ( ) Agribusiness

( ) Architecture and Design ( ) Automotive

( ) Beauty/Well-being ( ) Biotechnology

( ) Food and Beverage ( ) Civil Construction ( ) Education

( ) Pharmaceutical

( ) Waste Management

( ) Raw Materials and Chemicals ( ) Fashion and Textile

( ) Media ( ) Health

( ) Services

( ) Tech: IT & Software

( ) Tech: Hardware & Equipment ( ) Tech: Mobile

( ) Telecommunications ( ) Retail

( ) Other

6. Which programs, initiatives, or entrepreneurship and innovation movements does it execute?

7. Which programs, initiatives, or entrepreneurship and innovation movements does it participate in?

8. Which entities of the ecosystem does it have connections, frequent interactions, or partnership/collaboration projects with?

9. Does it have equipment available for shared use or for providing services within the Regional Ecosystem? If yes, which ones?

10. What is your type of client?

( ) Businesses (B2B) ( ) Consumers (B2C) ( ) Government

11. Does your company have a global market? (already operates in markets outside the country, with existing consumers or at least an official representation office)

( ) Yes ( ) No

12. Does it have military (or national/international security) influence or interest in the technologies and products developed?

( ) Yes ( ) No

13. What is the expected or ideal exit strategy for the company? ( ) Profitable growth for the global market

( ) Acquisition by a large company ( ) Merger with another company

( ) Initial Public Offering (IPO)

14. Is your startup knowledgeable or trained in the following methodologies? ( ) Lean Startup ( ) Business Model

( ) Design Thinking ( ) Others. Which?

15. Was the company founded within 5 years of the founders' graduation?

- Year of foundation:
- Number of partners:
- Has it received investment?
- How many rounds?

- Amount invested (in BRL and USD):

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16. What is the revenue model applied in your company? ( ) Unit sale (Product)

( ) Direct sale

( ) Indirect sale (agents or representatives) ( ) Freemium

( ) Software as a Service (SaaS) ( ) Advertising revenue

( ) License per user

( ) License per product ( ) Success fee

( ) Man-hour

( ) Commission ( ) Markup

( ) Other. Which?

17. Additional Information Link to the entity's logo:

Address: City: Meso-region:

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Model for Measuring Regional and Global Maturity of Innovation Ecosystems

Essentials	**Factors**			
Factor	**Description for Regional Maturity**	**Score**	**Description for Global Maturity**	**Score**
Global Market	Percentage of companies operating in markets outside the country, with existing consumers or at least one official representative office	**L1** < 10% **L2** 10 - 50% **L3** > 50%	Percentage of companies operating in markets outside the country, with existing consumers or at least one official representative office	**L1** < 10% **L2** 10 - 50% **L3** > 50%
Startup	Density of startups per number of inhabitants = number of startups per 100K inhabitants (n°startups/n°hab *100.000)	**L1** < 20 **L2=** 20-50 **L3** > 50	Number of startups founded.	**L1** >500 **L2** = 500 -3k **L3** >3K
Financing	Total investment volume and number of trades (USD/year)	**L1** = 200M **L2** = 200M - 1B **L3** >1B	Total investment volume and number of trades (USD/year)	**L1** = 200M **L2** = 200M - 1B **L3** >1B
High Technology companies	Number of high-technology companies with R&D centers (Technology Teams – Tech Team) located in the Ecosystem region.	**L1** <10 **L2** = 10-50 **L3** >50	Number of high-technology companies with R&D centers (Technology Teams – Tech Team) located in the Ecosystem region.	**L1** <10 **L2** = 10-50 **L3** >50
Human capital	Number of research programs such as master's and doctoral programs present in the ecosystem	**L1** <10 **L2** = 10-50 **L3** >50	Ecosystem position in the talent index of the Global Startup Ecosystem Report.	**L1**>20 **L2**=15-20 **L3**<15
Cultural values	Presence of programs aimed at entrepreneurship and innovation implemented in the ecosystem.	**L1** <10 **L2** = 10-50 **L3** >50	Position of the "cultural support" index of the Global Entrepreneurship and Development Index.	**L1**<0,5 **L2**=0,5-0,75 **L3**>0,75
Research and data	Existence of Ecosystem databases	**L1**=available **L2**=partially available **L3**>=unavailable	Existence of Ecosystem databases	**L1**=available **L2**=partially available **L3**>=unavailable
Ecosystem Entrepreneurs	Generations of ecosystem entrepreneurs are reinvesting in it.	**L1**=0 **L2**=1 **L3**>=2	Generations of ecosystem entrepreneurs are reinvesting in it.	**L1**=0 **L2**=1 **L3**>=2
Exit	Startup exit strategy	**L1**=0 **L2**=1 **L3**>=2	Startup exit strategy	**L1**=0 **L2**=1 **L3**>=2
Adding	**Factors**			
Factor	**Description for Regional Maturity**	**Score**	**Description for Global Maturity**	**Score**
Entrepreneurship in universities	Percentage of students who founded a startup within 5 years of graduation.	**L1**<2% **L2**=2-10% **L3**>10%	Percentage of students who founded a startup within 5 years of graduation.	**L1**<2% **L2**=2-10% **L3**>10%