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KNOWLEDGE-INTENSIVE SUSTAINABLE ENTREPRENEURSHIP: an analysis of the ecosystem perspective and the concept

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Dissertation presented to the School of Applied Sciences of the University of Campinas as a partial requirement for obtaining the title of Doctor in Administration.

Tese apresentada à Faculdade de Ciências Aplicadas da Universidade Estadual de Campinas como parte dos requisitos exigidos para obtenção do título de Doutora em Administração.

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THIS DIGITAL FILE CORRESPONDS TO THE FINAL VERSION OF THE DISSERTATION DEFENDED BY THE STUDENT ÉRICA HEVELLIN DA SILVA SIQUEIRA, AND ADVISED BY THE PROFESSOR DR. ADRIANA BIN AND DR. BRUNO BRANDÃO FISCHER.

ESTE EXEMPLAR CORRESPONDE À VERSÃO FINAL DA TESE DEFENDIDA PELA ALUNA ÉRICA HEVELLIN DA SILVA SIQUEIRA, E ORIENTADA PELA PROFª. DRA. ADRIANA BIN AND DR. BRUNO BRANDÃO FISCHER.

LIMEIRA
2024

Ficha catalográfica
Universidade Estadual de Campinas (UNICAMP)
Biblioteca da Faculdade de Ciências Aplicadas
Ana Luiza Clemente de Abreu Valério - CRB 8/10669

Si75k

Siqueira, Érica Hevellin da Silva, 1991-
Knowledge-intensive sustainable entrepreneurship : an analysis of the ecosystem perspective and the concept / Érica Hevellin da Silva Siqueira. – Limeira, SP : [s.n.], 2024.

Orientador: Adriana Bin.
Coorientador: Bruno Brandão Fischer.
Tese (doutorado) – Universidade Estadual de Campinas (UNICAMP), Faculdade de Ciências Aplicadas.

1. Ecossistema de empreendedorismo. 2. Sustentabilidade. 3. Empreendedorismo. I. Bin, Adriana, 1977-. II. Fischer, Bruno Brandão, 1983-. III. Universidade Estadual de Campinas (UNICAMP). Faculdade de Ciências Aplicadas. IV. Título.

Informações Complementares

Título em outro idioma: Empreendedorismo sustentável intensivo em conhecimento : uma análise do ecossistema e surgimento do conceito
Palavras-chave em inglês:
Entrepreneurship ecosystem
Sustainability
Entrepreneurship
Área de concentração: Gestão e Sustentabilidade
Titulação: Doutora em Administração
Banca examinadora:
Adriana Bin [Orientador]
Gustavo Hermínio Salati Marcondes de Moraes
Muriel de Oliveira Gavira
Edson Sadao Iizuka
Priscila Rezende da Costa
Data de defesa: 20-08-2024
Programa de Pós-Graduação: Administração

Identificação e informações acadêmicas do(a) aluno(a)
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- Currículo Lattes do autor: http://lattes.cnpq.br/0037962128286794

Folha de Aprovação

Autor(a): Érica Hevellin da Silva Siqueira
Título: Empreendedorismo Sustentável Intensivo em Conhecimento: uma análise do ecossistema e surgimento do conceito
Natureza: Tese
Área de Concentração: Empreendedorismo e Sustentabilidade
Instituição: Faculdade de Ciências Aplicadas – FCA/Unicamp
Data da Defesa: Limeira-SP, 20 de Agosto de 2024

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DEDICATION

To my loving family: my mother, Dora; my siblings, Akila and Samuel;
my husband, Marcelo; and my dog, Jake.

ACKNOWLEDGEMENTS

When I was young, I dreamed about this day, but I never thought I could really make it – and I did, thanks to a collective effort. For a girl who came from a simple, poor community, such a dream did not fit. Fortunately, God has blessed me and given me the opportunity to be in the right place at the right moment, so it is impossible not to start thanking the Lord for my life and surroundings. Throughout all these years of living in different states, my family has been my foundation and has supported me in all my choices. To my mother, whose invaluable support in all my decisions has made me grow independently, and to my sister and brother, who always receive me with love, laughter, and fun. The academic trajectory also brought me another person to be part of my family: my husband. Without your encouragement, support, and inspiration, this path would be more challenging… Thank you so much for believing in me and sharing your life as my partner. I cannot forget my dog and his countless attempts to make my research process lighter by offering me a toy to play with him. I am fully grateful for having you all by my side to share victories. Love you!

I am lucky to have special people helping me. I want to thank my friends whose friendship, kindness, joy, and wisdom guided my steps. Anne Rocha, not only as a lovely friend but also as coauthor; Igor Lobo, lifelong friend and firm support; Barbara Figliuolo, Bruna Guedes, and Eline Nepomuceno for connecting me with my roots; Juliane Lima and Maria Julia Boto, my adorable goddaughter, for our treasured laughs; Bia Sadalla and Carol Spatti, the sweetest friendship that master's gave me; Cintia Granja and our timeless conversations that always cheer me up; Matheus Dermonde, whose lightness enchanted me; and Silvia Lins, for being there for me since my first day in a new place. Special thanks to Brendon Zimmerman, Kenye Santos, and Fabio Gea for supporting me during my research application. I also acknowledge my therapist, Amélia Sineiro, my trainer, Luciana Ganzarolli, and my chiropractor, Tor Erik, for improving my mental and physical health – essential conditions to accomplish this dissertation.

Professors Adriana Bin and Bruno Fischer, there are not enough words to thank you! Having you as my guides during the Ph.D. made this process lighter and more creative. It was a pleasure to be advised by you and to have the chance to learn from you and your experiences. Thank you for being comprehensive and patient and bringing me to the light when I could not see the next steps.

I also thank the dissertation committee, namely Professors Edson Sadao, Gustavo Salati, Muriel Gavira, and Patrícia Rezende da Costa, whose generous comments helped me to refine this material. Special thanks to Professor Jill Kickul, who received me during my research period at the University of Southern California (USC); to all professors who shared my research with their students, especially Professors Cristiano Morini (Administration), Fabricia Zulin (Architecture), Nathan Shauer (Civil Engineering), Otávio Cabello (Administration), Paulo Albuquerque (Civil Engineering); and the people interviewed for this research.

Lastly, I want to thank myself for my resilience, dedication, and persistence in completing this cycle. It was challenging, but I am proud of the person I have become. And, for that young child, you did it!

This study was partially financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

EPIGRAPH

"O rio banha de luz
murmureja e vai seguindo
de porto em porto esculpindo
as margens do seu destino.

Destino de ser caminho
de ser barco e navegante
de ser leme e comandante
do seu próprio caminhar."

Celdo Braga

ABSTRACT

The entrepreneurial ecosystem concept emphasizes identifying the crucial components of such productive structures, the linkages among these dimensions, and their influence on the emergence and development of entrepreneurial ventures. Knowledge-Intensive Entrepreneurship (KIE) is embedded in this context; they are new organizations with a great amount of knowledge applied in their business, occurring in low-, medium- high-tech, and service sectors. KIE differs from non-KIE in the extent to which they use advanced levels of knowledge and innovation as a basis to compete in the market, representing a specific type of entrepreneurship. KIE also plays a consistent role in the sustainability achievement process once firms can support the development of new knowledge relevant to fulfilling socioenvironmental goals. This generates what this dissertation identifies as Knowledge-Intensive Sustainable Entrepreneurship (KISE), which follows KIE's basic assumptions and adds more layers. Socio-environmental issues are increasingly affecting the economic dimension of value creation, while knowledge-intensive activities can play a relevant role in addressing not only economic growth but also social and environmental concerns. Nevertheless, the theoretical background on the KISE Ecosystem still lacks some valuable acknowledgments. Therefore, this dissertation's main objective is to analyze the emergence of the Knowledge Intensive Sustainable Entrepreneurship concept through an ecosystem perspective. The research was developed through three articles. The first one analyzed the PIPE Program (Innovative Research in Small Business), funded by the São Paulo Research Foundation in Brazil (FAPESP), and indicated strong similarities in the ecosystem drivers of KIE and KISE. However, when disaggregating KISE into four domains (Cities, Health, Education, and Green Technologies), the ‘ecosystem readiness’ towards sustainable transitions varies from more mature (as in the case of HealthTechs with an inclusive orientation) to very incipient configurations (Cities and EdTechs). From a network patent and transfer agreements analysis and a qualitative case study at the University of Campinas (Unicamp, Brazil), the second article analyzed the process of sustainability institutionalization in an entrepreneurial university, considering the role of technology development and transfer. The primary outcomes suggest the need to integrate and coordinate strategies for sustainable processes through technology transfer. Sustainable patent technological development is primarily influenced by researchers and funded by public financing. Even with low levels of institutional engagement behind them, most licensing agreements come from sustainable patents. Finally, through an exploratory factor analysis, a Unicamp survey involving 485 students from business and hard sciences programs was applied in the third article. The results demonstrated a mismatch between the university context and sustainable entrepreneurial intentions. However, factors related to the university and student-university engagement highlighted positive significance. Students expressed heightened interest in flexible activities and maturing entrepreneurial intentions by interacting with complementary approaches (volunteering programs, community projects, student organizations, etc.). Overall, this dissertation argues that improving sustainable entrepreneurship with high levels of knowledge intensity requires bottom-up (i.e., cataloging what researchers, professors, staff, and students are already doing that effectively contributes to a positive change and boost them) and top-down (i.e., policy development, facilitating support mechanisms, partnerships, etc.) initiatives. Notably, all these endeavors will result in a sustainable culture that utilizes KISE's contributions to foster sustainable development – recognized as a vital asset for future generations.

Keywords: Entrepreneurial ecosystem; Entrepreneurial University; Sustainability; Sustainable Culture; Entrepreneurship; Sustainable ventures.

RESUMO

O conceito de ecossistema empreendedor enfatiza a identificação dos componentes cruciais dessa estrutura, as conexões entre as diversas dimensões existentes e sua influência no surgimento e desenvolvimento de negócios. O Empreendedorismo Intensivo em Conhecimento (KIE) está inserido neste contexto: são novas organizações com uma grande quantidade de conhecimento aplicado em seus empreendimentos, ocorrendo em setores de baixa e média-alta tecnologia e serviços. O KIE difere dos não-KIE na medida em que usam níveis avançados de conhecimento e inovação como base para competir no mercado, representando um tipo específico de empreendedorismo. O KIE também desempenha um papel consistente no processo alcance da sustentabilidade uma vez que essas organizações podem apoiar o desenvolvimento de conhecimentos relevantes para o cumprimento de metas socioambientais. Isso gera o que esta tese identifica como Empreendedorismo Sustentável Intensivo em Conhecimento (KISE) que segue as premissas básicas do KIE e adiciona a ela a camada da sustentabilidade. No entanto, o contexto teórico e empírico sobre o Ecossistema KISE ainda carece de discussões e refinamentos. Tendo em vista esse contexto, a tese tem como objetivo principal analisar o surgimento do conceito de Empreendedorismo Sustentável Intensivo em Conhecimento por meio de uma perspectiva ecossistêmica. A pesquisa foi construída a partir de três artigos. O primeiro fez uma análise do Programa de Pesquisa Inovativa em Pequenas Empresas (PIPE), financiado pela Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), e indicou fortes similaridades entre as características dos ecossistemas KIE e KISE. Contudo, ao desagregar o KISE em quatro domínios (Cidades, Saúde, Educação e Tecnologias Verdes), a "prontidão do ecossistema" para transições sustentáveis varia de mais madura (como no caso de HealthTechs com orientação inclusiva) a configurações muito incipientes (Cidades e EdTechs). A partir de uma análise de rede de patentes e acordos de transferência de tecnologia, além de estudo de caso qualitativo na Universidade Estadual de Campinas (Unicamp, Brasil), o segundo artigo analisou o processo de institucionalização da sustentabilidade em uma universidade empreendedora, considerando o papel do desenvolvimento e transferência de tecnologia. Os resultados sugerem a necessidade de integrar e coordenar estratégias para processos sustentáveis por meio da transferência de tecnologia. O desenvolvimento de patentes sustentáveis é realizado principalmente por pesquisadores via financiamento público. Mesmo com baixos níveis de engajamento institucional, a maioria dos acordos de licenciamento da Unicamp vem de patentes sustentáveis. O terceiro artigo usou de análise fatorial exploratória a partir de pesquisa envolvendo 485 alunos dos cursos de negócios e ciências exatas para demonstrar que há uma incompatibilidade entre o contexto universitário e as intenções empreendedoras sustentáveis. Mas, fatores relacionados à universidade e ao engajamento aluno-universidade destacaram significância positiva. Os alunos demonstraram maior interesse em atividades flexíveis ao interagir com abordagens complementares (programas de voluntariado, projetos comunitários, organizações estudantis, etc.). No geral, a tese argumenta que melhorar o empreendedorismo sustentável com altos níveis de intensidade em conhecimento requer iniciativas de baixo para cima (conhecer o que pesquisadores, professores, funcionários e alunos já estão fazendo que efetivamente contribui para uma mudança positiva e os impulsiona) e de cima para baixo (desenvolvimento de políticas, facilitação de mecanismos de suporte, parcerias, etc.). Notavelmente, esses esforços resultarão em uma cultura que utiliza as contribuições do KISE para promover o desenvolvimento sustentável – reconhecido como um vital para as gerações futuras.

Palavras-chave: Ecossistema empreendedor; Universidade empreendedora; Sustentabilidade; Cultura sustentável; Empreendedorismo; Negócios sustentáveis.

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LIST OF ACRONYMS AND ABBREVIATIONS

EE: Entrepreneurial Ecosystems

EU: Entrepreneurial University

FAPESP: The São Paulo Research Foundation

HEI: Higher Education Institution

IP: Intellectual Property

KIE: Knowledge-Intensive Entrepreneurship

KISE: Knowledge-Intensive Sustainable Entrepreneurship

KISEE: Knowledge-Intensive Sustainable Entrepreneurship Ecosystem

PIPE: Innovative Research in Small Business

SDG: Sustainable Development Goals

SEU: Sustainable Entrepreneurial University

SBIR: Small Business Innovation Research

TTO: Technology Transfer Officer

UNICAMP: University of Campinas

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INTRODUCTION[1]

Spiegel (2017, p. 2) defines entrepreneurial ecosystems (EE) as "combinations of social, political, economic, and cultural elements within a region that support the development and growth of innovative startups and encourage nascent entrepreneurs and other actors to take the risks of starting, funding, and otherwise assisting high-risk ventures." In this sense, entrepreneurial ecosystems are commonly understood by their main dimensions or pillars, including markets, human capital, human development and education, universities, support systems, culture, finance and investments, and infrastructure/policy (Isenberg, 2010; Alves et al., 2021). However, it seems clear that there is no single way but deep regularities among thriving ecosystems that lead to the need to consider "historical and contingent bottom-up organizing processes involved as well as the nature of conventions that organize and support initiatives" (Thompson et al., 2018, p. 113).

Knowledge-Intensive Entrepreneurship (KIE) is embedded in this context. It is acknowledged as the most important type of entrepreneurship in the current knowledge economy (Malerba & McKelvey, 2018). The conceptualization encompasses the relationships between the entrepreneur, the organization, knowledge, and the broader social and economic context considered here as the innovation system. Based on Schumpeter contributions, evolutionary economics theory and innovation systems approach, Malerba & McKelvey (2020, p. 508) assert that "knowledge-intensive innovative entrepreneurial firms are new learning organizations that use and transform existing knowledge and generate new knowledge to innovate within innovation systems". Summing up, KIE ventures are new organizations with a great amount of knowledge applied in their business (Malerba & McKelvey, 2020), occurring in low-, medium- high-tech, and service sectors (Gifford & McKelvey, 2019). KIE differs from non-KIE in the extent they use advanced levels of knowledge and innovation as a basis to compete in the market (Lassen et al., 2018), representing a specific type of entrepreneurship (McKelvey et al., 2020).

KIE also plays a consistent role in the sustainability achievement process once the firm's support "can be beneficial to develop new knowledge relevant to the fulfillment of specific sustainable development goals" (Gifford & McKelvey, 2019, p.1) by enabling

[1] This dissertation follows the theoretical complementarity of Sustainable, Social, and Green Entrepreneurship and uses academic literature from these fields interchangeably.

knowledge exchange across different organizational actors (Bertello et al., 2022). This generates what this dissertation identifies as Knowledge-Intensive Sustainable Entrepreneurship (KISE), which follows KIE's basic assumptions and adds more layers. Sustainable Entrepreneurship (SE) is strongly related to institutional voids and the confrontation of socio-economic problems, promotion of well-being, and regional and local development. This underlies the foundation of sustainable development concept, that is, “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations, 1987, p. 15). Given the growing attention to using technologies by sustainable ventures and the social efficiency of Knowledge-Intensive enterprises, KISE recognition seems to be a matter of urgent interest. How SE and KISE are supported and influenced by social, cultural, economic, and policy elements and by the interactions among these dimensions and different actors in a specific geographic area is still a question without a clear answer (Wurth et al., 2021; Kabbaj et al., 2016; Thompson et al., 2018; Thomsen et al., 2018; Bozhikin et al., 2019; Pathak & Mukherjee, 2020).

In addition to the EE function of supporting the creation and growth of new ventures that contribute to the growth of a nation or a region’s economy (Bhawe & Zahra, 2017), Knowledge-Intensive Sustainable Entrepreneurship Ecosystem (KISEE) also addresses social needs and environmental problems recognizing "the wider effects of entrepreneurship beyond narrow economic terms" (Wurth et al., 2021, p. 4). Nevertheless, leveraging resources (mainly financial, human, physical, and technological) is a relevant condition to the sustainability of sustainable ventures, which means the combination of financial and social performance (Guerrero et al., 2021). A KISEE provides fruitful opportunities for sustainability-oriented entrepreneurs, connecting them with a diversity of agents and valuable resources and supporting them to manage paradoxes in environmental, social, and economic spheres. According to Chaudhary et al. (2023, p. 13), “By identifying other relevant actors and their roles in achieving sustainability-related goals, we take a step forward in advancing scientific knowledge regarding the entrepreneurial ecosystem and the genesis of environmentally-friendly entrepreneurial ventures.”

A sustainable entrepreneurial ecosystem is distinguished from a conventional entrepreneurial ecosystem in some ways. Foremost, their networks are composed of a more diverse group of stakeholders to improve sustainable entrepreneurship performance, address unmet social needs, and create significant social change (Chaudhary et al., 2023;

Knudsen et al., 2021; Wagner et al., 2019; Pandey et al., 2017; Bozhikin et al., 2019; Znagui et al., 2019; Guerrero et al., 2020). Then, sustainable ventures are part of an institutional context of market-based capitalism that historically accommodated the rules and features of more traditional organizational forms and shaped access to resources and legitimacy. This presents them with more challenges than those faced by traditional organizational forms, which tend to fit relatively well within existing institutions (McMullen, 2018; Thompson et al., 2018; Villegas-Mateos & Vázquez-Maguirre, 2020). Nevertheless, even if one considers that sustainable companies have relative disadvantages in an operational sense, consumers/clients could still select and retain the business they believe will provide overall benefits and meet their needs (McMullen, 2018). Some contributions (Kabbaj et al., 2016; Purkayastha et al., 2020; Villegas-Mateos & Vázquez-Maguirre, 2020) that primarily focus on configurations of sustainable ecosystems in emerging economies sustain the view that actual configurations reflect an extension of conventional EE encompassing more institutions, actors and their interactions, and somehow different challenges. This larger group of institutions and actors comprehends, for instance, civil society, local communities, non-governmental organizations, multilateral agencies, and consultants in charge of social innovation methodologies, social and environmental indicators, and impact evaluation.

A distinguished KISE characteristic is its hybridization. KISE are companies formed by hybrid ventures pursuing different goals and not only financial ones (Saebi et al., 2019; Munõz & Cohen, 2018; Batillana, 2018), trying to solve a particular social and/or environmental issue (Neverauskiene & Pranskeviciute, 2021). Also known as sustainable development startups (van Rijnsoever, 2022), such enterprises blend elements from different organizational formats, creating a new and alternative one with the flexibility to absorb resources from a variety of funding types and practices from various management structures (Savarese et al., 2021; Park & Bae, 2020). They are ventures designed to solve a social or environmental problem using market strategies, meaning that profit is part of this conception. The entrepreneur in this type of company can identify a market opportunity and shape a proposal to answer it, creating a business that will positively impact society. An example of this type of venture is a company dedicated to improving education using artificial intelligence or an environmental venture focused on avoiding deforestation through online mapping. Thus, we define KISE hybrid ventures as market-oriented businesses that use significant knowledge focused on sustainable development. When incorporated in a commercial context, KISE ventures can achieve unique combinations of resources (Hermanson et al., 2018), different forms of interactions, partnerships, and co-creating of knowledge (Ghauri et al., 2022). Consequently, manifest positive externalities beyond economic development such as social impacts, societal well-being (Ibãnez et al., 2021; Mora et al., 2020; Fischer et al., 2018) and environmental value (Alsaleh et al., 2021; Vo-Thanh et al., 2021; Doherty & Kittipanya-Ngam, 2021).

Higher Education Institutions (HEIs) are often identified as a pivotal component of entrepreneurial ecosystems (Alves et al., 2021; Fischer et al., 2018; Guerrero & Urbano, 2012; Isenberg, 2010), being considered an integral piece within the dynamics of KISEE (Chaudhary et al., 2023; Nikolaou et al., 2023; Saha et al., 2022; Dibbern & Serafim, 2021; Leal-Filho et al., 2019). Known as an excellent environment for cultivating knowledge-intensive professionals (Malerba & McKelvey, 2019; Gifford & McKelvey, 2019), universities can engage in some actions such as courses and research on sustainability, as well as technological development, events, publications, and permanent support to students and alumni working on sustainable ventures through online crowdfunding and other sourcing platforms. Therefore, sustainability may provide an alternative for HEIs to better engage communities to solve social/environmental issues and simultaneously promote income generation (Eiselein et al., 2017).

Depending on the regional context, universities can improve sustainable entrepreneurial ecosystems through different configurations, pathways, and intervention points (Wagner et al., 2021), encompassing programs of energy saving, waste management, food services, campus improvements, and behavioral shaping that reach students directly and enables them to act sustainably (Dagliute, Liobikien, and Minelgaité, 2018). As proposed by Leal-Filho and colleagues (2019, p. 292), "providing staff development, support from top management and space in workloads to engage in different activities, could support the effective integration of the SDGs at an institutional level". This could also assist higher education institutions in enhancing their profile and potentially improving teaching, research, outreach, and knowledge exchange and transfer. Scholars have been acknowledged as active players in this emergent setting of social and environmental awareness once they facilitate and enable sustainability in the classroom (Alzoraiki et al., 2023; Carl, 2020; Leal-Filho et al., 2019; Wyness & Sterling, 2015). The sustainable development institutional approach requires a shift in perspective for faculty members, who must recognize the potential for their research and teaching endeavors to contribute to the advancement of knowledge and economic and social progress (Etzkowitz et al., 2021).

Universities can produce knowledge directly related to sustainability following an explicit strategic orientation or throughout their historical trajectory (Dibbern et al., 2023) — in this case, connecting to their third mission (Reymert & Thune, 2023; Compagnucci & Spigarelli, 2020). However, a shift to a new sustainable paradigm (Saha et al., 2022; Wagner et al., 2021) also implies changes not only in physical spaces but also in research, knowledge production, and technology transfer. According to Cai & Ahmad (2021), a Sustainable Entrepreneurial University (SEU) is based on the pluralism of knowledge production and co-creation, emphasizing partnership and collaboration among different agents. The research agenda is driven by sustainability issues to generate not only economic impact but also societal value. Thereby, universities can benefit from engaging in dialogue and collaboration with stakeholders to share knowledge about sustainable goals and simultaneously receive feedback to enhance institutional strategies that align with societal needs (Nikolaou et al., 2023). Knudsen, Frederiksen & and Goduscheit (2021, p. 210), assert that "the thickened perspective and the outside-in demand for solutions may stimulate the university to reconsider the nature and strengths of its technology transfer and commercialization capabilities," aspiring the need to rethink, for example, the Technology Transfer Officers (TTOs) due to the multidimensional nature of the societal and environmental responses.

A diverse range of actors is needed to address sustainability issues (Chaudhary et al., 2023; Knudsen, Frederiksen & Goduscheit, 2021; Wagner et al, 2019), but students hold a unique position as future leaders and decision-makers (Alfarizi & Herdiansyah, 2024; Jebsen et al., 2023; Aleixo, Leal & Azeiteiro, 2021). They are potential entrepreneurs (Peng et al., 2021) and can apply the knowledge acquired during the undergraduate process to solve local and global challenges, exploring their own values (Moon et al., 2018; Wyness & Sterling, 2015). Entrepreneurship engagement is not only recognized as a career option by many students (Liguori et al., 2020; Marshal & Gigliotti, 2020) but also as essential to sustainable development (Romero-Colmenares & Reyes-Rodríguez, 2022; Aleixo, Leal & Azeiteiro, 2021; Dagliute, Liobikien, and Minelgaité, 2018). This type is focused on the triple bottom line (Elkington, 1998) and aims to preserve nature, life support, and community through economic and non-economic returns (Shepherd & Patzelt, 2011). Audretsch, Belitski, and Guerrero (2023, p.1) assert that "the institutional quality and the sustainable orientation management of entrepreneurs both shape the productive and growth-oriented entrepreneurial activity necessary to reach the United Nations Sustainable Development Goals (SDGs)."

Motivations, values, and goals toward social, environmental, and economic returns are the main differences between sustainable and conventional entrepreneurs (Romero-Colmenares & Reyes-Rodríguez, 2022; Arru, 2020; Munõz e Cohen, 2018). The sustainability-oriented capacity may be stimulated by educational mechanisms enhancing pro-environmental attitudes to sensitize students (Jurdi et al., 2019; Dagliute, Liobikien, and Minelgaité, 2018), from previous social experience in solving sustainability problems (Hockerts, 2017), participatory and citizenship behaviors (Monavvarifard et al., 2019), and sustainable practice-oriented activities in partnership with private and public sectors (Leal-Filho et al., 2019). A combination of soft and hard skills offering an opportunity to take practical projects outside the traditional teaching formats are good strategies to improve students' sustainable skills (Franco et al., 2023). As individuals in the education process, students may access a variety of information and effectively contribute to sustainable development. This may not necessarily be translated into entrepreneurial intention, but it certainly improves their skills and worldview on how to deal with the challenges faced by society and how their knowledge abilities can support it.

Socio-environmental issues are increasingly affecting the economic dimension of value creation, while knowledge-intensive activities can play a relevant role in addressing not only economic growth but also social and environmental concerns (Bertello et al., 2022). Nevertheless, the theoretical background on the KISE Ecosystem still lacks some valuable acknowledgments. While there is fruitful literature on conventional entrepreneurship ecosystems (Fischer et al., 2022; Wurth et al., 2021; Bhawe & Zahra, 2017), little is known about knowledge-intensive sustainable ones. Scholars have advocated for more conscious research on how KIE can support sustainability transitions (Bertello et al., 2022; Gifford & McKelvey, 2019; Thompson et al., 2018; Thomsen et al., 2018), how knowledge and technology transfer occurs in sustainable entrepreneurial universities (Karahan, 2024; Chaudhary et al., 2023; Siqueira et al., 2023; Knudsen, Frederiksen & Goduscheit, et al., 2021), and what are students' behaviors, attitudes, and intentions towards sustainable entrepreneurship and how the universities affect it (Reuther et al., 2023; Jebsen et al., 2023; Dalvi-Esfahani et al., 2020; Thelken e Jong, 2020; Dagliute et al., 2018). Therefore, to answer these questions, this dissertation has as the main objective *to analyze the emergence of Knowledge Intensive Sustainable*

Entrepreneurship concept through an ecosystem perspective. Sustainable development and its grand challenges are a real threat to societies, and participatory and collaborative work can mitigate their effects. It is about time we combine the entrepreneurial ecosystem view with the urgent demands posed by social and environmental distress, proposing more than normative actions but mainly practical ones. To do so, the research is organized into three articles discussing specific topics that, combined, explain the arising of this phenomenon from ventures, university, and potential entrepreneur views.

The first paper introduced is "Entrepreneurial Ecosystems' Readiness towards Knowledge-Intensive Sustainable Entrepreneurship: Evidence from Brazil." It identifies the 'readiness' of entrepreneurial ecosystems in terms of enablers of Knowledge-Intensive Sustainable Entrepreneurship (KISE) events in a developing country context – and how they differ from 'traditional' Knowledge-Intensive Entrepreneurship (KIE). The empirical data comes from firms participating in the PIPE Program (Innovative Research in Small Business) funded by the São Paulo Research Foundation (FAPESP) in Brazil. The methodological approach relies on estimating entrepreneurial propensity functions that assess the statistical associations between city-level features and the generation of KISE for a panel of 629 municipalities. Findings indicate strong similarities in the underlying ecosystem drivers of KIE and KISE. However, when we disaggregate KISE into four domains (Cities, Health, Education, and Green Technologies), the 'ecosystem readiness' towards sustainable transitions varies from more mature (as in the case of HealthTechs with an inclusive orientation) to very incipient configurations (Cities and EdTechs).

The second one is "Technology Transfer as an Enabler for the Emergence of Sustainable Entrepreneurial Universities" which aims to analyze the process of sustainability institutionalization in an entrepreneurial university, considering the role of technology development and transfer. From a single in-depth network analysis, secondary data, and qualitative case study at the University of Campinas (Unicamp), the main outcomes indicate that it is necessary to integrate and coordinate strategies to conduct sustainable processes via technological transfer. The technological development of sustainable patents is mostly based on researchers' personal influence financed by public funding. Even with low levels of institutional engagement behind them, most licensing agreements come from sustainable patents. Therefore, the university management board, experts, scientists, firms, and funding agencies are central to the emergence of a Sustainable Entrepreneurial University, generating broader societal, environmental, and economic impacts. Lastly, the paper relies on three theoretical propositions that underscore HEI's transition process toward sustainability by addressing internal structures and external relations.

The third and last article is “University Effects on Undergraduate Student's Views and Sustainable Entrepreneurial Intentions”. Its main goal is to understand how universities may affect undergraduate students' views, behaviors, and entrepreneurial intentions toward sustainability. Through an exploratory factor analysis, a survey was conducted at Unicamp involving 485 students from business and hard sciences disciplines since they are taken as potential entrepreneurs. The results demonstrated a mismatch between the university context and sustainable entrepreneurial intentions. However, factors related to the university and student-university engagement highlighted positive significance. Students expressed heightened interest in flexible activities and maturing entrepreneurial intentions by interacting with non-conventional approaches. Underling this aspect, it is advocated for integrating top-down (such as training, events, sustainable incubators, partnerships, etc.) and bottom-up strategies (such as student organizations, volunteering programs, collaborative spaces, etc.) to develop sustainable initiatives. These initiatives have the potential to evolve into entrepreneurial intentions and, more importantly, foster long-term sustainable awareness, thereby creating a sustainable culture.

The dissertation is presented as follows. The first chapter starts with the article “Entrepreneurial Ecosystems’ Readiness towards Knowledge-Intensive Sustainable Entrepreneurship: Evidence from Brazil.” The second chapter introduces the article “Technology Transfer as an Enabler for the Emergence of Sustainable Entrepreneurial Universities,” and the third chapter is named “University Effects on Undergraduate Student's Views and Sustainable Entrepreneurial Intentions.” Discussion is held after that, following the Concluding Remarks that summarize the dissertation, present study limitations, and also venues for future research. Table 1 illustrates the connection among the articles, demonstrating how they support the objective and answer the research questions.

Table 1. *Connection among the articles*

Dissertation objective	Research questions	Article	Article's objective	Methodology	Main outcomes
To analyze the emergence of Knowledge Intensive Sustainable Entrepreneurship concept through an ecosystem perspective	How KIE can support sustainability transitions?	CHAPTER 1 Entrepreneurial Ecosystems' Readiness towards Knowledge-Intensive Sustainable Entrepreneurship: Evidence from Brazil	To identify the 'readiness' of entrepreneurial ecosystems in terms of enablers of Knowledge-Intensive Sustainable Entrepreneurship (KISE) events in a developing country context – and how they differ from 'traditional' Knowledge-Intensive Entrepreneurship (KIE).	Generalized Estimating Equations (population average models)	Strong similarities on the underlying ecosystem drivers of KIE and KISE. 'Ecosystem readiness' varies from more mature (HealthTechs) to very incipient configurations (Cities and EdTechs). Reorientation towards the inclusion of KIS firms in the agenda can offer a guide for the allocation of resources that facilitate sustainable transition.
	How does knowledge and technology transfer occur in sustainable entrepreneurial universities?	CHAPTER 2 Technology Transfer as an Enabler for the Emergence of Sustainable Entrepreneurial Universities	To analyze the process of sustainability institutionalization in an entrepreneurial university, considering the role of technology development and transfer	Network analysis, secondary data, and qualitative case study at the University of Campinas (Unicamp)	Similarities between the dynamics of technology development and intellectual property rights between sustainable and conventional technologies. Technological development of sustainable patents is mostly based on researchers' personal influence financed by public funding. It is necessary to integrate and coordinate top-down and bottom-up strategies to conduct sustainable processes via technological transfer.
	What are students' behaviors, attitudes, and intentions toward sustainable entrepreneurship, and how do the universities affect it?	CHAPTER 3 University Effects on Undergraduate Student's Views and Sustainable Entrepreneurial Intentions	To understand the effects universities may have on undergraduate students' views, behaviors, and entrepreneurial intentions toward sustainability.	Exploratory Factor Analysis (EFA)	Mismatch between the university context and sustainable entrepreneurial intentions. Students expressed heightened interest in flexible activities and maturing entrepreneurial intentions by interacting with non-conventional approaches. Integrating top-down (such as training, events, sustainable incubators, partnerships, etc.) and bottom-up strategies (such as student organizations, volunteering programs, collaborative spaces, etc.) to develop sustainable initiatives.

CHAPTER 1: ENTREPRENEURIAL ECOSYSTEMS' READINESS TOWARDS KNOWLEDGE-INTENSIVE SUSTAINABLE ENTREPRENEURSHIP: EVIDENCE FROM BRAZIL

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Journal: Technovation, Qualis A1 | https://doi.org/10.1016/j.technovation.2023.102820

Ethical Committee approval: not applicable

ABSTRACT

Pathways to sustainable development are a key to providing innovation transitions and well-being. In this context, knowledge-intensive entrepreneurs play a pivotal role in shaping the markets for new products, services, and business models. Prior literature has put emphasis on the contextual elements that shape entrepreneurial opportunities and business endeavors, i.e., entrepreneurial ecosystems. However, little is known about the extent to which these ecosystems are capable of nurturing the emergence of knowledge-intensive ventures with a sustainable orientation. Our goal in this article is to identify the 'readiness' of entrepreneurial ecosystems in terms of enablers of Knowledge-Intensive Sustainable Entrepreneurship (KISE) events in a developing country context – and how they differ from 'traditional' Knowledge-Intensive Entrepreneurship (KIE). Our empirical data comes from firms participating in the PIPE Program (Innovative Research in Small Business) funded by the São Paulo Research Foundation in Brazil. The methodological approach relies on the estimation of entrepreneurial propensity functions that assess the statistical associations between city-level features and the generation of KISE for a panel of 629 municipalities. Findings indicate strong similarities on the underlying ecosystem drivers of KIE and KISE. However, when we disaggregate KISE into four domains (Cities, Health, Education and Green Technologies), the 'ecosystem readiness' towards sustainable transitions varies from more mature (as in the case of HealthTechs with an inclusive orientation) to very incipient configurations (Cities and EdTechs).

Keywords: Knowledge-Intensive Entrepreneurship; Sustainable Entrepreneurship; Social Entrepreneurship; Entrepreneurial ecosystems; Developing country; Brazil.

1.1 INTRODUCTION

Tackling pressing issues related to social and environmental impacts can be considered a topic of great concern for development and growth both at the macro and micro levels of analysis (Neumann, 2022; Sarpong & Amankwah-Amoah, 2015). Accordingly, approaches related to sustainable development and sustainable transitions have received increased attention in the last decades not only from a conceptual perspective but also as an economic possibility with a high potential to address current global demands and challenges (Markard et al., 2012). This implies a transition in the business practices from those considered socially and environmentally unsustainable to those that generate value while respecting natural resources and promoting social inclusion (Mendéz-Picazo et al., 2020; Ghazinoory et al., 2020).

Within this context, sustainable entrepreneurship (SE) emerges as a pivotal phenomenon in triggering economic transitions towards more inclusive and environmentally-friendly models of production (van Rijnsoever, 2022; Anand et al., 2021; Muñoz & Cohen, 2018; Hoogendoorn et al., 2019; Turker & Ozmer, 2021; Surie, 2017). Accordingly, SE is dedicated to solving social and environmental challenges in a hybrid manner by combining social, environmental and economic institutional logics (Cornelissen et al., 2021; Belz & Binder, 2017; Maibom & Smith, 2016; Klewitz & Hansen, 2014). In this article, we propose the comprehensive notion of Knowledge-Intensive Sustainable Entrepreneurship (KISE), a derived concept from Knowledge Intensive Entrepreneurship (KIE, Malerba & McKelvey, 2020). Our assessment is based on the perspective that KISEs are embedded in Entrepreneurial Ecosystems (EE), thus being affected by contextual features of these socioeconomic structures.

The literature on EE is fruitful and embraces a diversity of discussions (Fischer, Meissner et al., 2022; Wurth et al., 2021; Bruns et al., 2019; Malecki, 2018; Bhawe & Zahra, 2017; Borissenko & Boschma, 2017; Kabbaj et al., 2016). Nevertheless, it has yet to embrace the KISE phenomenon as a driver of sustainable transitions (Pathak & Mukherjee, 2020; Tiba et al., 2020; Secundo et al., 2017; Hoogendoorn, 2016). Thus, the extent to which KISE is enabled (or constrained) by EE dimensions remains an open debate (Wurth et al., 2021; Gerli et al., 2021; Pathak & Mukherjee, 2020; Tiba et al., 2020; Bozhikin et al., 2019; Thomsen et al., 2018; Thompson et al., 2018; Roundy, 2017; Kabbaj et al., 2016).

Hence, our purpose in this article is to shed light on entrepreneurial ecosystems' readiness towards fostering KISE. Ultimately, our goal is to identify whether and to what extent the dynamics of 'traditional' entrepreneurial ecosystems can also apply to triggering sustainable transitions in terms of KISE activity. Our guiding research question can be stated as follows: *Are the local drivers of KISE aligned with the dimensions of mainstream entrepreneurial ecosystems*? In this way, we contribute to the debate on configurations of entrepreneurial ecosystems, generating inputs for research, policy and management *vis-à-vis* the urgent need to address sustainable development (Theodoraki et al., 2022; Tiba et al., 2020; Cohen, 2006).

Our empirical setting involves firms participating in the PIPE Program (Innovative Research in Small Business) funded by the São Paulo Research Foundation (FAPESP) in Brazil. The methodological approach relies on the estimation of entrepreneurial propensity functions that assess the statistical associations between city-level socioeconomic features and the generation of KISE for a panel of 629 municipalities. Findings indicate strong similarities on the underlying ecosystem drivers of KIE and KISE. However, when we disaggregate KISE into four domains (Cities, Health, Education and Green Technologies), the 'ecosystem readiness' towards sustainable transitions varies from more mature (as in the case of HealthTechs with an inclusive orientation) to very incipient configurations (Cities and EdTechs).

The remaining of the article is structured as follows. Section 1.2 discusses the literature review contributing to the debate about KISE and their connections with the Entrepreneurial Ecosystem concept. Section 1.3 presents the data and method. Section 1.4 outlines the empirical fndings and Section 1.5 discusses results and outlines some implications for theory and practice. Section 1.6 concludes with final remarks.

1.2 Literature Review

1.2.1 Knowledge-Intensive Entrepreneurship: A Sustainable Perspective

Following Malerba and McKelvey (2020), Knowledge-Intensive Entrepreneurship comprehends new organizations that use and transform knowledge to generate new forms of adding value. This conceptualization encompasses relationships between the entrepreneur, the organization, knowledge, and the broader social and economic context. According to the authors, there are four critical characteristics of these ventures: (i) they are innovative; (ii) they have significant knowledge intensity; (iii) they are embedded in entrepreneurial ecosystems; and (iv) they exploit innovative opportunities involving different sectors and actors. KIE ventures can derive value from interactions with myriad organizations such as incumbent firms, universities, non-governmental entities, as well as from the public sector (Malerba & McKelvey, 2020; Lassen et al, 2018; Mocelin & Azambuja, 2017). These elements show that scientific and technical areas are proeminent expressions of this kind of enterprise and demonstrate how the concept can be adaptative to different areas.

Sustainable entrepreneurship can be understood under the *entrepreneurship for sustainable development* umbrella (Johnson & Schaltegger, 2020) and focuses on a triple-bottom-line perspective (Elkington, 1998). Cohen and Winn (2007), in their seminal article, define SE as how entrepreneurial opportunities are discovered, created, and exploited by individuals generating social, environmental, and economic impact. This approach has many similarities with social entrepreneurship (Turker & Ozmer, 2021; Surie, 2017; Saebi et al., 2019; Dees, 2011), since both typologies are oriented to discovering market opportunities to solve societal and/or environmental issues as the key to generating value creation in a broad sense (Hoogendoorn et al., 2019). Considering them as the promising venue of research (Anand et al., 2021), we are following the plausible complementarity from Sustainable and Social Entrepreneurship and using academic literature from the both interchangeably. We understand sustainable businesses as ‘hybrid’ organizations in the sense of combining different institutional logics inside their business practices (Doherty & Kittipanya-Ngam, 2021; Bianchi, 2021; Park & Bae, 2020; Battilana, 2018; Agarwal et al., 2018; Maibom & Smith, 2016).

Based on these definitions, the concepts of KIE and SE can be merged as a function of the increasing intensity of knowledge and technology required to generate social and environmental impacts (Ibáñez et al., 2021; Vo-Thanh et al., 2021; Mora et al.; 2020; Alsaleh et al., 2021; Gidron et al., 2021; Manos & Gidron, 2021; Scillitoe et al., 2018). Therefore, in this article we follow the complementarities between the KIE and SE concepts to analyze the Knowledge-Intensive Sustainable Entrepreneurship (KISE) phenomenon. From this perspective, KISE is compatible with social, environmental and economic goals given that these ventures aim at promoting social and/or environmental agendas while contributing to economic development by undertaking knowledge-intensive activities in myriad sectors.

As outlined, knowledge-intensive new firms are deeply embedded in entrepreneurial ecosystems. We now turn to these contextual features and try to make sense of their connection with the dynamics of value creation for society and the environment.

1.2.2 Entrepreneurial Ecosystems and the Emergence of Knowledge-Intensive Sustainable Entrepreneurship

Both KISE events and entrepreneurial ecosystems are fields that have drawn significant attention from scholars, practitioners and policymakers (Spigel, 2017; Borissenko & Boschma, 2017; Cheah et al., 2019; Gali et al., 2020; Maalaoui et al., 2020; Pathak & Mukherjee, 2020; Wurth et al., 2021). Yet, overlaps between these concepts have seldom received systematic attention (Roundy, 2017). In this section, we dedicate efforts to bring these two phenomena together and build a conceptual rationale to address EE readiness toward KISE activity.

The use of the ecosystem concept places emphasis in identifying the crucial components of localized entrepreneurial structures, the linkages among these components, and their influence on the emergence and development of entrepreneurial ventures (Isenberg, 2010; Mason & Brown, 2014). Spigel (2017) defines entrepreneurial ecosystems as the combination of social, political, economic and cultural elements, embedded in a region that supports the emergence and growth of innovative ventures. In this sense, they are commonly understood by their main dimensions or pillars, including markets, human capital, education, support system, culture, finance, infrastructure, and policy (Isenberg, 2010; Stam, 2015; Spigel, 2017; Alves et al., 2021).

In addition to the function of supporting the creation and growth of new ventures (Bhawe & Zahra, 2017), entrepreneurial ecosystems with high levels of readiness towards KISE also foster the engagement of entrepreneurs with social needs and environmental problems through an intensive use of knowledge and innovation in their activities (Znagui et al., 2019). When ecosystems become effective in driving contextual conditions that steer the bulk of entrepreneurial activity in the direction of sustainable practices, literature identifies the existence of full-fledged sustainable entrepreneurial ecosystems (Cohen, 2006; Bischoff, 2021; Gali et al., 2020). However, these are likely exceptions within the dynamics of EE worldwide (Fischer, Bayona-Alsina et al., 2022). That is why considering a broader spectrum of ‘readiness levels’ towards fomenting KISE events can better inform our knowledge on how – and to what extent - EE agents and interactions are shaping the conditions for sustainable entrepreneurs to emerge.

In this vein, the following subsections discuss the main dimensions of Stam's (2015) entrepreneurial ecosystems framework and their respective articulations (or lack thereof) with the KISE phenomenon. Our research hypotheses are derived from these theoretical, conceptual and empirical insights.

1.2.2.1 Framework conditions

Stam (2015, p. 1766) defines framework conditions as a pillar of entrepreneurial ecosystems comprising "social (informal and formal institutions) and the physical conditions enabling or constraining human interaction". Although some of these elements are inherently complex to assess from a analytical point of view, efforts in terms of addressing components of the framework conditions have proven to qualify our understanding of EE underlying mechanisms (e.g. Fischer, Queiroz et al., 2018; Radosevic & Yoruk, 2013).

In this respect, a first framework condition of interest concerns Formal Institutions. This pillar of entrepreneurial ecosystems is strongly connected to local levels of socioeconomic development – a key enabler of knowledge-intensive entrepreneurship (Mello et al., 2022; Stam, 2015; Keeble & Walker, 2006). Second, Stam (2015) refers to cultural attributes of the ecosystem. Cultural processes are attached to feedback loops in terms of entrepreneurial behavior, affecting regional trajectories towards the intensity of entrepreneurial activity (Fotopoulos, 2014; Fritsch et al., 2019). According to Spigel (2017), cultural attributes involve risk tolerance, success stories, research culture, a positive image of entrepreneurship (a similar argument is also posed by Audretsch & Belitski, 2017).

A third framework condition comprises the quality of physical infrastructure available in the ecosystem. Such features provide support for early-stage organizations and operates in the background to enable the creation and growth of new businesses (Spigel, 2017). This physical arena provides a mechanism for start-ups' development and ranges from basic infrastructure – such as access to water and energy – to telecommunication/broadband facilities, office spaces, transportation, and so on (World Economic Forum, 2013; Audretsch & Belitski, 2017; Cohen, 2006). A fourth and final framework condition in Stam's (2015) model of entrepreneurial ecosystems makes reference to demand dynamics in the ecosystem. Here, knowledge-intensive entrepreneurship seems to be intrinsically associated to income levels, a driver of demand sophistication towards innovative products and services (Fischer, Queiroz et al., 2018; Radosevic & Yoruk, 2013; Naude et al., 2008; Wang, 2006; Santarelli & Tran, 2012). Complementarily, Stam (2015) states that exogenous demand conditions (i.e. beyond the local scope of the ecosystem) have an important role to play. Accordingly, the level of ecosystem openness to foreign markets can be a a critical driver of demand for new ventures (Spiegel, 2017).

Yet, KISE ventures have specificities that go beyond the 'traditional' logic of EE framework conditions. This happens because these businesses comprise a more diverse group of stakeholders to improve SE performance, address unmet social and environmental needs, and spur sustainable transitions (Theodoraki et al., 2022; Pandey et al., 2017; Bozhikin et al., 2019; Znagui et al., 2019; Guerrero et al., 2021; Cohen, 2006). This results in more challenges than those faced by traditional organizational forms that fit into existing institutions relatively well (McMullen, 2018; Thompson et al., 2018; Villegas-Mateos & Vázquez-Maguirre, 2020).

Recent contributions (Fischer, Bayona-Alsina et al., 2022; Kabbaj et al., 2016; Purkayastha et al., 2020; Villegas-Mateos & Vázquez-Maguirre, 2020) assert the view that ecosystem configurations leading to KISE activity face different challenges *vis-à-vis* KIE in general. This is a function of a lack of EE readiness to address matters associated with social and environmental aspects of entrepreneurial activity. As a result, EE framework conditions have demonstrated more limited impacts in triggering KISE than they have in nurturing innovative startups in general (Fischer, Bayona-Alsina et al., 2022). This leads to our first set of hypotheses:

> ***H1a.*** *There is a positive association between Framework Conditions of entrepreneurial ecosystems and the emergence of KISE events.*
> ***H1b.*** *The association between Framework Conditions and KISE events is weaker than the association between Framework Conditions and 'traditional' KIE activity.*

1.2.2.2 Systemic conditions

Although framework conditions represent key pillars upon which EE is based, the systemic conditions are what Stam (2015, p. 1766) refers to as 'the heart of the ecosystem.' The first systemic condition of interest concerns Networks. The formation of linkages amongst actors involved directly and/or indirectly with entrepreneurial endeavors is taken as the core feature of entrepreneurial ecosystems since they provide informational flows and enable the spread of talent and capital (Stam, 2015). They also allow connections between entrepreneurs, advisors, and investors, enabling the free movement of knowledge and skills (Audretsch et al., 2019; Cunningham et al., 2018; Spigel, 2017; Ács et al., 2009). The enabling role of networks also appears to be of central importance in the case of entrepreneurship with a sustainable orientation (Maalaoui et al., 2020; Surie, 2017).

Second, Stam (2015) refers to the role of leadership in the ecosystem, an aspect derived from the existence of role models in the ecosystem that can give a sense of coherence to individuals and firms (Knox & Arshed, 2022; Tiba et al., 2020; Roundy, 2020). Third, systemic conditions comprise the availability of finance for entrepreneurs (Stam & van de Ven, 2021; Guerrero et al., 2021). This represents not only the capacity of the ecosystems to supply new businesses with investments, but also the managerial role of investors in shaping the managerial capabilities of new ventures (Fischer, Meissner et al., 2022). Literature has highlighted the challenges inherent to funding of sustainable businesses through traditional sources due to their lack of alignment with 'traditional' market perspectives (Islam, 2020; Villegas-Mateos & Vázquez-Maguirre, 2020; Hoogendoorn et al., 2019; Cheah et al., 2019; McMullen, 2018; De Lange, 2017).

Next, Stam (2015) outlines the importance of Talent and Knowledge sources. Worker talent involves the availability of highly skilled professionals that can become entrepreneurs or form part of entrepreneurial teams. These features compose core human capital assets of entrepreneurial ecosystems, particularly those with a knowledge-intensive orientation (Alves et al., 2021; Chatterji et al., 2013). In turn, the Knowledge dimension is multifaceted in nature, involving mainly universities, research institutes and firms (Qian 2018; Malecki, 2018; Spigel, 2017; Theodoraki et al., 2018; Clarysse et al., 2014; Cohen, 2006). Nonetheless, it is not clear whether knowledge infrastructures are designed (or not) to nurture knowledge production and diffusion towards generating sustainable impacts (Thomsen et al., 2018). In this respect, no automatic contributions are expected to arise. Rather, the knowledge domain needs to be steered in the direction of sustainable initiatives in order to function as a true pillar for KISE events (Eiselein et al., 2017).

A last component of the Systemic conditions concerns support services and intermediaries. These are mainly represented by organizations that provide ancillary services to new ventures (Spigel, 2017). These organizations facilitate the flow of resources, the building of capabilities, the access to social networks, and the connection to funding sources. Incubators and tech parks are examples and can be specific for social entrepreneurs as they can be seen as agents oriented to stimulate connections and to facilitate action amongst social impact firms, private and public agents (Theodoraki et al., 2018; Kabbaj et al., 2016; Purkayastha et al., 2020; Guerrero et al., 2021; Pathak & Mukherjee, 2020; Villegas-Mateos & Vázquez-Maguirre, 2020; Pandey et al., 2017; Roundy, 2017). In the case of sustainable entrepreneurship, these support organizations play a prominent role in helping startups to overcome constraints in terms of ecosystem embeddedness, thus facilitating their insertion in relevant networks (Van Rijnsoever, 2022).

But despite some great examples of sustainable ventures around the world (Yunus, Moingeon & Lehmann-Ortega, 2010; Surie, 2017; Comini, Rosolen & Fischer, 2019), we cannot yet trace a prominent background in ecosystems supporting these ventures. Recent evidence has underscored a lack of 'readiness' in Systemic conditions of entrepreneurial ecosystems in shaping KISE events when comparing with more traditional kinds of KIE. Accordingly, we propose our second set of hypotheses:

> ***H2a.*** *There is a positive association between Systemic Conditions of entrepreneurial ecosystems and the emergence of KISE events.*
> ***H2b.*** *The association between Systemic Conditions and KISE events is weaker than the association between Systemic Conditions and 'traditional' KIE activity.*

1.3 Methodological Approach

1.3.1 Sample and Data

Our methodological approach relies on the estimation of entrepreneurial propensity functions that assess the statistical associations between ecosystem-level features and the generation of Knowledge-Intensive Social Entrepreneurship (KISE). The sample comprises panel information for 629 cities in the State of São Paulo, Brazil, over the period 2005-2017 (contextual features) and 2006-2018 (entrepreneurial events). Although there remains a conspicuous lack of agreement on the spatial reach of entrepreneurial ecosystems, connections and spillovers tend to be highly localized, making the city-level analysis an adequate empirical strategy (Malecki, 2018; Qian et al., 2013; Audretsch & Belitski, 2017; Bruns et al., 2017).

The State of São Paulo stands for a relevant analytical unit to gather insights on KISE events embedded in the context of a developing country. While this region stands as the leading economy in Brazil and in Latin America, it suffers from typical socioeconomic maladies that are present in catching-up countries, such as institutional voids, a difficult business environment for innovation-driven entrepreneurs, and strong agglomeration diseconomies (Fischer, Queiroz et al., 2018).

1.3.1.1 Dependent variables

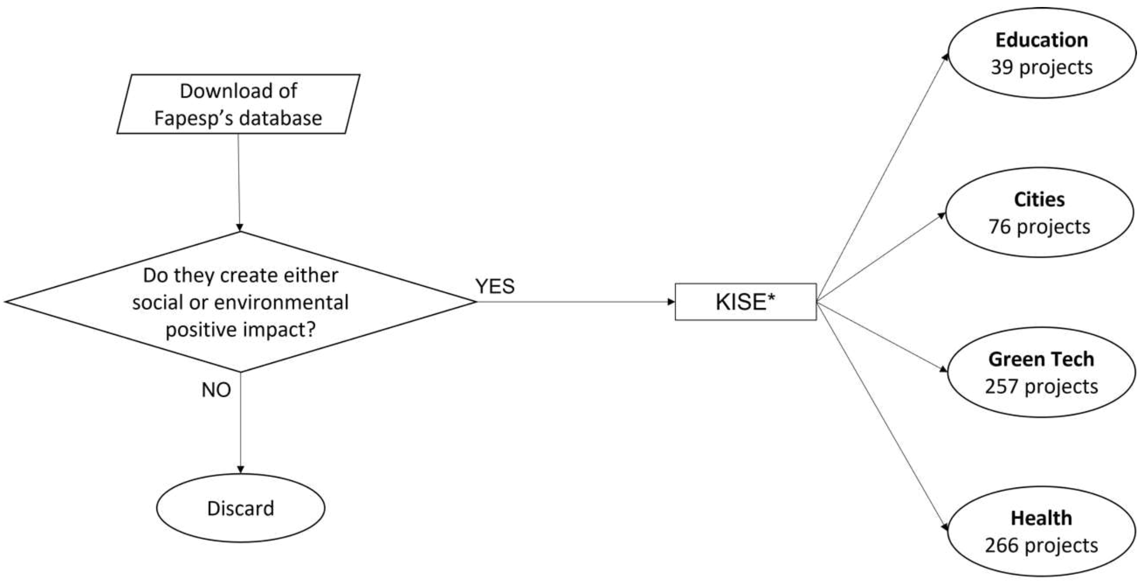
The analyzed database was extracted from the PIPE Program (Innovative Research in Small Business) managed by FAPESP (The São Paulo Research Foundation). PIPE was inspired by the Small Business Innovation Research (SBIR) Program that has run in the United States since the eighties (Salles et al., 2011). The rationale behind the PIPE program is to give support to the KIE ventures as a tool to promote technological innovation, entrepreneurship development, and increase competitiveness in small businesses. There are three relevant criteria to obtain the funding: enterprises must have less than 250 employees; research proposals must demonstrate high levels of human capital; and there must be an identification of a business opportunity (Fischer, Salles-Filho et al., 2021). We acknowledge that PIPE projects do not capture the entire population of KIE and KISE ventures. However, it does offer a robust indicator to analyze entrepreneurial firms and events. Similar approaches have been undertaken for the case of the SBIR Program in the US, based on the premise that "a basis for firms receiving Small Business Innovation Research (SBIR) research awards to develop commercializable technologies is not only their proposed creative ideas but also their endowment of attendant knowledge necessary to develop the technology being proposed" (Audretsch & Link, 2019; p.1). Other examples include Audretsch et al. (2016) and Van der Vlist et al. (2004). Since PIPE seems to follow similar patterns (Salles et al., 2011), its use in our assessment relies on sound empirical evidence.

We analyzed the PIPE dataset to identify enterprises that could be categorized as sustainable enterprises drawing from descriptive information of each project. For this categorization, we considered KISE from a broad perspective, including companies that demonstrated social and/or environmental engagement in their entrepreneurial endeavors regardless of their profit orientation (as suggested by Neverauskiene & Pranskeviciute, 2021; Mahfuz et al., 2019; Batillana, 2018; Defourny & Nyssens, 2017). Accordingly, in this research, we understand Knowledge Intensive Sustainable Entrepreneurship (KISE) as innovation-driven organizations that generate positive impacts for society and natural environment whether such aspects form part of their deliberate value proposition or not.

Starting from a database with 1575 finalized projects between the years 2005 and 2018, we identify 564 projects that fall within the KISE category. To obtain this number, we analyzed each one by their titles and content descriptions looking for elements related to positive social and environmental impacts. This analysis was carried out independently by three researchers to guarantee that the projects were in accordance to the criteria established above. Discrepancies were solved through discussions among the authors.

The final sample (564 projects) was categorized according to one or more possible impact areas: (i) education, (ii) city planning and living conditions, (iii) green technologies, and (iv) health (Hollenbach & Fonseca, 2021). This categorization helped us to better understand the field distribution and main needs of each type of KISE. This is key to understand specificities associated to the effects of ecosystem features on each cohort of KISE. As recent research has demonstrated (Spigel, 2022), the dynamics of EE seem to present sectoral patterns, i.e., EE configurations do not necessarily affect all entrepreneurs in a similar fashion, thus generating 'nested' ecosystems – rather than cohesive wholes. By complementing our core dependent variable with this view on specific cohorts we can dig deeper into latent differences within the KISE concept. The following flowchart (Figure 1.1) describes the phases and gates used to decide what kind of enterprises were to be included under the KISE concept.

Figure 1.1 *A flowchart of the sample design*



*There are 74 overlapping projects which means they comprise more than one category.

To meet our research goal, we have also added KIE companies that do not qualify as KISE as a dependent variable in our analysis. This procedure was also adopted by Fischer, Bayona-Alsina et al. (2022) to generate a benchmark for comparing the dynamics of 'traditional' EE with what goes on in the case of KISE. This is a key step in assessing hypotheses H1b and H2b, allowing verification of ecosystem 'readiness' when contrasting KIE and KISE events.

1.3.1.2 Independent variables

Drawing from Stam's (2017) framework, our set of independent variables comprise two main EE dimensions, namely Framework and Systemic conditions. Although we were not able to fully capture each and every condition, our EE representation covers eight of the ten conditions outlined in Stam (2015). The full set of variables is described in Table 1. Some cautions are needed. We were not able to generate reasonable proxies for EE-level leadership (a typically qualitative event) and Finance. In the latter case, data coverage was only available for loans from retail banks, a poor proxy for entrepreneurial sources of funds (Alves et al., 2021)[2]. In any case, our entire sample is representative of entrepreneurial ventures that received access to public investments to

[2] We used this variable to test our models, but its lack of statistical significance combined with its poor representation of the condition at stake justified its exclusion from our models.

undertake their activities. While this generates bias in our analyses, it also warrants Finance as a necessary condition of all locations under scrutiny.

In terms of the Framework conditions, the quality of institutions was assessed through the use of the city-level Human Development Index, a composite indicator that comprises health, knowledge and income, thus offering a strong *proxy* for the quality of policies and institutions (Suri et al., 2011; Binder & Georgiadis, 2010). Culture is addressed with a 1-period lead of the applicable independent variable. This offers an idea of the persistence of entrepreneurial activity in cities (Sternberg, 2021). The quality of infrastructure is represented both by Public Investments in infrastructure and an indicator of Energy consumption (Agénor, 2015; Geginat & Ramalho, 2018; Fischer, Queiroz et al., 2018). Demand conditions are represented by local levels of income per capita (Radosevic & Yoruk, 2013) and global connections via trade (Lee et al., 2021) and FDI (Ryan et al., 2021).

For the Systemic conditions, we use intensity of Technology Transfer agreements (Rondé & Hussler, 2005) and University-Industry interactions (Schaeffer et al., 2021) to approximate the density of local networks. Talent is measured as a function of tertiary enrollment, a typical indicator of human capital (Fischer, Queiroz et al., 2018). Knowledge conditions involve the presence of eminent research universities located in the State of São Paulo (based on the Scimago institutional ranking) and cross-checked results with data from the São Paulo Research Foundation Grants and Scholarships database. All selected locations/year corresponded to the group of leading cities in terms of research funding, warranting robustness to our selection of academic units. As identified in prior literature, Research Universities play a pivotal role in shaping the conditions for knowledge generation and dissemination at the local-level, an aspect that creates opportunities for entrepreneurs to exploit (Guerrero et al., 2016; Schaeffer et al., 2018). We complemented this academic view with the inclusion of a variable for Technological Activity, i.e. domestic patent deposits. This offers information on the innovation capabilities of cities (Kuckertz, 2019), a feature that has been previously associated with entrepreneurial events in developing countries (Tran & Santarelli, 2017). A last Systemic condition comprises incubators and tech parks as typical innovation habitats dedicated to fomenting innovation-driven entrepreneurship (Alves et al., 2021; Giner et al., 2016).

As control variables, we included three vectors. First, we added city-level Population to mitigate statistical effects associated with the sheer size of cities. Second, we added Population density as it provides a view on levels of human agglomeration in cities. Such conditions bring a perspective on key aspects associated with social distress and depletion of natural environments, considering the observed dynamics of urban agglomerations in developing countries (Glaeser & Xiong, 2017). Last, the distance to the main economic hub variable includes cities' road distance to São Paulo. As prior literature indicates, propinquity to urban agglomerations is associated to connections to larger markets and business networks, functioning as a 'center of gravity' for entrepreneurial activity (Fischer, Queiroz et al., 2018; Crescenzi & Rodríguez-Pose, 2012).

Table 1.1 presents the full set of analytical variables and their respective sources. Descriptive statistics can be found in Appendix I. Details on the sample profile concerning entrepreneurial activity in the analyzed region are provided in Appendix II.

***Table 1.1** Analytical Variables*

Ecosystem Dimension	Ecosystem Conditions	Variable	Description	Source
Entrepreneurial Events		KIE (excluding KISE)	Total count of Knowledge-Intensive Entrepreneurship (in the city in a given analytical period (excluding those cases classified as KISE).	São Paulo Research Foundation
		KISE	Total count of Knowledge-Intensive Social Entrepreneurship in the city in a given analytical period.	
		KISE Cities	Sub-group of KISE with impacts oriented to city planning and living conditions.	
		KISE Health	Sub-group of KISE with impacts oriented to the health sector.	
		KISE Education	Sub-group of KISE with impacts oriented to educational issues.	
		KISE Green	Sub-group of KISE with impacts oriented to the mitigation of environmental hazards.	
Framework Conditions	Institutions	HDI	Human Development Index for each city in a given analytical period.	Industry Federation of the State of Rio de Janeiro
	Culture	DV t-1	In each model we approximated the Cultural aspect through the insertion of a 1-period lead (t-1) of the corresponding dependent variable in each model.	São Paulo Research Foundation
	Infrastructure	Public Investments	Total investments per capita in infrastructure implemented by city-level governments in a given analytical period. Values in 2019 Brazilian Reais.	São Paulo Statistical Foundation
		Energy Consumption	Average consumption of electric energy (MWh) per capita in the city in a given analytical period.	
	Demand	GDP per capita	Average GDP per capita in the city in a given analytical period. Values in 2019 Brazilian Reais.	São Paulo Statistical Foundation
		Export-Import activity	Average share of companies involved with export and/or import activity in the city in a given analytical period.	Brazilian Ministry of Economics
		FDI	Occurrence of at least one Foreign Direct Investment event in the city in a given analytical period. Binary variable.	São Paulo Statistical Foundation
Systemic Conditions	Networks	Technology Transfer	Average number of technology licensing agreements per capita registered at the Brazilian Institute of Industrial Property in the city in a given analytical period.	Brazilian Institute of Industrial Property
		U-I interactions	Sum of reported university-industry interactions in the city in a given analytical period.	Brazilian Research Council - Directory of Research Groups
	Talent	Tertiary enrollment	Average share of city-level population enrolled in Higher Education Institutions in a given analytical period.	São Paulo Statistical Foundation
	Knowledge	Research University	Presence of at least one high-quality university campus in the city in a given analytical period. Binary variable.	Scimago Institutional Ranking
		Technological Activity	Average number of patent deposits per capita registered at the Brazilian Institute of Industrial Property in the city in a given analytical period.	Brazilian Institute of Industrial Property
	Support Services	Incubators & Tech Parks	Presence of at least one incubator or Tech Park in the city in a given analytical period. Binary variable.	São Paulo Investment Agency
Controls		Population	Number of inhabitants in the city in a given analytical period.	São Paulo Statistical Foundation
		Population Density	Average rate of inhabitants per square kilometer in the city in a given analytical period.	São Paulo Statistical Foundation
		Distance to main economic hub	Road distance from each municipality to the main economic hub, the city of São Paulo.	Google Maps

1.3.2 Estimation Strategy and Robustness Checks

We apply Generalized Estimating Equations (population average models) for panel data with count outcomes. Negative binomial models were used due to overdispersion in the distribution of dependent variables. Valid samples for city-level analysis comprise 7,491 observations (city/period). Z-scores were calculated for continuous variables with the goal of harmonizing coefficients with distinct scales. The structure of the dataset took into account that causal mechanisms between ecosystem features and KISE events take place with a temporal lag. In this regard, we follow a similar approach to that of Qian et al. (2013), using a 1-period lag[3]. A multiplicative interaction term was created for Research Universities and U-I interactions. This was done to capture the extent to which academic connectedness to industrial partners (i.e., the notion of entrepreneurial university) impacts entrepreneurial endeavors (Schaeffer et al., 2021). All procedures are also applied to the case of KIE companies excluding KISE cases, allowing to comparatively address the dynamics of EE from these different perspectives.

A total of six models were estimated, one for each dependent variable (KIE, KISE, KISE Cities, KISE Health, KISE Education and KISE Green). As a first robustness check, we ran the models with a sub-sample of cities that are geographically located within the Brazilian Megalopolis, a massive conurbation that comprehends over forty million people and responds for over a third of the Brazilian GDP. This was done because large urban agglomerations in developing countries suffer from endemic social and environmental distress (Chauvin et al., 2016; Glaeser, 2014; Henderson, 2002). In turn, by estimating these alternative specifications, we can address the consistency of our findings in a group of municipalities embedded in this specific urban setting.

1.4 EMPIRICAL FINDINGS

Results from econometric estimations for the total sample of municipalities are reported in Table 1.2. This includes models for our different specifications of KISE and the benchmark of KIE (excluding KISE cases). Table 1.3 provides the robustness tests for the alternative sample involving only municipalities located in the Brazilian Megalopolis area. For clarity, we divide our analytical approach following the Stam's (2015) ecosystem dimensions, namely Framework and Systemic Conditions.

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[3] We have also tested 2-period lags to check for consistency of estimations. Results remained unaltered. This alternative specification is not reported for brevity's sake, but they are available from the authors upon request.

Table 1.2 *Estimations – Full sample (637 cities) – GEE Negative Binomial*

EE dimensions	**Variables**	**Model**					
		KIE (exclud. KISE)	**KISE Total**	**KISE Cities**	**KISE Health**	**KISE Education**	**KISE Green**
Framework Conditions	HDI	0.399***[0.136]	0.649***[0.151]	-0.266[0.341]	0.938***[0.225]	0.317[0.484]	0.580***[0.195]
	DV t-1	0.126***[0.031]	0.127***[0.024]	0.086[0.105]	0.239***[0.056]	0.341*[0.207]	0.231***[0.052]
	Public Investments	0.113[0.076]	-0.026[0.091]	-0.341[0.264]	0.034[0.115]	-0.006[0.294]	-0.142[0.136]
	Energy Consumption	0.016[0.064]	-0.109[0.222]	-1.816[2.222]	-0.173[0.595]	-6.254[3.971]	-0.056[0.176]
	GDP per capita	0.128**[0.059]	0.177***[0.051]	0.261*[0.135]	0.207***[0.061]	0.361***[0.108]	0.104[0.09]
	Export-Import activity	0.160*[0.096]	0.148[0.105]	0.441**[0.219]	0.150[0.14]	0.359[0.297]	0.114[0.144]
	FDI	0.072[0.216]	0.033[0.214]	0.083[0.42]	-0.100[0.272]	-0.717[0.56]	0.043[0.276]
Systemic Conditions	Technology Transfer	-0.002[0.058]	0.105**[0.045]	0.127[0.1]	0.111*[0.059]	0.153[0.117]	0.092[0.066]
	U-I interactions	0.112***[0.041]	0.072*[0.04]	0.157***[0.059]	0.087*[0.045]	0.173**[0.08]	0.105**[0.044]
	Tertiary enrollment	0.229***[0.077]	0.410***[0.059]	0.467***[0.154]	0.294***[0.099]	0.509**[0.223]	0.454***[0.065]
	Research University	1.882***[0.279]	1.503***[0.27]	2.484***[0.72]	1.777***[0.382]	1.941**[0.905]	0.989***[0.348]
	Technological Activity	0.135***[0.051]	0.135***[0.044]	0.228***[0.069]	0.152***[0.051]	0.225**[0.092]	0.093[0.08]
	Incubators & Tech Parks	1.149***[0.263]	0.986***[0.257]	1.091[0.693]	0.883***[0.340]	0.397[0.866]	1.311***[0.339]
Controls	Population	-0.065*[0.036]	0.007[0.039]	0.389**[0.189]	-0.018[0.044]	-0.033[0.106]	0.022[0.058]
	Population Density	-0.074[0.063]	-0.177**[0.083]	-2.079***[0.787]	-0.076[0.094]	-0.414[0.336]	-0.391**[0.183]
	Distance to main economic hub	-0.763***[0.163]	-0.399***[0.148]	-1.309***[0.499]	-0.241[0.201]	-1.113**[0.52]	-0.498***[0.185]
	Valid N	7,491	7,491	7,491	7,491	7,491	7,491
	Wald chi sq.	781.09***	703.01***	186.62***	441.30***	122.79***	533.56

Std. Errors in brackets   *sig. at 10%; **sig. at 5%; ***sig. at 1%

Table 1.3 *Estimations – Megalopolis (173 cities) - GEE Negative Binomial*

EE dimensions	Variables	KIE (exclud. KISE)	KISE Total	KISE Cities	KISE Health	KISE Education	KISE Green
		Model					
Framework Conditions	HDI	0.289*[0.162]	0.438**[0.197]	-0.554[0.437]	0.368[0.300]	-0.166[0.503]	0.717***[0.276]
	DV t-1	0.019[0.038]	0.052*[0.028]	0.061[0.109]	-0.043[0.070]	0.267[0.221]	0.195***[0.062]
	Public Investments	-0.033[0.126]	-0.167[0.145]	-0.294[0.315]	-0.055[0.197]	-0.592[0.507]	-0.284[0.201]
	Energy Consumption	-0.736**[0.319]	0.030[0.162]	-0.118[0.713]	-0.052[0.255]	-2.699[1.663]	0.135[0.164]
	GDP per capita	0.289***[0.104]	0.247***[0.087]	0.394[0.246]	0.352***[0.105]	0.845***[0.306]	0.038[0.169]
	Export-Import activity	0.224[0.173]	0.188[0.192]	0.504[0.373]	0.057[0.266]	0.602[0.592]	0.171[0.257]
	FDI	0.093[0.247]	0.128[0.248]	0.038[0.484]	0.137[0.333]	-0.702[0.656]	0.078[0.324]
Systemic Conditions	Technology Transfer	0.126*[0.068]	0.141**[0.063]	0.177[0.173]	0.150*[0.090]	0.263[0.2]	0.132[0.086]
	U-I interactions	0.203***[0.054]	0.102*[0.054]	0.188**[0.084]	0.197***[0.064]	0.216*[0.129]	0.097[0.059]
	Tertiary enrollment	0.278**[0.124]	0.459***[0.089]	0.541**[0.268]	0.341**[0.157]	0.607[0.464]	0.486***[0.099]
	Research University	1.210***[0.344]	0.693*[0.389]	3.799***[1.113]	-0.300[0.617]	3.487***[1.293]	0.452[0.462]
	Technological Activity	0.055[0.119]	0.199***[0.06]	0.403***[0.13]	0.228***[0.085]	0.438***[0.169]	0.126[0.088]
	Incubators & Tech Parks	1.649***[0.374]	1.585***[0.427]	-0.224[1.011]	1.882***[0.618]	-1.38[1.305]	1.853***[0.511]
Controls	Population	-0.192**[0.087]	0.042[0.089]	1.018**[0.476]	-0.019[0.098]	-0.034[0.252]	0.101[0.129]
	Population Density	-0.212[0.138]	-0.278[0.191]	-5.333**[2.183]	-0.186[0.227]	-1.081[0.798]	-0.649[0.408]
	Distance to main economic hub	-0.289[0.211]	0.031[0.244]	-1.426*[0.791]	-0.409[0.376]	-0.758[0.683]	0.201[0.284]
	Valid N	2,034	2,034	2,034	2,034	2,034	2,034
	Wald chi sq.	478.99***	326.74	107.50***	230.52***	70.52***	270.25***
	Std. Errors in brackets				*sig. at 10%; **sig. at 5%; ***sig. at 1%		

1.4.1. Framework Conditions

First, for the case of local-level HDI, our measure of *Institutions*, positive associations could be perceived for both KIE and KISE events. This relationship is actually increased for KISE, but the effects are heavily concentrated in KISE Health and KISE Green. In terms of *Culture*, our representation of the dependent variable in t-1 (lead of entrepreneurial events) presents marked homogeneity between KIE and KISE models. Again, however, associations are heterogeneous when considering different scopes of KISE. Effects are particularly noteworthy for KISE Health and KISE Green, but significant effects (at 10%) are also present for KISE Education.

In turn, both variables associated with *Infrastructure* (public investments and energy consumption) are not significant across estimations, thus not representing an influential vector in the sample. While this is in contrast with typical EE models, it comes as no surprise considering the infrastructural deficits observed in developing countries such as Brazil (Chauvin et al., 2016; Venables, 2005). For the *Demand* dimension, as indicated, we have three indicators. GDP per capita refers to local demand capacity, and it is positively associated with both KIE and KISE, although it shows no significant effects on KISE Green. In turn, internationalization activity measured through exports/imports has significant effects only for KIE (at 10%) and KISE Cities (at 1%). FDI presence is not significant across models. This comes as no surprise, considering the existing barriers and lack of international orientation in knowledge-intensive entrepreneurs in Brazil (Cahen et al., 2016), a feature that can also be perceived at the ecosystem-level (Alves et al., 2021).

When we address our robustness tests based on cities embedded in the Brazilian Megalopolis, some of these associations could not be confirmed, thus deserving cautious appropriation (Table 1.3). In the case of the *Institutional* dimension, outcomes for KISE Health differed from original estimations, generating non-significant impacts associated with the corresponding variable. For the *Culture* vector, the persistence of KIE was not consistent for models involving KIE, KISE Health and KISE Education. The lack of significance of *Infrastructure* indicators remained equal. For *Demand*, the results for Export-Import activity related to KISE Cities was not supported in robustness tests. Table 1.4 sums up these main findings and their robustness levels based on a simple configurational visualization of econometric estimations. From this exercise, we can perceive different trends across estimations.

Although the conditions for KIE and KISE models indicate similar EE patterns in terms of Framework conditions, when we look into different specifications of KISE we notice substantial differences. This is particularly valid for KISE Cities (i.e. entrepreneurial ventures proposing solutions to urban issues). In this case, only a feeble association (non-robust) exists for Demand. These are interesting insights into both the 'nested' nature of EE dynamics (Spiegel, 2022) and the relative lack of maturity in entrepreneurial ecosystems' domains within the socioeconomic environment of developing countries (Fischer, Queiroz, et al., 2018).

This allows the examination of our first set of hypotheses (H1a and H1b). H1a is supported for KISE as a whole. In turn – and somewhat surprisingly – we could not identify that KIE drivers are more well-established than KISE in general. But the validity of these conclusions is challenged when we look into different specifications of sustainable entrepreneurship. This is an interesting insight into the idea that EE do not necessarily function as structures that can equally nurture all kinds of entrepreneurship in a similar fashion. In Section 5 we engage in further discussions on these matters.

1.4.2 Systemic Conditions

First, we look into the *Network* aspects of our models. Intensity of Technology Transfer agreements does not demonstrate significant effects in the case of KIE events, but has positive effects in the case of overall KISE – even though other specifications indicate such conditions are restricted to the case of KIE Health. In turn, for University-Industry Interactions, the association is positive and significant across models with varying levels of statistical significance. Second, our measure of the local *Talent* pool indicates a consistent relevance of educational levels for all cases of KIE events. Interestingly, coefficients indicate larger effects in specifications of KISE events than for KIE in general.

Next, assessing the *Knowledge* dimension, special weight can be attached to the presence of leading Research Universities in driving both KIE and KISE (and the different specifications of the latter). In turn, the role played by Technological Activity (Patents per capita) demonstrates more marginal impacts, and these are of similar magnitude for KIE and KISE events. Again, the strength of these associations changes when we look into different orientations of KISE, and the predictor loses significance in the case of green technologies (KISE Green). Last, concerning the importance of *Support Services*, the local availability of incubators and/or science parks has a pivotal influence in most cases, but it shows no significant association with the emergence of KISE Cities and KISE Education.

Taken together, results from our models indicate slight differences between KIE and KISE events. Remarkable distinction, however, appear when analyzing within-KISE cases. The universities should also be highlighted. Not only for their direct impacts related to the Research Universities variable, but also to their effects through human capital formation and establishment of ties through university-industry linkages. Yet another 'hidden' feature here takes place through patenting activity and technology transfer dynamics. In Brazil, leading universities dominate the intellectual property scene. Following these trends, these academic institutions are also extremely important in setting the foundations for entrepreneurial ecosystems to emerge and thrive (Schaeffer et al., 2018). While this is obviously valid for EE worldwide, more incipient ecosystems have a disproportional importance attributed to these institutions due to the relative lack of knowledge capabilities embedded in incumbent firms (Schaeffer et al., 2021).

Robustness tests confirm the rather complete configurations for both KIE and KISE events in terms of Systemic Conditions. This provides support for H2a, but it does not indicate that there is a lack of EE readiness towards sustainable entrepreneurship in our sample. Hence, *prima facie*, H2b can be rejected. But, once again, when we look into distinct orientations of KISE activity, a much more nuanced picture emerges (Table 1.4). For instance, while we perceive a consistent and complete configuration in terms of Systemic Conditions for KISE Health, the picture for KISE dealing with education and green technologies is much more fragmented. Accordingly, our rejection of H2b (and this is also valid for H1b) raises the issue of understanding what goes on within entrepreneurial ecosystems when it comes to specific orientations of sustainable entrepreneurship. We now turn our attention to discussing such findings and their respective implications.

***Table 1.4** Configurational Summary of Estimations*

EE Dimensions	Entrepreneurial Event											
	KIE (exclud. KISE)		**KISE Total**		**KISE Cities**		**KISE Health**		**KISE Education**		**KISE Green**	
Framework Conditions	Institutions	⬢	Institutions	⬢	Institutions	⊗	Institutions	⬡	Institutions	⊗	Institutions	⬢
	Culture	⬡	Culture	⬢	Culture	⊗	Culture	⬡	Culture	⬡	Culture	⬢
	Infrastructure	⊗	Infrastructure	⊗	Infrastructure	⊗	Infrastructure	⊗	Infrastructure	⊗	Infrastructure	⊗
	Demand (Local)	⬢	Demand (Local)	⬢	Demand (international)	⬡	Demand (Local)	⬢	Demand (Local)	⬢	Demand	⊗
Systemic Conditions	Networks	⬢	Networks	⬢	Networks	⬢	Networks	⬢	Networks	⬢	Networks	⬡
	Talent	⬢	Talent	⬢	Talent	⬢	Talent	⬢	Talent	⬡	Talent	⬢
	Knowledge (Academic)	⬢	Knowledge	⬢	Knowledge	⬢	Knowledge	⬢	Knowledge	⬢	Knowledge (Academic)	⬡
	Support	⬢	Support	⬢	Support	⊗	Support	⬢	Support	⊗	Support	⬢

⬢ Robust Conditions ⬡ Non-robust conditions ⊗ Non-significant conditions

1. 5 DISCUSSIONS

A growing number of authors focus on discussing how technology is relevant to empowering sustainable entrepreneurship (Gerli et al., 2021, Ghazinoory et al., 2020; Desa & Basu, 2013). This background suggests a need for advanced ways to combine knowledge and innovation to foment new combinations and disruptive technologies for grand societal challenges. While knowledge-intensive *sustainable* entrepreneurship is not the only mechanism to tackle social and environmental issues, it is certainly an important piece of the puzzle towards sustainable transitions. In this respect, although the dynamics of entrepreneurial ecosystems have emerged as a topic of growing interest worldwide due to its potential of generating economic growth and development for cities and regions, discussions are still strongly oriented towards business models that often fail to tackle pressing issues related to social and environmental impacts (Jütting, 2020; Ghazinoory et al., 2020; Surie, 2017; Sarpong & Amankwah-Amoah, 2015; Sarpong & Davies, 2014).

Accordingly, to generate the necessary shifts towards more responsible entrepreneurship, adaptive and supportive entrepreneurial ecosystems that can actively promote these hybrid organizations becomes necessary (Thompson et al., 2018; Del Giudice et al., 2019; Hoogendoorn et al., 2019). In this article we have delved into these aspects in order to shed additional light on the extent to which EE are ready to offer the necessary contextual inputs for sustainable new ventures. With this in mind, we have explored the dynamics of KISE in the State of São Paulo, Brazil. Unraveling the mechanisms that promote KISE activity in a developing country can be key to deriving policy insights for nurturing the sort of entrepreneurship that can generate pervasive social and environmental gains. Transitions towards innovation-driven entrepreneurship that address these needs are likely a way to mitigate fundamental problems of traditional technology management (Sarpong & Davies, 2014; Cohen, 2006)

Our findings indicate a high level of similarity between the configuration of typical entrepreneurial ecosystems and those observed for KISE, in line with prior literature (McMullen, 2018; Thompson et al., 2018; Villegas-Mateos & Vázquez-Maguirre, 2020; Cohen, 2006). This can be interpreted as a fortunate situation, since transitions towards more sustainable entrepreneurial ecosystems does not seem to be farfetched. Of course, entrepreneurial ecosystems are organic, bottom-up structures and entrepreneurial agency should not be confronted by top-down guidelines – a typical mistake of mission-oriented policies (Audretsch & Fiedler, 2022). But this does not mean that addressing the sustainable development issues should be left to market forces alone. KIE and KISE can and should co-exist, and, from our data, this diversity can come from highly similar configurations. Hence, policies aiming at further legitimizing KISE activity can help overcome the existing barriers to sustainable transitions in cities.

However, our assessment has revealed some striking differences when we look into more specific details in terms of orientations of KISE ventures. This brings some novel elements to the debate on the association between entrepreneurial ecosystems and sustainable entrepreneurship – features that are actually in line with the 'nested ecosystem' argument laid out by Spigel (2022). In his work, the author identifies that EE in the United Kingdom do not function as cohesive wholes, rather being represented by sub-communities that actively coalesce according to their characteristics, goals, norms and behaviors. This creates a notion of 'coherence' that promotes interconnectedness in the ecosystem (Roundy et al., 2017).

When we disaggregate KISE into four domains (Cities, Health, Education and Green Technologies), the strength of EE Framework and Systemic conditions reveals a highly heterogeneous pattern. In this case, the 'ecosystem readiness' towards sustainable transitions varies from more mature (as in the case of HealthTechs with an inclusive orientation) to very incipient configurations (Cities and EdTechs). This brings important implications for policy in understanding (i) what are the primary social and/or environmental goals to be addressed; and (ii) how well ecosystems (or a given specific ecosystem) are equipped to help shaping the conditions for new ventures that are aligned with these challenges to emerge. Alternatively, from a less interventionist perspective, it allows policymakers and practitioners to better comprehend what are the ecosystem strengths and foster specialization in sustainable goals in which the ecosystem has comparative advantages.

In spite of particularities and strong indications of 'nested ecosystems' when it comes to KISE activity, we ought to pinpoint the pervasive positive effects associated directly and indirectly with high-quality Research Universities. These institutions by themselves generate positive and robust impacts in most of our estimations. More than that, they represent pivotal actors in terms of generating and diffusing technological activity in entrepreneurial ecosystems, thus acting simultaneously as knowledge sources and brokers. This is not entirely unexpected, considering that universities often function as 'anchors' of EE in less mature socioeconomic environments (Schaeffer et al., 2021; Alves et al., 2021; Fischer et al., 2018). Yet, when it comes to understanding the dynamics of KISE events, it highlights the importance of academic institutions in sowing the seeds for ecosystem-level sustainable transitions. Nonetheless, it is worth noting that the connection between sustainable ventures and Universities is still considered unclear (Cinar, 2019; Thomsen et al., 2018). Therefore, this relationship must be improved with well-defined strategies for promoting impact interactions such as university-industry collaboration resulting in resources and solutions to positively impact the community life (García-González & Ramírez-Montoya, 2020; Roslan et al., 2020). A better comprehension of the mechanisms, enablers and barriers of this phenomenon is a promising field for further examination.

1.6 CONCLUDING REMARKS

From our analysis, a substantial overlap emerges between the configurations of entrepreneurial ecosystems in promoting 'traditional' and 'sustainable' knowledge-intensive entrepreneurship (in line with observations from the seminal contribution of Cohen, 2006). Considering these similarities, there seems to be room for initiatives that look for both knowledge-intensive and sustainable orientation in their entrepreneurial activities, aligning social and environmental positive impact with innovation towards economic development. Although entrepreneurship is based on bottom-up activities, we are facing, as a society, an unprecedented historical moment that requires orchestrated transition processes to an *impact-oriented entrepreneurship*. Our analyses indicate that EE features do not need to be reconfigured to promote the emergence of sustainable entrepreneurial practices. Rather, a reorientation towards the inclusion of KISE firms in the agenda can offer a guide for the allocation of resources that facilitate the process of transition to a more inclusive and sustainable economy (Eiselein et al., 2017; Pandey et al., 2017; Roundy, 2017; Thomsen et al., 2018; Cohen, 2006).

Our empirical results also underscore the different levels of 'ecosystem readiness' towards sustainability when it comes to different areas of concentration in the activity of entrepreneurial firms. In this respect, we found relatively mature EE in driving HealthTechs with an inclusive orientation, but the configurations leading to KISE ventures dedicated to address urban and educational challenges (KISE Cities and Green) still seem to be at embryonic stages. This is a contribution that resonates with Spigel's (20022) call to view EE as 'nested communities' rather than 'cohesive wholes'.

Overall, such elements provide relevant guidelines for public policies, regulations for sustainable enterprises and expand impact investing (Bozhikin et al., 2019; Guerrero et al., 2021; Gali et al., 2020; Cheah et al., 2019; Islam, 2020). The main global challenges cannot be solved by one actor alone (Jünning, 2020), thus highlighting that collaboration among different actors such as enterprises, society, government, scientists, and industry can help establish the conditions for a new and more sustainable innovation trajectory in entrepreneurial ecosystems. In this vein, 'steering' EE towards more socially and environmentally sustainable goals is likely to generate valuable gains for human society.

Finally, our findings are not without limitations. First, by focusing solely in one region of Brazil, our conclusions do not necessarily apply to other contexts. In this regard, analyses provide a restricted representation of: (i) the relevant dimensions to involved in ecosystem dynamics, and (ii) the interactions and flows of resources and knowledge that occur in the locations studied. In addition, there is a sample bias since we used only funded projects which means they passed our institutional evaluation filter. Hence, we encourage new research topics to address these issues. Promising avenues for future research include deeper approaches on the interplay between technological capabilities and sustainable orientation of entrepreneurial firms, and the role of universities in sustainable technology development. Further, it would be valuable to understand the development process of new kinds of ventures using the KISE concept in other emerging countries. This will offer us a better understanding of the organizations, institutions, patterns, pathways, and management lessons that can be followed to foster sustainable innovation within the context of entrepreneurial ecosystems.

1.7 References

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APPENDIX I - SUMMARY STATISTICS

	N		Min.		Max.		Mean		Median		St. Dev. (within)		St. Dev. (between)	
Variable	**Total**	**Megalopolis**	**Total**	**Megalopolis**	**Total**	**Megalopolis**	**Total**	**Megalopolis**	**Total**	**Megalopolis**	**Total**	**Megalopolis**	**Total**	**Megalopolis**
KIE (excluding KISE) t-1	7740	2124	0	0	19	19	0.054651	0.1426554	0	0	0.3994359	0.7001054	0.480081	0.8139387
KISE total	7740	2124	0	0	35	35	0.05801	0.1356932	0	0	0.5284651	0.9083257	0.593684	0.9195667
KISE Cities	7740	2124	0	0	10	10	0.007364	0.0221239	0	0	0.1444976	0.2649282	0.084325	0.1469853
KISE Health	7740	2124	0	0	14	14	0.028165	0.0589971	0	0	0.2409883	0.3763261	0.347568	0.5355189
KISE Education	7740	2124	0	0	6	6	0.003876	0.0113078	0	0	0.0761885	0.1435564	0.067558	0.1117894
KISE Green	7740	2124	0	0	15	15	0.025323	0.0599803	0	0	0.2217897	0.3831653	0.273257	0.390089
FDI	7644	2076	0	0	1	1	0.02551	0.0811209	0	0	0.0791529	0.1353893	0.16225	0.2771485
Research University	7644	2076	0	0	1	1	0.057954	0.0963618	0	0	0.1251984	0.1563359	0.234802	0.2964419
U-I Interactions	7644	2076	0	0	515	515	1.896128	4.52409	0	0	11.56513	20.30553	20.13938	35.06199
Incubators & Tech Parks	7644	2076	0	0	1	1	0.031528	0.0619469	0	0	0.0901921	0.1223847	0.178118	0.2427476
HDI	7680	2113	0.3407	0.340681	0.935799	0.935799	0.749508	0.7687492	0.7547654	.778654	0.0425095	0.0426881	0.077786	0.0792807
Export-Import activity	7740	2124	0	0	0.1843575	0.1843575	0.013085	0.0294005	0.0054945	.0216016	0.0114303	0.016123	0.021067	0.0306773
Distance to main economic hub	7740	2124	0	0	758	314	343.6605	134.7689	352	134	98.6858	38.9464	183.6867	73.26186
Tertiary enrollment	7644	2076	0	0	0.2483603	0.2483603	0.0086	0.0143577	0	0	0.0115903	0.0148663	0.02144	0.0270562
Technological Activity	7644	2076	0	0	0.0015861	0.0007505	1.34E-05	0.0000205	0	0	0.0000223	0.000027	5.18E-05	0.0000386
Technology Transfer	7644	2076	0	0	0.000361	0.0003333	2.29E-06	0.00000584	0	0	7.92E-06	0.00000988	1.25E-05	0.0000165
GDP per capita	7644	2076	3182.9	3182.94	401304	376459.1	21230.16	27104.31	16180.78	19035.32	10920	15186.99	20382.33	28962.92
Population density	7644	2076	3.73	7.13	13159.64	13159.64	305.6153	971.937	38.29	162.10	628.4368	1132.611	1224.887	2197.447
Population	7644	2076	803	2287	11600000.00	11600000.00	64576.33	171941.2	12638	42254	10679.98	20083.04	457814.7	866467.2
Energy Comsumption	7644	2076	0.3937	0.662759	367.629	32.68278	2.831709	3.171698	1.764488	2.461377	5.800727	1.586499	12.85488	2.896743
Public Investments	7644	2093	0	0	6490.826	6490.826	303.3039	312.9657	222.734	227.8965	0	0	407.1924	434.0928

APPENDIX II – SAMPLE PROFILE

A. TEMPORAL EVOLUTION OF KISE IN THE STATE OF SÃO PAULO, BRAZIL

Year	KIE (exclud. KISE)	KISE Total	KISE Cities	KISE Health	KISE Education	KISE Green	KISE Total %
2005	4	2	0	1	0	1	33%
2006	17	16	3	4	1	8	48%
2007	17	11	2	5	0	5	39%
2008	9	8	1	6	0	2	47%
2009	30	28	3	16	2	9	48%
2010	20	29	1	13	0	16	59%
2011	33	33	2	19	2	14	50%
2012	29	24	0	17	0	8	45%
2013	63	59	4	32	5	26	48%
2014	48	56	9	26	4	23	54%
2015	60	68	10	31	4	30	53%
2016	93	115	22	48	12	54	55%
Overall	423	449	57	218	30	196	51%

B. LEADING CITIES ORDERED BY TOTAL KIE ACTIVITY (KISE & NON-KISE)

City	Total	KIE (exclud. KISE)	KISE Total	KISE Cities	KISE Health	KISE Education	KISE Green
São Paulo	24.2%	20.1%	28.1%	36.8%	30.3%	43.3%	21.9%
São Carlos	15.9%	14.7%	17.1%	12.3%	17.9%	10.0%	18.9%
Campinas	15.5%	19.9%	11.4%	15.8%	7.8%	10.0%	13.8%
São José dos Campos	8.3%	12.3%	4.5%	8.8%	3.7%	6.7%	4.6%
Ribeirão Preto	6.4%	4.3%	8.5%	0.0%	14.2%	3.3%	3.6%
Piracicaba	2.9%	2.6%	3.1%	1.8%	0.5%	0.0%	6.6%
Sorocaba	2.4%	2.4%	2.4%	0.0%	2.8%	3.3%	3.1%
Botucatu	1.7%	0.9%	2.4%	1.8%	1.8%	0.0%	3.6%
São José do Rio Preto	1.4%	0.9%	1.8%	0.0%	2.8%	0.0%	1.0%
Mogi das Cruzes	1.3%	1.2%	1.3%	0.0%	1.4%	0.0%	1.5%
Rest of cities	20.1%	20.8%	19.4%	22.8%	17.0%	23.3%	21.4%

CHAPTER 2: TECHNOLOGY TRANSFER AS AN ENABLER FOR THE EMERGENCE OF SUSTAINABLE ENTREPRENEURIAL UNIVERSITIES

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Journal: Submitted to the Special Issue "The impact of university-industry engagement and the rise of competency transfer partnerships" – The Journal of Technology Transfer, Qualis A1

Ethical Committee approval: CAAE 51636221.1.0000.5404

ABSTRACT

Sustainability is a prominent topic that practitioners, scholars, and society have discussed, requiring the engagement of a diversity of agents to happen effectively. In turn, universities, as recognized knowledge producers and crucial professional trainers, play a significant role in collaborating to solve socio and environmental issues. Yet, the process through which academic institutions combine technology transfer and sustainability remains largely uncharted by dedicated literature. Through analysis of patent portfolios, technological transfer agreements, and agents' perspectives, the article's main goal is to analyze the process of sustainability institutionalization in an entrepreneurial university, considering the role of technology development and transfer. From a single in-depth network analysis, secondary data, and qualitative case study at the University of Campinas, Brazil, our main outcomes indicate that it is necessary to integrate and coordinate strategies to conduct sustainable processes via technological transfer. The technological development of sustainable patents is mainly based on researchers' personal influence financed by public funding. Even with low levels of institutional engagement behind them, most licensing agreements from the University come from sustainable patents. Creating institutional guidelines, coordination, and strategies to reinforce sustainable developments and partnerships can promote more sustainable technological development and technology transfer agreements.

Keywords: Entrepreneurial university, technology transfer, social impact, public policy, sustainable development goals.

2.1 INTRODUCTION

Sustainable development is a pressing research topic and has gained significant attention from different agents in recent decades (Chaudhary et al., 2023; Anand et al., 2021; Wagner et al., 2021; Shepherd & Patzelt, 2011). Certainly, it is widely acknowledged that economic growth alone will not suffice as a solution to all the challenges confronting our society (Carl, 2020; Giuliani, 2018). Moreover, the disparity between economic development and well-being has notably widened in recent years (Saha et al., 2022). Environmental and social challenges demand complex knowledge recombination (Audretsch et al., 2023) and require various institutions and actors in multiple spheres and formats to be addressed (Knudsen et al., 2021; Besharov & Mitzinneck, 2020). Higher Education Institutions (HEIs) have been demonstrated as relevant agents within a knowledge-based economy (Liu & van der Sijde, 2021; Ramaswamy et al., 2021; Theodoraki et al., 2018; Wagner et al., 2019), incorporating effectively social and environmental aspects alongside technological innovation and economic returns to properly respond to a more sustainable and inclusive society (Menter, 2023).

Universities' role in terms of socioeconomic contributions has evolved over time (Audrestch, 2014), recognized as crucial in advancing Sustainable Development Goals (SDGs) in contemporary discourse (Knudsen et al., 2021; Nikolaou et al 2023; Leal-Filho et al., 2019). They have multiple missions (Reymert & Thune, 2023; Compagnucci & Spigarelli, 2020; Wagner et al., 2019; Siegel & Wright, 2015), and sustainable challenges impose a shift from the "traditional university research and knowledge push toward a mission-driven demand for knowledge and solutions" (Knudsen et al., 2021, p. 210). Many studies have discussed universities' sustainable aspects (see Guerrero & Lira, 2023; Dibbern et al., 2023; Cai & Ahmad, 2021; Gifford & McKelvey, 2019; Leal-Filho et al., 2019), the role of faculty members (Etzkowitz et al., 2021; Carl, 2020; Wyness & Sterling, 2015) and scientific community in sustainable transitions (Dibbern & Serafim, 2021; Zeigermann, 2021). Yet, little is known about the role of technology transfer in this process (Chaudhary et al., 2023; Siqueira et al., 2023; Knudsen et al., et al., 2021).

Prior literature has widely acknowledged that technological development is critical to enhancing the sustainability pillars (Omri et al., 2024; Jie et al., 2023; Ahmed et al., 2022). In the same vein, sociotechnical transitions require multidimensional interactions, and innovative technology-based solutions play a fundamental role (Gerli et al., 2024; Marinakis et al., 2024; Benvenutti et al., 2023; Edge et al., 2020). Nonetheless, we still fall short on contributions that empirically address how universities fit into the sustainability challenges faced by innovation systems. While the Entrepreneurial University concept (Audretsch & Belitski, 2021; Guerrero & Urbano, 2012; Etzkowitz & Leydesdorff, 2000) has been instrumental in further comprehending how technology transfer from universities contributes to innovative endeavors, it is about time we combine this view with the urgent demands posed by social and environmental distress.

To contribute to this debate, the article's main goal is *to analyze the process of sustainability institutionalization in an Entrepreneurial University considering the role of technology development and transfer.* Thus, the question that arises is *how are entrepreneurial university technology transfer dynamics aligned (or not) with sustainable transitions?* Through a single in-depth qualitative case study based on secondary data, network analysis, and interviews at the University of Campinas (Unicamp, Brazil), our findings indicate that Unicamp has addressed approximately half of the Sustainable Development Goals in its technology development and transfer processes, and similarities were identified between sustainable and conventional technology groups. Moreover, *university-level strategic voids*, *endogenous push (bottom-up initiatives)*, and *technology demand as an enabler* are the main emerging topics when discussing the transitional process towards a Sustainable Entrepreneurial University (SEU). University management boards, experts, scientists, firms, and funding agencies are central to SEU transformation, generating broader societal, environmental, and economic impacts.

Through the research and results, we advanced Gifford & McKelvey's (2019) contribution by adding examples of how knowledge-intensive producers are effectively contributing to sustainable development; Guerrero & Lira (2023), and Anand et al. (2021) by presenting a deeper understanding of the entrepreneurial university transition dynamics in a developing country context considering that universities have particular centrality in the dynamics of local innovation ecosystems in these economies (Schaeffer et al., 2021; Fischer et al., 2019); and Cai & Ahmad (2021) once we introduced another layer in their model – government through funding agencies – that places a central role in promoting SEU. Therefore, our findings contribute to two literature streams. First, we discuss technology development and transfer processes, highlighting their internal and external dynamics in universities. Additionally, we advance the scope of sustainable entrepreneurial universities by integrating new points of view on this yet under-analyzed phenomenon. By outlining these, we argue for transforming how we conceive, develop, and deliver technology, aiming for a sustainable transition.

The remaining of the article is organized as follows. The next section presents our theoretical background with the primary references, followed by our methodological procedures using research methods and data. Sections 2.4 and 2.5 are dedicated to results and discussion, and the last section concludes with final remarks, limitations, and avenues for future research.

2.2 LITERATURE REVIEW

2.2.1 Entrepreneurial university

The *entrepreneurial university* (EU) concept emerged in the late 20th and early 21st century (Etzkowitz et al., 2021). It comes from the third mission concept (Reymert & Thune, 2023; Compagnucci & Spigarelli, 2020; Wagner et al., 2019; Siegel & Wright, 2015) based on the need to provide technological solutions to economic systems by means of combining mechanisms and institutions dedicated to facilitating the spillover of knowledge from the university to firms and non-profit organizations (Audrestch, 2014)[4]. Guerrero & Urbano (2012) recognize the EU as a higher education institution aiming to establish an environment to conduct entrepreneurship and innovation within the academic community, encompassing students, professors, scientists, and alumni. Beyond that, entrepreneurial universities perform brokering roles by connecting external partners in the ecosystem and providing and receiving strategic inputs (Schaeffer et al., 2021). The overarching aim is to foster regional development. It serves as a tool that not only generates a skilled workforce and adds value through the creation or transformation of knowledge but also enhances individuals' values and attitudes regarding these matters (Guerrero & Urbano, 2012). In this vein, the entrepreneurial university plays a relevant role in entrepreneurial ecosystems by supplying human capital, education, culture, enabling networks, access to investors, and support systems (such as incubators and science parks), among other facilities (Alves et al., 2021; Fischer et al., 2018; Isenberg, 2010).

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[4] Hence, although initiatives dealing with social and environmental challenges might be included in the scope of the EU, they compose the analytical core of this literature. This is a critical issue when one considers universities' pivotal role in shaping local ecosystems' capacity to promote sustainable transitions (Siqueira et al., 2023).

The EU is at the heart of the triple helix model (Goldstein, 2009; Etzkowitz et al., 2008), consisting of university-industry-government relations that overlap among these institutional spheres (Etzkowitz & Leydesdorff, 2000). In this context, the Technology Transfer Offices (TTOs) are one of the main instruments created by entrepreneurial universities to support knowledge dissemination beyond the university (O’Kane et al., 2021; Audretsch & Belitski, 2021; Compagnucci & Spigarelli, 2020; Audrestch, 2014). In most academic settings, TTOs serve as intermediaries between scientific research and industry, employing specific procedures and practices designed to implement university intellectual property (IP) and technology transfer policies (Owen-Smith & Powel, 2001). Nevertheless, O'Kane et al. (2021) suggest that TTOs have expanded the ‘university-industry intermediaries’ view to be seen as ‘entrepreneurial and innovation ecosystem brokers,’ actively supporting value creation and accelerating entrepreneurship activities where they operate. For instance, in the Latin American context, policies facilitating technology transfer have been marked by enhancing collaboration between universities and industrial partners (Guerrero et al., 2021).

2.2.2 Sustainable Entrepreneurial University

HEIs are well-positioned to promote sustainable entrepreneurial ecosystems (SEE) (Chaudhary et al., 2023; Saha et al., 2022; Theodoraki et al., 2018), having a relevant role in supporting competence development for sustainability (Fischer et al., 2021; Dibbern & Serafim, 2021; Lans et al., 2014). They can support sustainable knowledge transfer (Nikolaou et al., 2023), economic revitalization, and the development of regions (Wagner et al., 2021) from new products and services that prove advantageous for society (Audretsch et al., 2019). Cai & Ahmad (2021) argue that a Sustainable Entrepreneurial University (SEU) represents a new model, describing how SDGs can effectively integrate and transform the mission of the current entrepreneurial university. There are three societal engagement roles in this perspective: (i) universities must be seen as the anchor organization for facilitating knowledge exchange in a multi-stakeholder view; (ii) they are responsible for building trust among diversified collaborators in innovation systems; and (iii) shape a better future by fostering institutional changes (Cai & Ahmad, 2021).

Despite transformation processes in HEIs being case and context-specific, literature has indicated that some general patterns may manage them (Karahan, 2024). Transforming their governance systems to embrace sustainable principles and practices

(Moon et al., 2018), ensuring that the academic community acquires sufficient skills, abilities, and a culture to address societal challenges concretely (Guerrero & Lira, 2023; Fischer et al., 2021), university mechanisms such as changes in curriculum, research orientation, operational aspects (Nikolaou et al., 2023), and producing new sustainable knowledge, or even cumulative knowledge (Dibbern et al., 2023), actively promote sustainability. Scientific research undertaken in universities can play a pivotal role in addressing societal and environmental issues (Leal-Filho et al., 2023), particularly because HEIs play a dual role by both creating and spreading knowledge while participating as contributors to global knowledge discourse (Ramaswamy et al., 2021).

Funding access for sustainability-related activities and sustainability-related policy changes are considered significant external enabling mechanisms (Karahan, 2024), frequently associated with barriers to promoting sustainable initiatives (Aleixo et al., 2018). While analyzing a Belgium university, Verhulst & Lambrecht (2015, p. 195) found out that without extra financing made by local, regional, and national organizations, "a lot of initiatives would not have taken place, or would be realised at a much slower pace, or at the level of individual staff members." Amaral et al. (2023) acknowledge the crucial role of the academic community in securing external funding through patronage to implement clean energy on Portuguese university campuses. Government policies, regulations, and policymakers can foment institutional changes and adoption of sustainable practices at universities, driving its integration and implementation in higher education places (Menon & Suresh, 2022; Pizzi et al., 2022). For instance, Fiselier et al. (2018) highlight the relevance of the United Kingdom government in integrating sustainability into universities through policies that emphasize education for sustainable development and sustainability initiatives (i.e., internal programs and academies).

In the same vein, knowledge spillover arising from academic technology transfer is a key determinant not only for innovation (Compagnucci & Spigarelli, 2020; Audretsch & Belitski, 2021) but also for sustainability achievement (Knudsen et al., 2021; Wagner et al., 2019). Technological development has also proved to be a driver for sustainability with positive results in the green transformation of manufacturing (Cheng et al., 2024), eco-efficiency (Seclen-Luna et al., 2024), on energy issues (Zhang & Yu, 2024; Asghar et al., 2024), and poverty reduction (Kakeu et al., 2024). Research can enhance the quality of technological innovation in such a way as to improve the condition of individuals' lives effectively (Zhang & Yu, 2024), shifting to a new sustainable paradigm (Saha et al., 2022; Wagner et al., 2021). To do that, there is a need to rethink the TTO mission to insert the multidimensional nature of the university research and its value to society “by moving from internal profit creation to capturing other performance indicators, like an increased number of collaborative contracts (Knudsen et al., 2021).”

2.3 RESEARCH METHOD AND DATA

University of Campinas (Unicamp) was used as a single case study, considering the need for exploratory analysis of an emerging research topic (Eisenhardt, 1989). We investigate new concepts and practices according to theory (Yin, 2009), assuming that the “organizational world is socially constructed” (Gioia et al., 2012, p. 17). Unicamp is a great example of an innovative and research university (Granja & Visentin, 2023) following a research university model (Schwartzman et al., 2021). It is also one of the main Brazilian universities in technology production and transfer (Fischer et al., 2021) and a high-level education center (da Silva et al., 2018). The university is recognized as the 2nd best university in Brazil, 8th in Latin America, and 220th internationally according to the QS World University Rankings 2024[5]. In the SCImago[6] Ranking, Unicamp is the 3rd best university in Brazil, 4th in Latin America, and 273rd globally.

Founded in 1966 in Campinas, State of Sao Paulo, Brazil, Unicamp integrates teaching, research, and extension (or third mission) – a new approach at that time. In 2024, the university has around 23 teaching and research units, 37,619 students, 51 undergraduate programs, and 156 graduate ones (stricto and lato sensu) in many fields of knowledge (Unicamp, 2024). Since its inception, Unicamp has taken interaction with firms as a core activity, and this strategy allowed public and private partnerships with various organizations, thus being an illustrative example of an entrepreneurial university. Unicamp’s TTO dates back to the 1980s, and it was the first national university to implement an Innovation Agency, INOVA, in 2003, which is responsible for TTO activities. Since then, the agency has updated the university’s patents list, licensing information, and related topics every year – the only agency in Brazil to publish such details in an official report, following international best practices. Data from the National Institute of Industrial Property (INPI, 2021), the Brazilian patent office, indicates that in 2021, almost 70% of the total fillings in the country were made by universities – Unicamp is in the top 10 applicants.

[5] More info https://www.qs.com/rankings-released-qs-world-university-rankings-2024
[6] More info https://www.scimagoir.com/rankings.php

Our analysis was based on two different sources to identify the processes through which Unicamp has incorporated sustainable development as an institutional feature. From one side, we analyzed patent and licensing information from Unicamp regarding their sustainable alignment, available in public repositories. This allowed us to create two groups for comparison. From the other, we conducted interviews with institutional agents in charge of sustainability actions at the university and explored official documents such as Strategic Planning, website, events, and courses to comprehend the degree of sustainability institutionalization at Unicamp. We triangulate the results to describe (i) how the sustainable technologies and associated intellectual property rights were developed under the university domain and transferred to the market and (ii) what policies/activities the university administration is conducting to foster sustainable practices.

2.3.1 Secondary Data Collection and Analysis

Patent network analysis was used to comprehend knowledge production and technology transfer at the University. The patents included two sets of information: (i) technology characterization based on intellectual property rights and (ii) transfer agreement characterization. This analysis explored the types of licensing companies and/or with which Unicamp collaborated, the leading knowledge producers, and how the connections have been created.

2.3.1.1 Data collection

According to the INOVA's annual report published in 2021, between 2004 and 2021, the university had a portfolio summing up 1276 patents (including both submitted and/or granted in worldwide offices), 275 licensing agreements, and 197 active licensing agreements[7] (Inova, 2021). We characterized these 197 active agreements according to technology and transfer agreement features. It was necessary to use different sources of information to complement and/or validate them, such as the INOVA Website, INPI, and Espacenet[8] detailed in Table 2.1:

[7] 'Active licensing' refers to those that have still a valid/active agreement. The same intellectual property can be licensed more than once.
[8] More info https://worldwide.espacenet.com

Table 2.1 *Secondary data collection sources*

Type	Source	Use
Patent number	INPI	Technology characterization
Applicants/assignee (other than Unicamp)	INPI	Technology characterization/ Collaboration
Inventors (inside and outside Unicamp)	INPI	Technology characterization/ Collaboration
Technical information	INPI	Technology characterization
Year of deposit	INPI	Technology characterization
Year of granted (when applied)	INPI	Technology characterization
Patent family	Espacenet	Technology characterization
Citations (cited and citing documents)	Espacenet	Technology characterization
Legal events (submission and approval history)	Espacenet	Technology characterization
General description (commercial info)	INOVA	Transfer agreement characterization
Inventors from Unicamp	INOVA	Transfer agreement characterization/ Collaboration
Companies that licensed patents	INOVA	Transfer agreement characterization

2.3.1.2 Data classification

The criteria used to classify licensed IPs were made by text analysis identifying characteristics under SDGs definition and indicators, adding them to a specific goal whenever possible. Words such as green and clean technology, energy efficiency, quality of life, waste reuse, disease treatment, nutritional improvements, natural materials, clean fertilizing, water treatment, biodiversity, and climate change were used as classifications (ONU, 2023). Two groups emerged:

- *Sustainability-oriented technologies:* composed of licensed technologies that have sustainable aspects in their core development. They can be separated into 71 patents (with 77 licensed agreements), 11 software, 11 know-how, 3 biological agreements transfers, 3 trademarks, and 1 copyright, and they include 207 inventors.
- *Conventional technologies:* composed of licensed agreements considered under traditional development and without direct relations with any SDGs indicators. We categorize them as 54 patents (with 60 licensed agreements), 4 software, 3 sui generis rights, 2 biological agreements transfer, 2 know-hows, and 1 copyright, summing up 155 inventors involved.

Considering the higher number of patents compared with other types of intellectual property licensed, we decided to remove all other IP types and use exclusively patent information and their transfer agreements. We use patent licensing in these two groups as a market interaction proxy to compare them, examining how knowledge extends beyond the university to bolster or hinder sustainable development. Additionally, attributes such as collaboration and funding are compared on the demand side.

We split licensing organizations' names into categories according to their size (number of employees) and type. *Spin-offs* are those companies created by Unicamp's students/scientists based on technologies developed within the university; *small-medium (national)* and *small-medium international* (operating outside Brazil) companies are enterprises with up to 499 employees; *national large* companies from 500 employees; *multinational* companies are those operating in at least one country outside their home countries; *public organizations & government* included public and private universities and government; and *confidential* are entities without information on the Unicamp's database. Furthermore, information obtained during the interviews helps to understand and validate the comparison between the two groups.

2.3.1.3 Data analysis

Network analysis was employed to recognize the structure, patterns of relationships, and connections between actors (Maghsoudi et al., 2023; Wichmann & Kaufmann, 2016). This technique offers an additional methodological triangulation, allowing a distinct approach to analyzing and interpreting the same dataset (Smiraglia, 2015). We used Gephi 0.10.1 to create graphs to visualize the extent of interconnectedness among the patent's development, collaboration, and dissemination through transfer agreements.

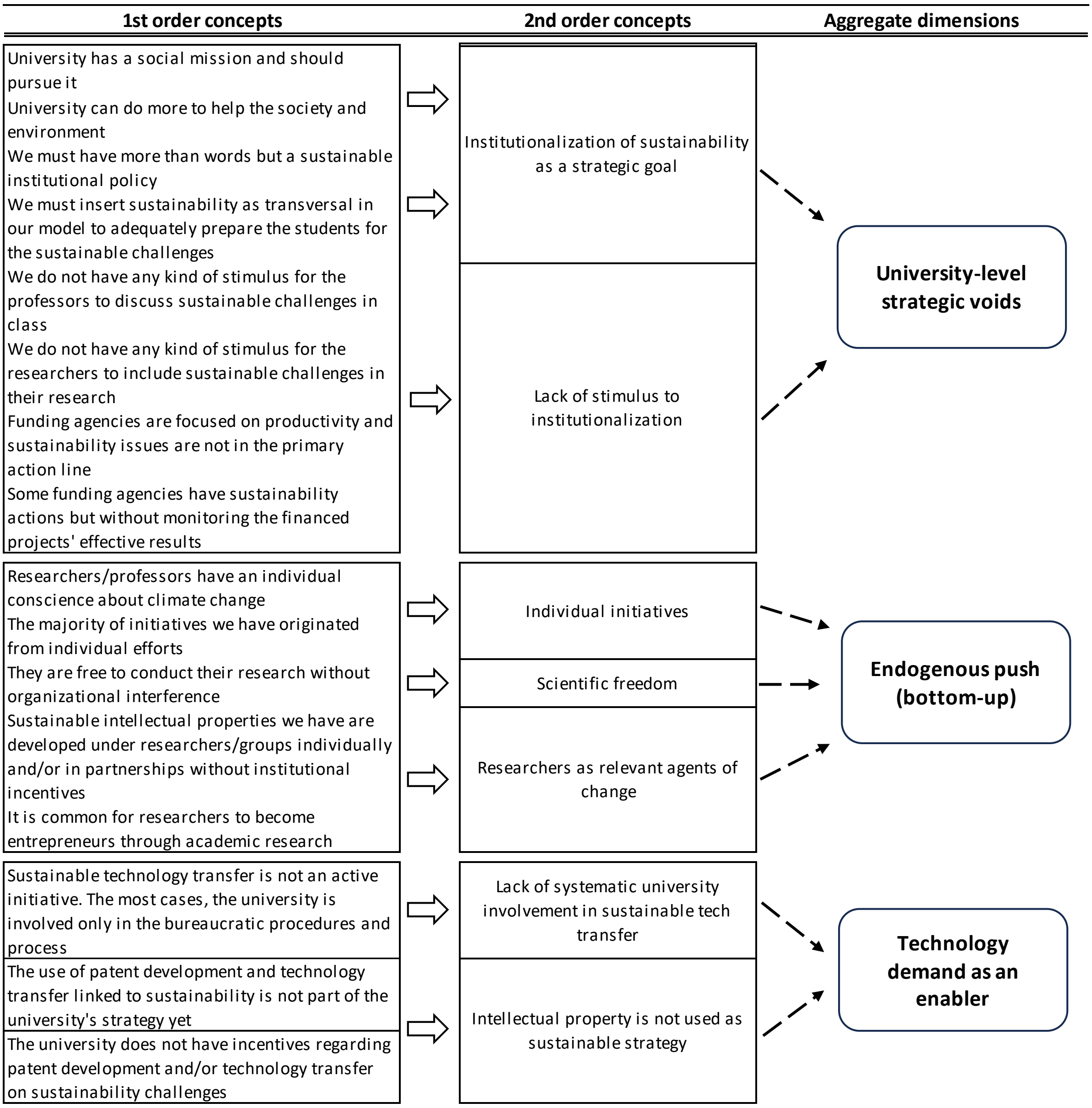
2.3.2 Primary Data Collection and Analysis

Alongside the document analyses, we conducted 10 in-depth interviews with project coordinators, managers, professors, and administrative personnel from Unicamp between September and November 2023 to identify how technology transfer dynamics occur in the university environment. These are considered "knowledgeable agents" and can explain their thoughts, intentions, and actions profoundly once they know what they are trying to do inside their organizational realities (Gioia et al., 2012, p. 17). All participants gave their consent for the interviews to be recorded, after which they were transcribed completely using specialized software and subsequently reviewed by the authors. An overview of the interviewees can be found in Appendix I. The topics discussed during the interviews were:

- University and its role in the society (Carayannis and Campbell, 2010; Etzkowitz & Leydesdorff, 2000);
- Level of institutionalization of sustainable practices in the university (organizational structure, inclusion in official documents, guidelines, and events, etc.) (Cai & Ahmad, 2021);
- Teaching and research practices around sustainability (Saha et al., 2022; Carl, 2020; Moon et al., 2018; Wyness & Sterling, 2015; Lans et al., 2014);
- Technology development, patents and technology transfer as sustainable strategies (Nikolaou et al., 2023; Knudsen et al., 2021; Wagner et al., 2019);
- Policy development to sustainability (Allen, Metternicht & Wiedmann, 2021; Zeigermann, 2021; Arnott et al., 2020).

The results were codified following these categories to predict similar findings and contrasting results (Eisenhardt, 1989). The codification protocol is taken from Gioia et al. (2012) and involved participative and iterative processes among the authors. We employ first-order concepts from the transcripts to understand the data and create similar patterns, giving them phrasal descriptors based on interviewees' words. The *university-level strategic voids* represent the institutionalization of sustainability as a strategic goal and a lack of stimulus to it, reflecting current internal arrangements at Unicamp. Then, we obtained the *second-order concepts* from that initial list and identified emerging concepts that explain the phenomena we are studying. *Endogenous push* combines individual initiatives, scientific freedom, and researchers as relevant agents of change to corroborate the bottom-up initiatives. The last step was developing an *aggregate dimension* that further specified the concepts we had found in the previous round. The lack of systematic university involvement in sustainable tech transfer and the fact that intellectual property has not been seen as a sustainable strategy result in *technology demand as an enabler*. All these processes are illustrated in Figure 2.1.

***Figure 2.1** Interview Data Structure*



2.4 RESULTS

2.4.1 NETWORK ANALYSIS

2.4.1.1 Collaborations for technology development

The network analysis supports the determination of how the researchers are connected inside and outside the university. Using data about 207 inventors of sustainable-oriented patents (Appendix II), we discovered that some of them were associated with Unicamp and other external organizations, primarily universities (18). Researchers from the Institute of Biology (41), Faculty of Food Engineering (32), Institute of Chemistry (30), and School of Medical Sciences (19) of Unicamp were responsible for developing the most sustainable-oriented licensed technologies. All of them have connections at some level within the university – among themselves – and outside with other universities (16 national and 2 international), small-medium companies (4), spin-offs (4), national large companies (3), multinationals (2), international research institutes (2), and national research institutes (2). Nevertheless, taking together all external collaborations with private organizations, only a small number of researchers from those companies worked directly in partnership with Unicamp (15) – many of them during master's or doctorate studies.

Out of 71 intellectual properties, we discovered that 25 (35%) involved Unicamp and other organizations as co-assignees, with 21 private companies (national and multinational) and four other universities and/or university foundations. Considering that funding agencies are the main agents responsible for research investments in Brazil and private companies have little participation in Unicamp's IP protection, we highlight that knowledge is transferred, not co-created, and most sustainable technologies were developed through public investments from governmental sources. Despite some companies being patent co-assignees, this does not translate into more collaboration between researchers from university labs and company labs. As previously shown, only 15 inventors from these 21 companies were involved in the development of the patents.

Enclosing all those 155 inventors of *conventional technologies* (Appendix III), the School of Electrical and Computer Engineering (40), Computing Institute (21), School of Mechanical Engineering (13), and School of Chemical Engineering (12) are the most representative affiliations at Unicamp behind the development of those licensed technologies. Inventors from national research institutes (5), spin-offs (5), multinationals (3), small-medium companies (2), national large company (1), and university (1) also appear in the sample. Interactions with private companies as co-assignees also followed similar patterns of the sustainable group. Among 60 PIs, we identified that 25 (41%) were made by Unicamp alongside other co-assignees, of which 23 were private enterprises, and 2 were Sao Paulo Research Foundation (FAPESP) and Brazilian Center for Research in Energy and Materials (CNPEM). Thus, around 38% of the investments in conventional technologies have some private funding participation.

To sum up, sustainable technologies involve slightly more external interactions among researchers than conventional ones, which are mostly developed inside university institutes and departments. In both cases, technological development in terms of researcher interactions derives more from university collaboration (internal or external groups) than university-industry. Interestingly, private companies' participation as co-assignees demonstrates fruitful results, with almost one-third of sustainable technologies patented in partnerships and almost half in the conventional group.

2.4.1.2 Patents and License Agreements Characterization

In the *sustainability-oriented technologies* group (77 licensing agreements), we discovered a significant range of organizations that have licensed Unicamp's university technologies (Appendix IV). The most prevalent are small-medium enterprises (34), followed by spin-offs (24), national-large (9), multinational companies (6), confidential companies (3), and a public organization (1). This diversification of organizations utilizing Unicamp's technologies, particularly in the national sector, underscores the broad impact of Unicamp's technology transfer efforts. In contrast, conventional technologies (60 licensed agreements) are licensed by a different set of organizations, with spin-offs (27) being the most common, followed by small-medium enterprises (19), multinationals (6), national large companies (3), confidential (2), small-medium international companies (2), and a public organization (1) (see Appendix V).

Despite the similarities between the two groups, we can observe a slight inversion in the main categories of licensing organizations. For instance, the conventional group has licensed technology across borders, achieving small-medium companies outside the country. From this perspective, we have more internationalized licensed IPs in the conventional group. Another interesting finding is that we identify two public organizations with licensing roles in both groups (Adamantina City Hall and Central Laboratory), meaning some governmental spreading of technology produced under the university.

Our analysis also considered the classification of sustainable patents according to the SDG and the type of licensing company for the first group of technologies. From a total of 17 goals, our sample addresses a significant eight of them: Second - Zero Hunger, Third - Good Health and Well-being, Sixth - Clean Water and Sanitation, Seventh - Affordable and Clean Energy, Tenth - Reduced Inequalities, Eleventh - Sustainable Cities and Communities, Twelfth - Responsible Consumption and Production, and Thirteenth - Climate Action. The most common goal appearing in the IPs is goal twelfth, followed by goal third. This alignment of Unicamp's technologies with these crucial SDGs underscores the societal impact of these technologies. Small-medium companies and spin-offs are the main types of licensing companies.

Almost half of the patents relate to two or three goals regarding their characteristics, and some arrangements are common. For instance, patents linked in goals 2, 3, and 6 are frequently connected with 12, mixing issues on (i) nutrition improvement and sustainable agriculture; (ii) healthy systems aggregating vaccination and disease control; and (iii) sustainable water and chemical management, simultaneously with the reuse of waste in the food/agriculture industry, managing chemical products in an environmentally friendly way, and working on efficiency use of natural resources.

2.4.2 INTERVIEW AND DOCUMENTARY ANALYSIS

2.4.2.1 University-level strategic voids

Unicamp has a Strategic Planning (GePlanes, 2023) process discussed since 2004 that considers medium- and long-term horizons, with the main goal of enhancing university management. Nevertheless, it was only in the 2021-2025 Strategic Planning that sustainability was effectively conceived as a core axis, and all the planning was developed under a sustainable framework (Planes, 2020). Interviewees reinforced that the university must have a social and environmental commitment and needs strategies to conduct sustainability at different levels. Although Unicamp has not yet implemented a sustainability policy, it has made some efforts in this direction. For instance, it is part of the University Network for Sustainable Development[9] and of the International Union for Conservation of Nature and Natural Resources Academy[10], and it is in the 10th position at Green Metrics Latin America Ranking[11] and 73rd worldwide in 2023. Other relevant actions are the International Hub for Sustainable Development (HIDS, 2024), Sustainable Campus (Campus Sustentável, 2021), and environmental practices such as changing old electrical systems for more efficient ones and introducing electrical buses at the main campus. All projects are developed and/or funded via external partnerships or submitted to the university directorship for analysis: "*We are in the approval process to get a specific budget for sustainability area to apply in actions yearly [2023].* (Inter1)"

Through these initiatives, we captured some conflicts in institutionalizing sustainability and a lack of incentives for sustainable technological development. We have monitored sustainability discourse in official documents, websites, and specific actions. However, its translation into practice remains limited in scope since "*we still have*

[9] https://unitar.org/ny/universities/university-of-campinas
[10] https://www.iucn.org/our-work/iucn-academy
[11] https://greenmetric.ui.ac.id/rankings/overall-rankings-2023

a fragile organizational structure to deal with sustainability issues inside the university" (Inter8). According to the interviewees, there is no stimulus to include sustainable challenges in teaching and/or research practices and technology development efforts. There seems to be a joint agreement among the interviewees about the need for guidelines and incentives to support researchers and professors around sustainable topics, and the university should embrace these actions firmly as one interviewee highlights, "*I think it makes perfect sense [top-down actions] to prioritize the emergency we have been experiencing. If we do not take care of this, there is no future; there is no point in research if the planet is not habitable*" (Inter5).

Interviewees believe that the university lacks coordination and prioritization with explicit goals regarding the institutionalization of sustainability; research projects are too pulverized without efforts to aggregate them, as declared, "*I do not see the strategic planning unfolding into an articulated action plan*" (Inter8). According to interviewees and the network analysis, there is a fertile ground for sustainable technological development at Unicamp. The university leadership could support the growth of solutions to the most urgent challenges, which will, through licensing, impact society.

2.4.2.2 Endogenous push (bottom-up)

Even though there are institutional projects addressing sustainability, most of the sustainability initiatives at Unicamp have been driven by individual actions from researchers and faculty members. Their awareness has led to the inclusion of sustainability topics at the university level, resulting in the creation of specific courses, research projects, and groups, as well as the pursuit of funding and partnerships. A survey by the HIDS initiative identified around 78 independent sustainable research projects/initiatives at the university in different themes, such as education, renewable energy and water, climate change, human rights, and health (HIDS, 2023). Unicamp has started recognizing and organizing laboratories and research centers created in different periods and fields, often supported by funding agencies. These entities may have sustainable connections and are referred to as Thematic Centers "[…] *the centers were opened by individual initiatives or research groups. The conclusion we have a posteriori is that most of them are linked to some SDGs, and the institutional effort now is to conduct them in some way to fulfill these centers' needs*" (Inter9). Thus, there is an initial effort to recognize, map, and formalize existing sustainable initiatives, providing them with administrative and management support rather than encouraging new ones.

However, some interviewees criticized the university executive board for its insufficient actions while highlighting the faculty's position on addressing the sustainability challenges: "*Despite the lack of institutionalization of sustainability, Unicamp is very engaged with society's movements. Sustainability issues are latent, people are mobilizing, and this is reflected in their study's objects, research, project's management, and represents how researchers are sensitive to what happens around them*" (Inter2). Even without many official incentives to support sustainable projects within the university, researchers have become important agents of change. This is evident through their internal and external collaborations to develop sustainable technologies, as seen in network analysis. As a result, there is an intrinsic drive with bottom-up actions from specific groups. When individuals hold sustainable views, sustainable inquiries are developed, but when they do not, no efforts are made.

Entrepreneurship is another individual action made by researchers using technologies developed under university projects and research groups. Recognizing the potential applications of their findings, researchers become entrepreneurs obtaining licenses for the technologies they helped develop. In the latest UI Green Metric Report (2021), Unicamp identified 15 sustainable spin-off companies whose technology development occurred inside the university, but the number could be higher. There is no cooperation between departments to provide a reliable official number "*We do not have a separation on what is [sustainable] and what is not. [...] Most of the time, I must look into it by myself, one by one, and identify them [companies] based on evidence*" (Inter3). We note miscommunication and a lack of internal cooperation that could support the university's sustainable development. Institutional support can amplify individual actions, translating them into sustainable technologies for society, leading to a broader impact through transfer agreements.

2.4.2.3 Technology demand as an enabler

University researchers are primarily responsible for driving the development of sustainable technologies. They often work independently with limited involvement from private companies; their primary research funding comes from the government through research and innovation funding agencies whose commitment still relies on traditional metrics of productivity and visibility. When submitting a project, some agencies have requested that researchers describe which SDG the research addresses. However, after the investment is secured, "*There is no monitoring or mandatory indicator to be followed* *during the delivery of the reports, and it falls into oblivion. The researcher will only remember SDG again when submitting a new project. In the end, they want to know how many articles you have produced, how many thesis/dissertations were written... traditional metrics*" (Inter4). In other cases, the funding agencies attribute SDGs to their projects according to their interpretation, which one interviewee criticizes "*there is no self-declaration from researchers, someone makes a bureaucratic choice from the agency. […] We must leave the discursive sphere and go to practice*" (Inter6).

Even with few incentives to research sustainable topics, some groups are working on knowledge-based technologies and offering them to the market through patenting and agreements. The university's actions are limited to bureaucratic procedures such as legal support, agreement signing, and patent deposit support without a proactive approach to contacting companies to transfer their potentially sustainable technologies. Unicamp's Innovation Agency, responsible for TTO, has been striving to incorporate a sustainable agenda into its activities since 2023, as patent development and tech transfer are not yet part of the university's sustainable strategy. "*We still do not have guidelines on developing projects in sustainability. There is PLANES (Strategic Planning), some premises within the university, but our area does not act to guide the researcher; what we can do is offer some stimuli, and we are starting to do that [this year, 2023]" (Inter10), the* interviewee said. As part of a national certification to its incubator, the agency has created some sustainable initiatives such as an Environmental, Social, and Governance (ESG) committee to promote sustainable actions across the university and support researchers, a Social and Environmental Responsibility Policy, waste management, reverse logistics agreement, some events, among others. "*The certification is made for the incubator, but considering our agency runs it, we decided to apply sustainable practices in all our departments and for Unicamp as a consequence*" (Inter10), demonstrating a commitment to a sustainable agenda. They plan to implement new strategies and projects for the next few years, including special sustainable calls to incentivize scientists to develop new projects. We also highlight that the Inova Jovem Project, an entrepreneurial competition for high school students open to all country, has included sustainable topics since 2022 (Inova, 2023).

On the one hand, there are high levels of sustainable interest from researchers; on the other, there is a lack of systematic university involvement. Meanwhile, a new organizational setup is emerging to promote and improve sustainable incentives, which could potentially have a significant impact. The process of integrating sustainability initiatives into Unicamp through technology development and transfer appears to be lacking. As a result, the university is missing out on the opportunity to transfer improved technologies to the market, both to public and private organizations. This strategy seems to be underemphasized in current discussions.

2.5 DISCUSSION

Our primary goal in this article is to analyze the transitional process of an entrepreneurial university towards sustainable contributions through technology development and transfer. We reveal different layers of how sustainability topic is included and implemented in a particular university, resulting in sustainable actions. Assuming that institutional configuration and policy environment can promote or hamper scientific/technological transfer (Zeigermann, 2021), we argue that sustainability can potentially influence technological development and transfer dynamics at HEIs positively. At the institutional level, Unicamp is addressing those challenges by recognizing and inserting them into their strategic planning even though few practical results have arisen; at the policy level, we observe insufficient incentives by public research funding agencies to conduct a sustainable transition inside HEIs.

This background fails to promote sustainable technological development and transfer, hinders sustainable management, and ignores scientific research's full potential and associated technologies. Funding agencies could stimulate this process by (i) elaborating guidelines and structural requirements for actionable results (i.e., grants proposal, calls, etc.), (ii) improving the review and analysis of proposals submitted, including explicitly sustainability indicators, (iii) providing financial support not only for research but also for the sustainability implementation process, (iv) learning through evaluation to track the process of sustainable evolution in projects/programs (Arnott et al., 2020), and (iv) disseminating guidelines and best practices to the universities once institutionalization has potential to boost sustainable technologies. This set leads us to the first proposition:

P1: University sustainability institutionalization requires internal and external collaboration as transversal strategies. At the government level, research and innovation funding agencies are pivotal in R&D investments in public universities. They should embrace sustainability as a priority policy to promote sustainable technology development and transfer.

Science must play a relevant role in SDGs achievements (Allen et al., 2021; Shrivastava et al., 2020) and researchers' awareness can positively impact the sustainable agenda. The academic community is well-positioned and can influence the public debate (Dibbern & Serafim, 2021); effective responses to universal challenges require essential two-way communication between researchers and policy actors (Allen et al., 2021). We observe a considerable internal mobilization among researchers to conduct their practices according to sustainable ones. Nevertheless, the extent to which sustainable practices are integrated into scientific research depends on researchers' personal inclinations and access to funding.

Ideally, universities should align the priorities of funding agencies with research activities to provide a clear direction for research. It is not about delimitating the researcher's inquiries but orienting to encircle areas to canalize this bottom-up movement (that already exists) in specific directions. While we agree that scientific freedom is valuable for scientists (Posso & Zhang, 2023; Hutchens et al., 2023; Kinzelbach et al., 2022), we also recognize that applied science with oriented outcomes toward sustainability should be prioritized (Shaw, 2022). The university must overcome its limitations to enable sustainability both in theory and in practice, combining leadership, innovation, institutional commitment, top-management support, communication, and teamwork (Sacchi et al., 2023; Menon & Suresh, 2022; Blanco-Portela et al., 2017). Thus, HEIs must assume their responsibility by finding ways to enhance individual/group actions that already exist and to stimulate when they do not happen. An additional proposition emerges in this debate:

P2: A Sustainable Entrepreneurial University combines bottom-up and top-down initiatives, with researchers as relevant agents driving technology development converging with a sustainable agenda.

Universities are central axes of local ecosystems (Siqueira et al., 2023; Wagner et al., 2019; Alves et al., 2021; Fischer et al., 2018), and Unicamp has a relevant role. Using the technology transfer level as the unity of analysis for sustainable results, we found that the university provides sustainable technologies to the market despite the lack of incentives. A great amount of investment in sustainable patents comes from public sources – essential to enhance sustainability (see Ahmed et al., 2022) – while private companies have minor participation. However, the connection between universities and industry could be intensified by (i) project collaboration fulfilling specific appeals of development for firms regarding sustainability, (ii) regulatory requirements and incentives policies, (iii) partnerships focused on the development of new products/services replacing unsustainable ones, and (iii) TTOs engagement through sustainable guidelines devoted to building science and technology processes not only from an economic view but also societal ones.

TTOs have a distinguished place in this new configuration once they are strategically positioned to take the knowledge produced by the university and connect it with the market needs. Therefore, an SEU must rebrand its TTO activities to include a sustainable view beyond the traditional agreements, reinforcing the positive impact the technology may have on society. To properly embrace sustainable technology transfer, innovation agencies can develop flexible mechanisms (i.e., partnerships with spin-offs to access internal technology) that consider the potential impact of technology on society. A specific policy for sustainable transfer approaches seems a reasonable path to potentialize technology transfer and knowledge flow outside universities. Science commercialization can generate long-term societal impact rather than strictly generating profits only (Knudsen et al., 2021; Fini et al., 2018); companies and universities aiming for sustainable development must change their approach to innovation, fostering different types of collaboration and a shared agenda.

Our last proposition is as follows:

P3: Flexible technology transfer agreements focusing on social and environmental impact generation are a course of action to foster Sustainable Entrepreneurial Universities.

We advocate for a rethink on entrepreneurial universities in the context of their purposes (Knudsen et al., 2021; Siegel & Wright, 2015), (re)configuring how they move towards sustainable components to generate positive impacts (Guerreiro & Lira, 2023) through collaboration among different actors (Chaudhary et al., 2023; Knudsen et al., 2021; Wagner et al., 2019). A reasonable path is a participative approach in which national policies through research and innovation funding agencies ensure sustainable investment alongside the university administrative board actively leading and encouraging collaborative actions among researchers, government, and industry. The concept of the Sustainable Entrepreneurial University is multidimensional, and so are the strategies employed to achieve it. It is not only about top-down initiatives or even bottom-up efforts developed by specific groups. However, it involves a broader range of agents, including economic and production systems, governmental policies, and funding agencies.

Specific roles for each key agent involving core competencies that can overlap each other are part of our proposal. For instance*, research and innovation funding agencies* are responsible for fostering science and technology development by creating programs and allocating financial resources to foster transitions at both national and state levels. The *university* provides physical structures, laboratories, equipment, and salaries, but it must also stimulate changes in its internal policies and resources for research to improve its governance. *Companies* can demand but also develop technologies in partnership with universities, becoming active players in these processes and accelerating them. In turn, *researchers* collaborate in all spheres, producing actionable science (Arnott et al., 2020). Leadership commitment and external partnerships are central to the transformation process (Karahan, 2024).

2.6 CONCLUDING REMARKS

Universities are critical players in entrepreneurial ecosystems and achieving sustainable development, providing knowledge, technology, scientists, highly qualified teaching, and a workforce to deal with current challenges. From the results, we consider Unicamp as an Entrepreneurial University transitioning to a Sustainable Entrepreneurial University at the initial stage, with room to develop and be a model for Brazil and Latin America. In order to achieve this, a university must prioritize and coordinate its efforts to address institutional gaps – this applies to any university aiming to be sustainable. Higher education institutions must integrate social value into their work, with support from researchers who offer a creative mix of knowledge. This will generate new solutions that can be adopted by society and/or the market. On the research and innovation funding agencies' side, investments can be driven by sustainable paths with specific criteria and indicators to prioritize and monitor results.

This background grounded in sustainable institutionalization will allow the knowledge and technology generated at the university to flow outside and positively impact the social, environmental, and economic aspects through technology transfer agreements. These agreements are vital tools in sustainable development, and universities are well-positioned to contribute to this discussion. The patent analysis suggests the existence of sustainable initiatives even without institutional frames positioning them, revealing that the science community is already addressing sustainable challenges. While it is not the ideal scenario, it is worth mentioning that Unicamp has addressed approximately half of the Sustainable Development Goals in its transfer process. However, this number can increase with the appropriate stimulus in the coming years.

It can also be emphasized that similarities between the dynamics of technology development and IP rights between sustainable and conventional technologies were identified. For example, technological development in terms of researcher interactions derived more from university collaboration (internal or external groups) than university-industry in both cases. Interestingly, private companies' participation as co-assignees demonstrates fruitful results, with almost one-third of sustainable technologies patented in partnerships with firms and nearly half in the conventional group. Therefore, the universities do not need to completely rebuild their TTOs and Innovation Agency to include sustainability once it has been already happening. Instead, creating guidelines, coordination, and strategies to reinforce sustainable developments and partnerships will promote more sustainable technological development and technology transfer agreements.

We know that our data comes from a localized primary and secondary qualitative source, and generalizations should be taken cautiously. Despite limitations, the paper provides a theoretical and practical contribution to comprehending the intersection of sustainable technological development and transfer with the level of sustainable institutionalization inside the university. Promising avenues for future research could complement our paper by adding other universities, both local and international, to reveal the technological dynamics around sustainability process and transfer. Another possibility is using quantitative data to explore how technology transfer impacts university sustainable engagement. We believe the analytical propositions in this article can offer a robust starting point for endeavors dealing with such pressing topics in the domain of academic impacts in innovation systems.

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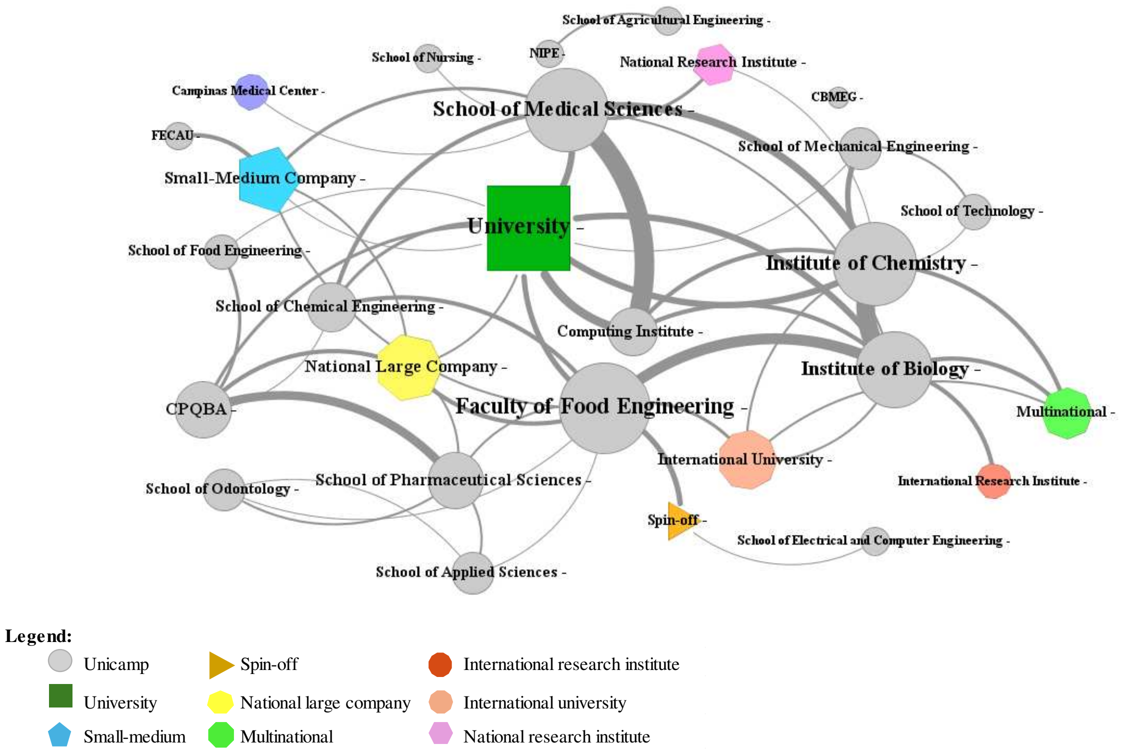
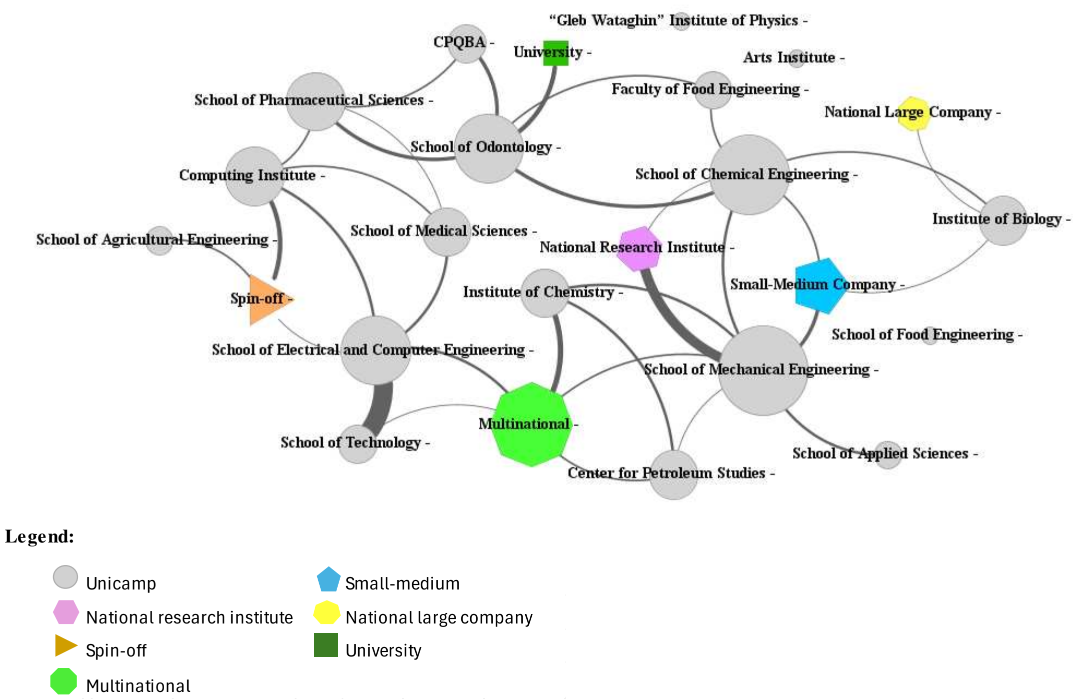
APPENDIX I – SUMMARY OF INTERVIEWEES' PROFILES

Position	Affiliation at University or field	Code	Date	Duration of interview
Coordinator	Sustainable initiative	Inter1	September, 14th	1h 25' 19"
Researcher	Sustainable initiative	Inter2	September, 19th	40'42"
Coordinator	Sustainable initiative	Inter3	September, 19th	39'22"
Coordinator	Sustainable initiative	Inter4	September, 22nd	35'38"
Researcher	Hard sciences	Inter5	September, 25th	19'24"
Director	Institute representative	Inter6	September, 29th	1h 30' 25"
Researcher	Social sciences	Inter7	October, 6th	1h 34' 55"
Researcher	Hard sciences	Inter8	October, 11th	1h 33' 22"
Director	Administration	Inter9	October, 17th	1h 08' 04"
Manager	Innovation Agency	Inter10	November, 7th	42'16"

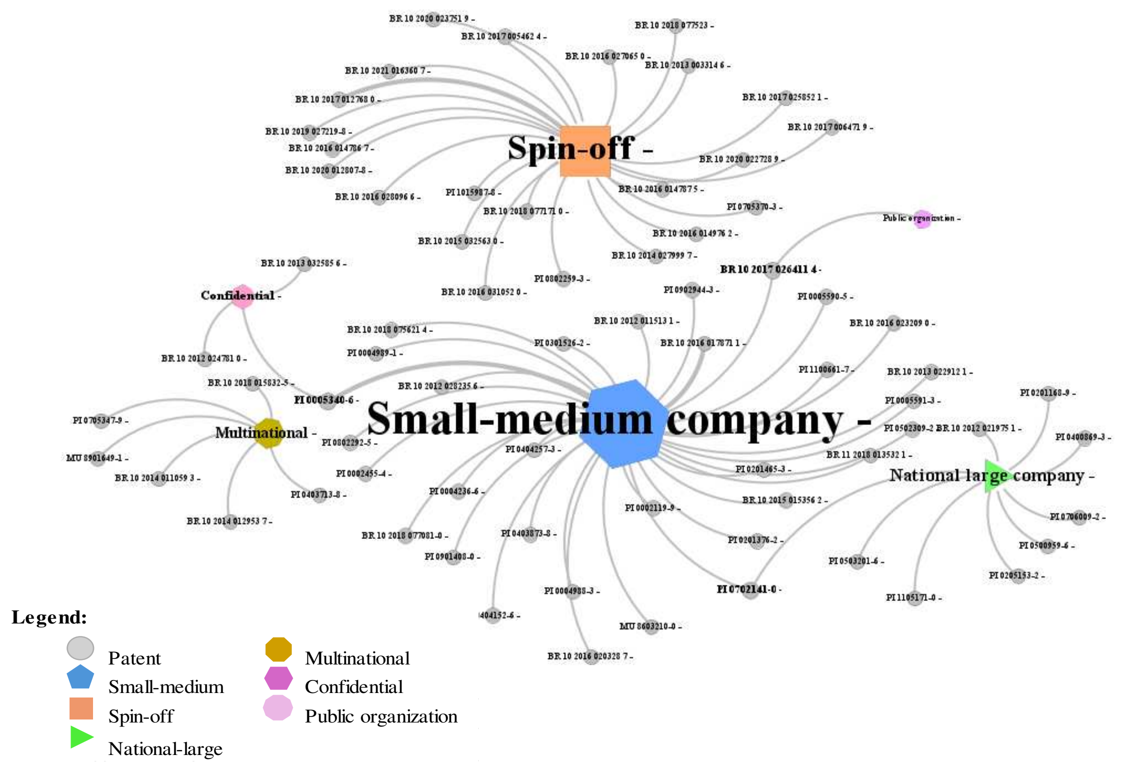
APPENDIX II – SUSTAINABILITY-ORIENTED TECHNOLOGIES | COLLABORATION AMONG UNICAMP'S DEPARTMENTS AND EXTERNAL PARTNERS



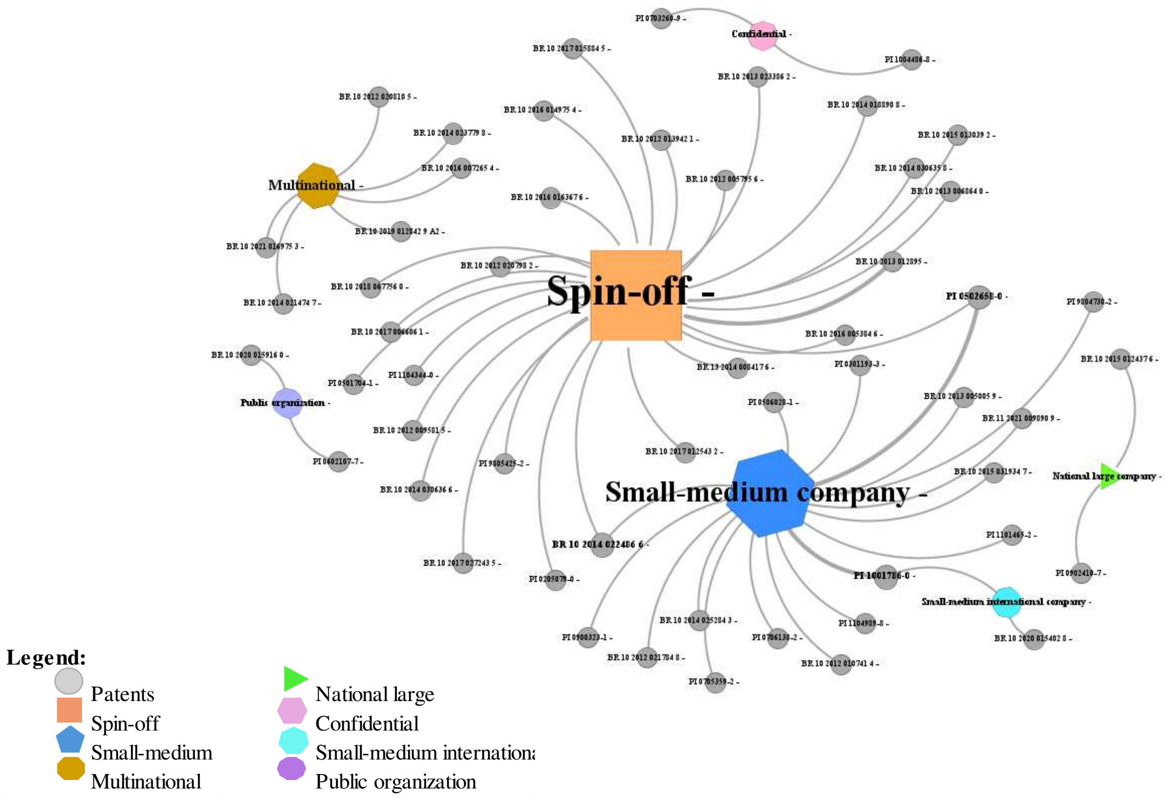
APPENDIX III – CONVENTIONAL TECHNOLOGIES | COLLABORATION AMONG UNICAMP'S DEPARTMENTS/FACULTIES AND EXTERNAL PARTNERS



APPENDIX IV: SUSTAINABILITY-ORIENTED TECHNOLOGIES – PATENTS LICENSING PER TYPE OF COMPANY



APPENDIX V: CONVENTIONAL TECHNOLOGIES – PATENTS LICENSING PER TYPE OF COMPANY



CHAPTER 3: UNIVERSITY EFFECTS ON UNDERGRADUATE STUDENTS' VIEWS AND SUSTAINABLE ENTREPRENEURIAL INTENTIONS

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Journal: Submitted to the International Journal of Sustainability in Higher Education, Qualis A1

Ethical Committee approval: CAAE 75700423.6.0000.8142

ABSTRACT

Sustainability issues have gathered significant attention in academic circles, prompting extensive debates regarding the role of universities in fostering sustainable development. Despite the literature's advancements, there remains a lack of understanding of university students' behaviors and entrepreneurial intentions toward sustainability. To contribute to this debate, this article's main goal is to delve into the effects universities may have on undergraduate students' views, behaviors, and entrepreneurial intentions toward sustainability. Through an exploratory factor analysis, we conducted a survey at the University of Campinas (Sao Paulo, Brazil) involving 485 students from business and hard sciences disciplines since they are taken as potential entrepreneurs. Our results demonstrated a mismatch between the university context and sustainable entrepreneurial intentions. However, factors related to the university and student-university engagement highlighted positive significance. Students expressed heightened interest in flexible activities and maturing entrepreneurial intentions by interacting with organic approaches. Underling this aspect, we advocate for integrating top-down (such as training, events, sustainable incubators, partnerships, etc.) and bottom-up strategies (such as student organizations, volunteering programs, collaborative spaces, etc.) to develop sustainable initiatives. These initiatives have the potential to evolve into entrepreneurial intentions and, more importantly, foster long-term sustainable awareness, thereby creating a sustainable culture.

KEYWORDS: Sustainable ecosystems; Sustainability; Entrepreneurship; Sustainable Universities.

3.1 INTRODUCTION

The topic of sustainability within universities has garnered significant attention in academic circles, sparking debates on various aspects such as alignment with Sustainable Development Goals (SDGs), the role of universities in the entrepreneurial ecosystems contributing to the SDGs, the influence of academic commitment on sustainable transformations, and the potential of researchers and faculties as transformative agents (Nikolaou et al., 2023; Guerrero & Lira, 2023; Alzoraiki et al., 2023; Cai & Ahmad, 2021; Carl, 2020). Universities, with their third mission and moral responsibility to society (Reymert & Thune, 2023; Compagnucci & Spigarelli, 2020; Leal-Filho et al., 2019), are seen as fertile ground for addressing local, regional, and global challenges (Karahan, 2024; Giannetti et al., 2023; Chuvieco et al., 2018). As hubs for the development of knowledge-intensive professionals (Malerba & McKelvey, 2019; Gifford & McKelvey, 2019), they have the potential to shape students' worldviews (Nikolaou et al., 2023; Alzoraiki et al., 2023; Zhang & Yu, 2024).

However, the university's efforts in efficient resource use, greener infrastructure, and consumption reduction mechanisms may not be enough to foster a sustainable society without a shift in students' lifestyles (Giannetti et al., 2023). The development of new skills, behaviors, values, and attitudes is a crucial aspect for all members of society, particularly for students, in shaping a sustainable future (Aleixo et al., 2021). Individual differences also play a mediating and moderating role in how norms and attitudes influence human behavior (Dagliute et al., 2018). Moreover, there is a strong correlation between self-perception of environmental concern and sustainability practices, as heightened awareness of their ability to impact environmental issues leads to a stronger commitment to sustainable attitudes among students (Chuvieco et al., 2018). This mindset can also influence an individual's entrepreneurial intentions (Reuther et al., 2023; Vuorio et al., 2018), as environmental values drive sustainable entrepreneurship, fostering respect for natural resources and advocating for cleaner production (Peng et al., 2021).

Although literature has made some efforts in exploring this topic (Romero-Colmenares & Reyes-Rodríguez, 2022; Aleixo, Leal & Azeiteiro, 2021; Thelken & Jong, 2020; Dalvi-Esfahani et al., 2020; Chuvieco et al., 2018), there remains a lack of sufficient explanation regarding university students' behaviors (Dalvi-Esfahani et al., 2020; Dagliute et al., 2018) and entrepreneurial intentions towards sustainability (Peng et al., 2021; Thelken e Jong, 2020). Specifically, few studies included environmental issues on entrepreneurial sustainable intentions (Peng et al, 2021; del Brio González, 2022; Barba-Sánchez, 2022). To address this research gap, we assume that (i) universities are relevant supporting actors that influence students through their knowledge spillover (Karahan, 2024; Wagner, 2021; Leal-Filho et al., 2019) and (ii) sustainable attitudes and knowledge can influence an individual's entrepreneurial intention to create a business that positively impacts the environmental, social, and economic spheres (Reuther et al., 2023; Jebsen et al., 2023; Thelken e Jong, 2020). Encouraging students in sustainable entrepreneurship might cultivate future leaders with a higher commitment to addressing global challenges (Alfarizi & Herdiansyah, 2024; Jebsen et al., 2023; Chuvieco et al., 2018) through their transition into influential roles and decision-making positions in the future (Aleixo, Leal & Azeiteiro, 2021). Therefore, our objective in this article is *to understand the effects universities may have on undergraduate students' main views, behaviors, and entrepreneurial intentions toward sustainability.* This leads us to a fundamental question: *What is the university's influence on students' sustainable entrepreneurial intentions?*

To answer these, we conducted a survey with 485 business and hard sciences students from the University of Campinas (Sao Paulo, Brazil), considering them as potential entrepreneurs (Peng et al., 2021). Our results demonstrated a mismatch between the university context and the sustainable entrepreneurial intentions of students. However, the university's factors and student-university engagement highlighted positive significance. Students revealed more interest in flexible activities and maturing entrepreneurial intentions by interacting with non-conventional approaches. Underling this aspect, we advocate for associating top-down (such as training, events, sustainable incubators, partnerships, etc.) and bottom-up strategies (such as student organizations, volunteering programs, collaborative spaces, etc.) to develop sustainable initiatives. They can then be turned into entrepreneurial intentions and, more importantly, foster long-term sustainable awareness.

We organized the paper as follows. In the next section, we present an overview of the theoretical background with the main studies regarding the topic. Then, we describe the methodological procedure, data collection, and analysis process. Results and Discussion are placed in parts 3.4 and 3.5, while Concluding Remarks summarize the paper and present limitations and avenues for future research.

3.2 LITERATURE REVIEW

3.2.1 University-level approaches towards sustainability

Higher Education institutions (HEIs) play a fundamental role not only in education and research (Reymert & Thune, 2023; Alves et al., 2018) but also in sustainable development (Aleixo et al., 2021; Fischer et al., 2021; Dibbern & Serafim, 2021; Carayannis & Campbell, 2010). Nevertheless, to make a meaningful contribution, universities must undergo a thorough transformation of their internal policies (Guerrero & Lira, 2023; Cai & Ahmad, 2021; Moon et al., 2018; Adams et al., 2018), research activities (Leal-Filho et al., 2023; Dibbern & Serafim, 2021; Etzkowitz et al., 2021), teaching (Nikolaou et al., 2023; Alzoraiki et al., 2023; Carl, 2020; Monavvarifard et al., 2019), and campus interactions among staff, students, community, etc. (da Silva et al., 2018; Hu & Yu, 2017). It requires a diversity of shared goals and values among the academic community to inspire and motivate consistent behaviors and actions (Adams et al., 2018).

Dagliute, Liobikien, and Minelgaité (2018) assert that the higher the university's sustainable commitment, the higher the students' involvement in these issues. However, commitment itself is not a sufficient condition for establishing student engagement nor for sustainable transformations. While students' engagement tends to increase (Nikolaou et al., 2023; Cai & Ahmad, 2021; Lozano et al., 2015), it might not necessarily lead to a sustainable path (Dagliute et al., 2018; Nejati & Nejati, 2013). Beyond the university's commitment, other university-related factors (i.e., training activities, information and communication technology infrastructure, and university management support for sustainable activities) have an impact on students' engagement in the value co-creation process toward sustainability (Monavvarifard et al., 2019).

Furthermore, diversity among students and representativeness are also at the center of a sustainable university debate, once "the presence of LGBTQIAP+ faculty and staff in promoting diversity and providing support and inspiration to students" is increasingly relevant (Cembranel et al., 2023, p. 8). Focusing on Gender Equality, the United Nations' Fifth Goal (2024) underscores the need to empower women as essential agents in sustainability achievement, whereas literature has recognized them as relevant catalysts for change with higher levels of sustainable practices (Aleixo, Leal & Azeiteiro, 2021; Jurdi-Hage et al., 2019; Chuvieco et al., 2018; Hockerts, 2017). In sum, a "sustainable university requires individuals who behave sustainably: autonomous, selfregulating and responsible" (Adams et al., 2018, p. 440), integrating infrastructure development and institutional change, inside and outside the campus.

3.2.1.1 Students' views and behaviors

The Theory of Planned Behavior (TPB) explains that an individual's behavior is preceded by their intention to act. According to Ajzen's construct (1991), intention is influenced by three determinants: attitude toward the behavior, subjective norm, and perceived behavioral control. Attitude towards the behavior reflects how favorable a person is about a specific behavior. Subjective norm refers to the perceived social pressure to behave according to external expectations. Finally, perceived behavioral control refers to the level of difficulty a person feels in performing a particular behavior. Therefore, as per the TPB, the stronger an individual's attitude and subjective norm towards a specific behavior, and the greater their perceived behavioral control, the stronger their intention will be to possibly perform that behavior.

Dagliute, Liobikien, and Minelgaité (2018, p. 9) argue that "conscientious individuals perform pro-environmental behaviors because they consider them socially acceptable behaviors." The different levels of consciousness will lead to different paths of sustainable engagement through the student's knowledge, attitudes, intentions, and consumer behavior (Aleixo, Leal & Azeiteiro, 2021). In this sense, Zsóka et al. (2013) developed five student clusters: (i) active environmentalist, (ii) familiar, (iii) techno-optimist, (iv) hedonist, and (v) careless. Lambrechts et al. (2018) speak in segments aggregating the previous one: (i) moderate problem solvers, (ii) pessimistic non-believers, (iii) optimistic realists, and (iv) convinced individualists. In turn, Chuvieco et al. (2018) use a simpler approach, splitting only two categories: (i) more sustainable or (ii) less sustainable.

Student education has also been identified as deeply influencing students' knowledge of sustainability (Wagner et al., 2021; Aleixo, Leal & Azeiteiro, 2021; García-Gonzalez; Jimenez-Fontana & Goded, 2020). Ideally, all students should address sustainability initiatives not only in courses but also at a general level once they can both impact and be impacted by those issues (Leal-Filho et al., 2019). Students' sustainability-oriented values may be shaped via awareness of sustainable issues, educational mechanisms (Jurdi-Hage et al., 2019), and participatory and citizenship behaviors (Monavvarifard et al., 2019). Understanding students' perceptions toward sustainability issues (Aleixo et al., 2021; Dalvi-Esfahani et al., 2020; Dagliute et al., 2018) and how their words determine their attitudes (Jurdi-Hage et al., 2019) is a critical flow of action to research.

Therefore, taking the aforementioned, we hypothesized:

H1: *University-level approaches have positive effects on students' sustainable views and behaviors towards sustainability.*

3.2.1.2 Sustainable Entrepreneurial Intentions

Shepherd & Patzelt (2011) define Sustainable Entrepreneurship (SE) as preserving nature, life support, and community that permeates economic and non-economic gains. This consists of achieving the triple-bottom-line perspective (Elkington, 1998) through discovering, creating, and exploiting opportunities to generate social, environmental, and economic impact (Belz & Blinder, 2017; Hockerts & Wüstenhagen, 2010; Cohen & Winn, 2007) across various agents. The sustainable entrepreneur manages to identify business opportunities (Audretsch et al., 2023; Lans et al., 2014) and achieve a positive impact on social and environmental areas while balancing the three dimensions of SE (Hoogendoorn et al., 2019; Thompson et al., 2011). Students also emerge as central agents in sustainable entrepreneurship (Aleixo et al., 2021; Romero-Colmenares & Reyes-Rodríguez, 2022; Thelken & Jong, 2020; Vuorio et al., 2018), leveraging high levels of knowledge and innovation to compete in the market (Lassen et al., 2018). This knowledge-intensive approach consistently contributes to the sustainability achievement process, as the firms they establish can actively contribute to fulfilling those goals (Gifford & McKelvey, 2019).

In their analysis of Colombian university students, Romero-Colmenares & Reyes-Rodríguez (2022) demonstrated that Sustainable Entrepreneurial Intention (SEI) is influenced by individuals' attitudes, perceived difficulty level, and social pressure (subjective norms), which is closely aligned with the TBP framework. Moreover, altruistic values, education for sustainable entrepreneurship, and personal beliefs to solve those issues have positive connections with the intention to build a career in sustainable entrepreneurship. Similarly, Vuorio, Puumalainen, and Fellnhofer (2018) state that altruism significantly impacts attitudes toward sustainability. However, they also highlight that perceived entrepreneurial desirability is motivated by intrinsic factors (i.e., creativity and problem-solving opportunities, challenging tasks) and extrinsic rewards (i.e., higher salaries, power, prestige). Thelken and Jong (2020) bring interesting findings by highlighting the individual-level factors. According to the authors, desirability and feasibility play a relevant role in SEI, meaning that personal traits/habits result in more entrepreneurial sustainable action. Hockerts (2017) adds that prior experience with social problems is significantly correlated with SEI, as field experience fosters familiarity with them.

Furthermore, research suggests that environmental consciousness plays a significant role in SEI among students (del Brio González, 2022; Barba-Sánchez, 2022). Internal and external drivers improve entrepreneurs' recognition of environmental value creation, while "the mediating effects of experience on attitude, social norms, and self-efficacy directly promote the enhancement of intention to sustainable entrepreneurship, so as to predict sustainable entrepreneurial behavior." (Peng et al., 2021, p. 16). Sher et al. (2021) emphasized that individual perceptions of environmental issues significantly impact attitudes toward sustainable business adoption. Education on ecology and the environmental impact of ventures also supports the engagement of students in SE (Alfarizi & Herdiansyah, 2024). Jebsen et al. (2023) analyzed university students' profiles and suggested five subgroups: (i) *confident entrepreneurial mindset students*, who have high levels of entrepreneurial orientation but focus more on traditional entrepreneurship; (ii) *sustainable students*, represented by those who exhibit highly sustainable attitudes, however, average levels of entrepreneurial intentions; (iii) the third group is *average sustainable and entrepreneurial students*, represented by individuals that are average not only in sustainable attitudes but also in entrepreneurial characteristics; (iv) then *sustainable, non-entrepreneurial students* with average levels of sustainability consciousness but low levels of entrepreneurial characteristics; (v) finally they present *sustainable and entrepreneurial diffident students*, composed by those who have not sustainable attitudes neither entrepreneurial engagement.

These elements lead us to our last set of hypotheses:

H2a: *The university's sustainable practices positively influence students' sustainable entrepreneurial intentions.*

H2b: *The student-university engagement positively influences students' sustainable entrepreneurial intentions.*

H2c: *The university's gender issues awareness positively influences students' sustainable entrepreneurial intentions.*

3.3 METHODOLOGICAL PROCEDURES

3.3.1 RESEARCH SETTING

Established in 1966 in Campinas, State of Sao Paulo, Brazil, the University of Campinas (Unicamp) embodies teaching, research, and extension dimensions following a research university model (Schwartzman et al., 2021). Unicamp is acknowledged as an entrepreneurial university with a strong integration between its academic mission and societal demands (Fischer et al., 2021). In 2024, the university had 23 teaching and research units, 37,619 students, 51 undergraduate programs, 156 graduate programs (stricto and lato sensu) across many fields of knowledge, and 3 hospitals (Unicamp, 2024). Renowned for its academic excellence, Unicamp ranks as the 2nd best university in Brazil, 8th in Latin America, and 220th internationally according to the QS World University Rankings 2024[12], while in the SCImago Ranking[13], it is the 3rd best university in Brazil, 4th in Latin America, and 273rd globally. Its current Strategic Planning 2021-2025 was conceived aligned with Sustainable Development Goals (SDGs) and explicitly recognizes the university's commitment to sustainable issues (GePlanes, 2024).

This can be unfolded in some initiatives the university has made towards sustainable development. For instance, Unicamp is part of the University Network for Sustainable Development[14] and the International Union for Conservation of Nature and Natural Resources Academy[15]. In 2023, it was ranked 10th in the Green Metrics Latin America Ranking[16] and 73th worldwide. Besides, it supported the creation of the International Hub for Sustainable Development, dedicated to generating solutions to sustainable development challenges in partnership with universities, research centers, private companies, startups, entrepreneurs, investors, public authorities, and the community interacting in a mixed-use territory, with laboratories, offices, commerce, industry, and residences. In 2020, the Inter-American Development Bank (IDB), Unicamp, and the Campinas City Hall signed an agreement to prepare a master plan for the development of the area (HIDS, 2024). Recently, the university has implemented several environmental practices, such as replacing old electrical systems with more efficient ones and introducing electric buses on the main campus. Sustainable Campus is

[12] More info https://www.qs.com/rankings-released-qs-world-university-rankings-2024
[13] More info https://www.scimagoir.com/rankings.php
[14] https://unitar.org/ny/universities/university-of-campinas
[15] https://www.iucn.org/our-work/iucn-academy
[16] https://greenmetric.ui.ac.id/rankings/overall-rankings-2023

another initiative conceived in partnership with an energy company whose aim is to develop a management and energy efficiency model that can be replicated in other universities (Campus Sustentável, 2021). Unicamp also has a Sustainability Coordination embedded in the Executive Board of Integrated Planning (DEPI, 2024), which was created to integrate the university's sustainable planning and actions.

From approximately 7,000 undergraduate subjects available[17], our analysis revealed that only 44 are somehow related to sustainability based on their descriptions, with most of them in Civil Engineering and Architecture programs. Notably, 36 of these 44 are electives, and 8 are required. A detailed summary can be seen in Appendix I.

3.2.2 Survey Design and Analytical Approach

A literature review was conducted to identify potential measures and items for survey development oriented to Unicamp's students. The questionnaire was organized into sections, starting with a descriptive one that collected input on gender, year of undergraduate, family monthly income, and field of study. *University-level approaches toward sustainability* questions regarding university effects on students' sustainable awareness were grounded on studies by Dagliute, Liobikien, and Minelgaité (2018), Monavvarifard et al. (2019), and Cembranel et al. (2021), as well as own constructs developed for this research. These are the basis for what the article calls a *university context* formed by sustainability behaviors and interactions with universities, such as campus activities, knowledge sharing through official events, recycling practices, participation in organizations, strategic documents and commitments, etc. *Individual views and behaviors* were organized into (i) reuse and recycling, (ii) governmental, (iii) environmental, and (iv) social variables, based on Chuvieco et al. (2018) and Gericke et al. (2019) previous research. Finally, the *Sustainable Entrepreneurial Intention* was discussed under Vuorio et al. (2018) assumptions on social and environmental entrepreneurial goals and attitudes toward entrepreneurship. All questions were translated into Portuguese.

Students answered the questions using a Likert Scale ranging from 1 (strongly disagree) to 7 (strongly agree) for each of the statements presented. A pre-test was administered to some students to verify adherence and adjust the questions;

[17] Available, in this context, means that the subject is registered in the undergraduate catalog; however, this does not necessarily imply that the subject has been offered recently.

minor modifications were made afterward. Between April 1st and May 6th, 2024, a survey application was conducted online and in person across various programs among business, hard science, and health students at Unicamp (see Aleixo et al., 2021; Thelken & Jong, 2020; Jurdi-Hage et al., 2019). The research was conducted across different fields as we believe sustainable development requires collaboration across multiple areas and disciplines (Dibbern & Serafim, 2021; Knudsen et al., 2021). In total, 604 students initiated the questionnaire; however, only 485 satisfactorily completed the questions, with 244 from business, 225 from hard sciences, and 16 from health. The research was approved by the Brazilian Ethic Committee under CAAE 75700423.6.0000.8142, ensuring anonymity and confidentiality.

Our analytical approach begins with deriving a set of constructs that can be applied to test our set of hypotheses. Each element is described in Table 3.1 below. Mostly, these constructs were based on factor analysis extracted from items included in the questionnaire. Since the data structure of variables is mostly composed of Likert scales, exploratory factor extraction was performed using the principal-component factors method applied to the polychoric correlation matrix of variables with orthogonal varimax rotation. Due to missing data in specific items, the factor analysis procedure reduced our valid sample to around 190 observations (numbers vary slightly across econometric estimations, as demonstrated in the Results Section). It should be noted that some factors do not demonstrate high levels of consistency (Sustainable Consumption Behavior, Recycling, Resource Use, Institutional and Organizational Accountability, and, particularly, Gender Perspectives). Yet, due to the exploratory nature of our assessment and the grounding of these factors in prior literature, we decided to keep them in our empirical assessment. Any conclusion regarding these dimensions should be taken with caution. Appendix II provides further details of each factor, and Appendix III lists the courses approached in the survey.

Table 3.1 *Analytical Constructs*

Dimension	Factors	Description
Entrepreneurial Intentions	Entrepreneurial Intention	Binary variable. 1 if the respondent intends to start a new business; 0 otherwise.
	Social Entrepreneurship*	Elements associated with the social orientation of those individuals who demonstrate entrepreneurial intentions.
	Environmental Entrepreneurship*	Elements associated with the environmental orientation of those individuals who demonstrate entrepreneurial intentions.
	Sustainable Entrepreneurship*	Elements associated with the intention of creating sustainable companies (combination of economic, environmental, and social aspects) of those individuals who demonstrate entrepreneurial intentions.
University-Level Approaches towards Sustainability*	University Sustainable Practices*	Students' perceptions concerning institutional-level sustainable practices implemented by the university.
	Student-University Engagement*	Level of engagement of students in sustainable initiatives of the university.
	Gender Issues at the University*	Students' perceptions concerning gender-related and LGBTQIA+ practices and initiatives at the university.
Individual Views and Behavior*	Social and Environmental Commitment*	Level of students' commitment with social and environmental practices.
	Sustainable Consumption Behavior*	Students' attitudes towards consumption of goods.
	Sustainable Mobility*	Students' attitudes concerning mobility issues (means of transportation).
	Recycling*	Students' attitudes towards recycling.
	Resource Use*	Students' attitudes towards the use of natural resources.
	Institutional and Organizational Accountability*	Perceptions concerning the responsibility of governments and corporations concerning sustainability.
	Gender Perspectives*	Perceptions related to issues about gender equality and LGBTQIA+ issues.
Individual Descriptors	Male	Binary variable. 1 if the respondent identifies as a Male; 0 otherwise.
	STEM field	Binary variable. 1 if the respondent is enrolled in a STEM program; 0 otherwise.
	High income group	Binary variable. 1 if the respondent is classified in the top income group (upper 25th percentile); 0 otherwise.

*The construction of this analytical construct was based on factor extraction based on the polychoric correlation matrix. Details on the composition of factors (items) and diagnostics are provided in Appendix II.

The analytical strategy to test our hypotheses is based on Heckman selection models with the application of maximum likelihood estimates. Since the qualification of Entrepreneurial Intentions (Social Entrepreneurship, Environmental Entrepreneurship, and Sustainable Entrepreneurship) is contingent upon the existence of student-level intentions to become entrepreneurs, our modeling approach requires a sample selection stage, where models were estimated based on the complete set of analytical constructs. However, because the selection procedure causes a significant reduction in the sample size, we tried to keep the core estimations as parsimonious as possible, only addressing our key variables of interest, i.e., those assigned to the Dimension "University-Level Approaches towards Sustainability".

In order to complement our analysis and achieve an in-depth comprehension of the analytical constructs at play, we estimated an additional set of models looking at the interplay between the Dimensions "University-Level Approaches towards Sustainability" (taken as predictors) and "Individual Views and Behavior" (dependent). Our goal with this empirical step is to understand any nuances between students' behavior and their respective perception of the academic environment vis-à-vis sustainable issues that could not be captured in previous models, i.e., those assessing the direct effects of university-level constructs on sustainable entrepreneurial intentions.

3.4 RESULTS

Results for estimations of Heckman selection models are reported in Table 3.2. Model I refers to the final outcome of Social Entrepreneurship, Model II is dedicated to addressing Environmental Entrepreneurship, and Model III concerns intentions for Sustainable Entrepreneurship. The model fit is weak for Social Entrepreneurship, showing statistical adequacy only for the cases of Environmental Entrepreneurship and Sustainable Entrepreneurship. In an overall assessment, it becomes somewhat clear that the emergence of sustainable entrepreneurial intentions is a rather complex phenomenon that can be moderated explained by our analytical strategy. Such conditions may be interpreted as a signal that fostering such sort of entrepreneurial intention in academia is a challenging task with unclear targets. Yet, some interesting insights can be drawn from this exercise.

First, student-level Social and Environmental Commitment is a significant predictor at the selection stage. Since around half of the valid sample demonstrate the intention of becoming entrepreneurs, this association points in the direction of the university as a potential cradle for entrepreneurs who can perform a transformative role in society. Surprisingly, however, actions associated with Recycling are negatively related to the selection dependent variable. At this initial examination, no consistent estimates concerning the role of University-level Approaches Toward Sustainability could be identified.

Looking into the second stage of estimations, Student-University Engagement stands out as the only significant predictor for Environmental Entrepreneurship and Sustainable Entrepreneurship. University Sustainable Practices and Gender Issues at the University appear to play no role in these dynamics. We may interpret this situation as evidence in favor of a lack of effectiveness in institutional-level policies and initiatives toward fostering sustainable entrepreneurship. Instead, what seems to matter more is how such approaches at the university actually include students and make them active parts of the learning and teaching process concerning different perspectives on sustainability.

This issue becomes clearer once we evaluate the complementary estimations based on the interplay between the Dimensions "University-Level Approaches towards Sustainability" (taken as predictors) and "Individual Views and Behavior" (dependent), presented in Table 3.3. *Student-University Engagement* is significantly associated with five out of seven models (exceptions are Model VII – Recycling and Model VIII – Resource Use). Again, *University Sustainable Practices* and *Gender Issues* at the Universities are not significant. These findings suggest that creating a sustainable "community" within academia is likely the way ahead – institutional policies and initiatives that do not necessarily promote the proximity of students with sustainable concepts and practices can be easy to implement but seem likely to fall short in generating sustainable transitions in the student entrepreneurship scene.

Table 3.2 *University Association with Sustainable Entrepreneurial Intentions in Students (Heckit Models with Maximum likelihood estimates)*

Dimension	Predictor	Model I Social Entrepreneurship		Model II Environmental Entrepreneurship		Model III Sustainable Entrepreneurship	
		Coeff.	**Std. Err.**	**Coeff.**	**Std. Err.**	**Coeff.**	**Std. Err.**
University-Level Approaches towards Sustainability	University Sustainable Practices	0.0090	0.0790	0.082	0.084	0.031	0.083
	Student-University Engagement	0.1139	0.0708	0.210***	0.074	0.277***	0.074
	Gender Issues at the University	0.0821	0.0741	0.079	0.078	0.010	0.077
		Selection Stage (DV Sustainable Entrepreneurial Intention)					
		Coeff.	**Std. Err.**	**Coeff.**	**Std. Err.**	**Coeff.**	**Std. Err.**
Individual Descriptors	Male	0.308	0.205	0.191	0.201	0.274	0.199
	STEM field	-0.194	0.196	-0.277	0.194	-0.181	0.190
	High income group	0.127	0.228	0.167	0.224	0.105	0.220
Individual Views and Behavior	Social and Environmental Commitment	0.155**	0.067	0.185***	0.067	0.125*	0.067
	Sustainable Consumption Behavior	-0.061	0.064	-0.060	0.066	-0.083	0.066
	Sustainable Mobility	-0.073	0.050	-0.069	0.048	-0.062	0.048
	Recycling	-0.136**	0.056	-0.161***	0.058	-0.129**	0.056
	Resource Use	-0.085	0.059	-0.063	0.057	-0.075	0.057
	Institutional and Organizational Accountability	-0.085	0.077	-0.106	0.079	-0.085	0.078
	Gender Perspectives	-0.137	0.089	-0.126	0.089	-0.164*	0.088
University-Level Approaches towards Sustainability	University Sustainable Practices	0.098	0.062	0.103*	0.063	0.092	0.062
	Student-University Engagement	0.014	0.066	-0.010	0.065	0.022	0.064
	Gender Issues at the University	0.038	0.057	0.039	0.056	0.029	0.056
	Wald chi sq.	4.2		10.32		14.21	
	Valid N	190		190		191	
	Selected cases	96		96		97	

***sig. at 1%; **sig. at 5%; *sig at 10%

Table 3.3 *Alternative estimations - University Association with Sustainable Behavior in Students (OLS models)*

Dimension	Predictor	Model IV Social and Environmental Commitment		Model V Sustainable Consumption Behavior		Model VI Sustainable Mobility		Model VII Recycling		Model VIII Resource Use		Model IX Institutional and Organizational Accountability		Model X Gender Perspectives	
		Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
University-Level Approaches towards Sustainability	University Sustainable Practices	-0.135**	0.061	0.056	0.067	0.130	0.083	0.112	0.075	0.038	0.072	0.021	0.056	0.060	0.050
	Student-University Engagement	0.441***	0.056	0.175***	0.062	0.276***	0.077	-0.038	0.069	0.036	0.066	0.236***	0.050	0.146***	0.045
	Gender Issues at the University	0.003	0.060	-0.001	0.066	-0.124	0.081	0.041	0.073	-0.011	0.070	-0.054	0.054	-0.008	0.048
Individual Descriptors	Male	0.328	0.213	-0.763***	0.234	0.966***	0.290	-0.268	0.262	0.304	0.249	-0.226	0.193	-0.439**	0.172
	STEM field	-0.531**	0.216	-0.193	0.237	0.274	0.294	0.233	0.266	0.013	0.253	-0.257	0.195	0.149	0.174
	High income group	0.673***	0.229	-0.874***	0.251	-1.052***	0.312	0.555**	0.281	0.143	0.268	0.043	0.204	-0.273	0.182
	Adjusted R sq.	0.281		0.161		0.141		0.012		-.0.018		0.109		0.076	
	Valid N	193		193		193		193		193		203		202	

***sig. at 1%; **sig. at 5%; *sig at 10%

3.5 DISCUSSION

Our main goal in this article is to delve into how universities may affect undergraduate students' views, behaviors, and entrepreneurial intentions toward sustainability. With this in mind, we sample students from business, engineering, and health sciences to identify the university's influence on students' sustainable entrepreneurial intentions and whether sustainable awareness plays some role in it.

Institutional-level policies toward sustainable attributes and entrepreneurship lack effectiveness. Even though literature has demonstrated that undergraduate students possess high levels of sustainable awareness (Jebsen et al., 2023; Romero-Colmenares & Reyes-Rodríguez, 2022; del Brio González, 2022; Thelken and Jong, 2020), the results of this study revealed that this awareness cannot be directly translated into more actionable outcomes on the topic, such as sustainable oriented entrepreneurship. Despite Unicamp's demonstrated commitment to sustainability - evidenced by signing declarations, participating in international rankings, and having some internal initiatives - our estimations indicate that this alone is not sufficient for students to act and undertake sustainable actions. These insights are aligned with the findings of Nejati & Nejati (2013) and Dagliute, Liobikien, and Minelgaité (2018), who also assert that institutional actions, per se, may not have the potential to influence students' actions. Our results do not demonstrate any significance about women and the LGBTQIAPN+ community issues. Nevertheless, we acknowledge that a diverse and inclusive environment is necessary for building sustainable behaviors and entrepreneurial engagement and encourage further exploration of the topic. Thus, we reject H1, H2a, and H2c hypotheses.

Interestingly, *student-university engagement* is a significant predictor of sustainable entrepreneurial intention, suggesting that more structured actions seem to have less impact than non-structured ones. Academic entrepreneurship literature has already called attention to the limited effectiveness of traditional approaches (i.e. entrepreneurship courses and training) in promoting entrepreneurship among students (Farias et al., 2024; Moraes et al., 2023; Fischer et al., 2019). Farias et al. (2024) advocate for initiatives stimulating entrepreneurship, such as alumni programs, student organizations focused on small businesses, and student business support services. Furthermore, sustainable entrepreneurial intentions of students might be fomented by volunteering programs, community projects (Hockerts, 2017), participatory and citizenship behaviors (Monavvarifard et al., 2019), teamwork, real-world learning, problem-solving, social collaboration activities (Ripollés & Blesa, 2024), and sustainable practice-oriented activities in partnership with private and public sectors (Leal-Filho et al., 2019). In this sense, extension activities included in the student's curricula have the potential to positively impact their social and environmental awareness. This transformative learning provides a "technical, specialized, and experiential environment content base and the skills necessary for desirable behavioral change" (Jurdi-Hage et al., 2019, p.54). To embody sustainability-oriented values, individuals must share information, take responsibility for sustainable development, understand themselves as agents of change, and support sustainable initiatives within the university environment (Monavvarifard et al., 2019). The elements required to establish sustainable communities are interconnected, reflecting the complex nature of the ecosystem and the necessity for supportive interactions to achieve sustainability through education (Suguna et al., 2024).

This background implies that the university must foster a closer relationship with students, supporting their engagement in organic activities as an opportunity for sustainable entrepreneurship. Combining soft and hard skills offers room for practical projects outside traditional teaching formats, representing an excellent strategy to improve students' sustainable skills (Franco et al., 2023). Establishing a sustainable culture at universities involves more than only including sustainable subjects in academic programs; it requires comprehensive student involvement through various types of interventions. Therefore, we accept the H2c hypothesis, arguing that active participation in social and environmental activities, a thorough understanding of strategic documents and implementation reports, and the university's sustainability commitment and involvement in student organizations positively affect sustainable entrepreneurial engagement.

3.6 CONCLUDING REMARKS

As active players, universities must adapt to new objectives and methods not only for their teaching and research missions but also for addressing local socioeconomic issues while actively contributing to regional development (Thomas et al., 2023). Our estimations point out a mismatch between the university context and students’ sustainable entrepreneurial intentions, suggesting a lack of direct relation between them despite the university's actions. However, the alternative models associated with the university’s factors and student-university engagement demonstrated positive significance. In other words, the activities promoted by universities and how the students engage with them seem to shape the individual's behaviors at the first stage, which may then relate to an entrepreneurial intention focused on social and environmental issues (indirect relation) in the future. Students demonstrated more significant interest in flexible activities, acquiring sustainability awareness, and developing entrepreneurial intentions toward those issues through complementary approaches.

This does not diminish the relevance of disciplines and curricula in training; rather, it suggests that policymakers and university managers should adopt a broader perspective. This includes practice approaches and interactions with real challenges, allowing students to use their creativity, knowledge, and skills to solve social and environmental problems. Encouraging sustainable entrepreneurship among students is crucial, as it can nurture future leaders who comprehend global challenges and can develop sustainable solutions (Alfarizi & Herdiansyah, 2024). The ideal approach is to associate both top-down strategies (such as training, events, sustainable incubators, partnerships, etc.) and bottom-up strategies (such as student organizations, volunteering programs, collaborative spaces, etc.) to develop sustainable initiatives. These initiatives may foster not only entrepreneurial intentions but also long-term sustainable awareness.

While our results enhance the knowledge of sustainability at universities and students' entrepreneurial intentions, they also have some limitations. Firstly, our study consists of a student’s perception analysis, which cannot fully capture the phenomena once perceptions have their own bias. Secondly, we aimed to develop an adaptative and concise questionnaire to minimize the number of questions (Dagliute et al., 2018); however, this approach may reduce our understanding of this complex and multifaceted subject. Therefore, we encourage future studies to include new variables, such as cultural and economic influences both in sustainable practices and business creation, self-efficacy, risk-taking, and opportunity recognition. Additionally, by including business and hard science students and capturing their impressions on sustainability practices we approached a diverse range of programs with a small number of respondents in each group. To gain a more comprehensive understanding, it would be beneficial to increase the participation of these specific groups, including students in engineering, statistics, physicists, mathematicians, and so on. They play crucial roles in technology development and have the potential to improve society's quality of life.

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APPENDIX I – LIST OF UNICAMP'S SUBJECTS

Course	Faculty	Type	Offered in
Fundamentals of Agribusiness	School of Applied Sciences	Elective	2014 - 2020
Development and Environment	Institute of Geosciences	Elective	Never has been offered
Science, Art and Society, for a Culture of Peace	Dean's Office	Elective	2002 - 2011
Zero Waste Strategy	School of Civil Engineering and Architecture	Elective	2020 - 2023
Project Methodology IV: Social Interest Architecture	School of Civil Engineering and Architecture	Elective	2012 - 2017
Projects with MÓBILE - Model Office of Architecture and Urbanism	School of Civil Engineering and Architecture	Elective	2022
Theory and Design III: Conceptual Strategies in Architecture	School of Civil Engineering and Architecture	Elective	2015 - 2020
Theory and Design IV: Social Interest Architecture	School of Civil Engineering and Architecture	Required	2015 - 2024
Theory and Design: Vertical Studio 1	School of Civil Engineering and Architecture	Elective	2018 - 2020
Theory and Design: Vertical Studio 2	School of Civil Engineering and Architecture	Elective	2021
Theory and Design: Vertical Studio 3	School of Civil Engineering and Architecture	Elective	2021 - 2023
Theory and Design: Vertical Studio 4	School of Civil Engineering and Architecture	Elective	2022
Theory and Design: Vertical Studio 5	School of Civil Engineering and Architecture	Elective	2023
Theory and Design: Vertical Studio 6	School of Civil Engineering and Architecture	Elective	Never has been offered
Theory and Design: Vertical Studio 7	School of Civil Engineering and Architecture	Elective	2024
Theory and Design: Vertical Studio 8	School of Civil Engineering and Architecture	Elective	Never has been offered
Theory and Design: Vertical Studio 9	School of Civil Engineering and Architecture	Elective	Never has been offered
Sustainable Architecture: Design and Construction	School of Civil Engineering and Architecture	Elective	2015 - 2022
Environmental Sciences	Institute of Biology	Required	1998 - 2024
Ecology of Communities and Ecosystems	Institute of Biology	Elective	2015 - 2023
Sustainability and Environment	School of Civil Engineering and Architecture	Required	2023 - 2024
Sustainability, Society and Environment	School of Civil Engineering and Architecture	Elective	2022 - 2024
Sustainable Design and Construction	School of Civil Engineering and Architecture	Elective	2009 - 2024
Environmental Sanitation Management	School of Civil Engineering and Architecture	Elective	2011 - 2024
Introduction to Environmental Sciences in Transport	School of Technology	Required	2020 - 2024
Development and Environment	School of Mechanical Engineering	Elective	2004 - 2024
Work, Health and Sustainability	School of Medical Sciences	Elective	2012 - 2013
Environmental Management	School of Applied Sciences	Elective	2009 - 2015
Sustainable Management	School of Applied Sciences	Required	2015 - 2023
Sustainable Production	School of Applied Sciences	Elective	2015 - 2022
Education and Interdisciplinarity with an Eye on the Future	School of Electrical and Computer Engineering	Elective	2023
Sustainability actions: cultivating a Living Pharmacy	School of Nursing	Elective	2024
Concepts of urbanism and sustainability	School of Civil Engineering and Architecture	Elective	2024
Social Responsibility and Sustainability Management in Agribusiness	School of Agricultural Engineering	Elective	Never has been offered
Soil Management and Conservation	School of Agricultural Engineering	Elective	Never has been offered
Soil Management and Conservation	School of Agricultural Engineering	Elective	Never has been offered
Soil Management and Conservation	School of Agricultural Engineering	Elective	2007 - 2024
Food and Society	School of Food Engineering	Required	2022 - 2024
Management, Governance and Sustainability	Institute of Geosciences	Required	2024 - 2024
Tourism and New Territorialities	Institute of Geosciences	Elective	Never has been offered
Sustainable Business Models	School of Applied Sciences	Required	2024
Contemporary Issues in Law	School of Applied Sciences	Elective	2022 - 2023
Introduction to Green Chemistry	Institute of Chemistry	Elective	2020 - 2023
Environment and Development	School of Technology	Elective	2000 - 2013

APPENDIX II – QUESTIONNAIRE MODEL

Sustainable views, behaviors, and entrepreneurial intentions included in the questionnaires. In all cases, students classified each phrase on a Likert Scale (1=totally disagree to 7=totally agree):

Dimension	Factors	Items	Source	Cronbach's alpha	Variance explained	KMO test
Entrepreneurial Intentions	Social Entrepreneurship	1. If you had the required time and resources, I would consider the social impact (poverty reduction, employment, and increasing equality) that the venture would have. 2. If I would set up a firm, it probably would positively impact society's weakest members. 3. If I would set up a firm, it probably would positively contribute to the world's poverty reduction.	Vuorio et al. (2018)	0.775	74%	0.69
	Environmental Entrepreneurship	1. If you had the required time and resources, I would consider the environmental impact (e.g. use of natural resources, protecting biodiversity, and energy type) that the venture could have. 2. If I would set up a firm, it probably would positively use natural resources responsibly. 3. If I would set up a firm, it probably would help to reduce environmental problems.	Vuorio et al. (2018)	0.712	68%	0.63
	Sustainable Entrepreneurship	1. If I would set up a firm, it would enhance sustainable development. 2. If I would set up a firm, it would maximize societal, environmental, and economic profit (adapted).	Vuorio et al. (2018)	0.709	81%	0.5
University-Level Approaches towards Sustainability	University Sustainable Practices	1. University represents itself as environmentally friendly and clearly declares environmental objectives 2. There is a possibility to recycle waste at the university 3. University contributes to energy and resource-saving 4. I feel that my university cares about the social and environmental impacts it generates (own) 5. University supports holding scientific conferences/events/workshops on sustainable development (adapted) 6. University encourages use of public transport, bikes	Dagiliute et al. (2019), Monavvarifard et al. (2019), Cembranel et al. (2021), and own development	0.798	55%	0.85

Dimension	Factors	Items	Source	Cronbach's alpha	Variance explained	KMO test
	Student-University Engagement	1. I am actively involved in social-environmental activities at the University (adapted) 2. I take part in environmental and social activities organized by the university (adapted) 3. I have read strategic documents of the university and their implementation reports 4. Participating in university student organizations helps me to have a more sustainable outlook (own) 5. University website presents a lot of information regarding university's position on environmental objectives	Dagiliute et al. (2019), Monavvarifard et al. (2019), and own development.	0.757	57%	0.71
	Gender Issues at the University	1. The proportion between men and women in the teaching staff is balanced (own) 2. Women are respected and have space at the university (own) 3. There are inclusive and sustainable policies for the diversity and security of the LGBTQIAP+ population (adapted) 4. There are affirmative actions and/or exclusive scholarships for LGBTQIAP+ population (adapted) 5. I have read declarations of inclusion of gender and gender diversity in institutional documents and/or website (adapted)	Cembranel et al. (2021), and own development	0.716	53%	0.7
Individual Views and Behavior	Social and Environmental Commitment	1. I volunteer for nature conservation activities (examples, e.g. saving rain forests, cleaning deserts, cleaning beaches). 2. I join actions in favor of the environment in public places (cleaning of beaches, planting trees, etc.). 3. I plan my vacations by the environmental interest of the destination. 4. I usually read blogs and participate in social networks or pages related to environmental protection. 5. I buy fair-trade products (products that ensure better trade and social conditions for producers). 6. I do things which help poor people.	Chuvieco et al. (2018) and Gericke et al. (2019)	0.736	51%	0.77
	Sustainable Consumption Behavior	1. I try to reuse things that can be useful for me or for others (furniture, packaging, sports equipment, books, etc.). 2. I try to respect the environment (adapted) 3. I change my mobile phone for a more recent one even if it is not broken. 4. I usually buy used items (clothing, books, sports equipment, etc.).	Chuvieco et al. (2018)	0.48	59%	0.58
	Sustainable Mobility	1. I tend to use public transportation or bike except when the private one is essential 2. I walk or use a bike on distances where a vehicle is not necessary.	Chuvieco et al. (2018)	0.68	80%	0.5
	Recycling	1. I throw waste materials to the areas designed for them. 2. I separate garbage by type (glass, plastics, paper, organic or other). 3. I tend to reuse plastic bottles.	Chuvieco et al. (2018)	0.455	54%	0.58
	Resource Use	1. I try to buy energy-efficient appliances (lights, irons, water boilers, electrical devices such as washing machines, televisions,	Chuvieco et al. (2018)	0.435	66%	0.5

Dimension	Factors	Items	Source	Cronbach's alpha	Variance explained	KMO test
		air conditions, etc.). 2. I try to save water at home (by showering instead of bathing, faucets economizers, keep the tap not running while brushing teeth, etc.).				
	Institutional and Organizational Accountability	1. I think that the government should make all its decisions on the basis of sustainable development. 2. I think that we need stricter laws and regulations to protect the environment. 3. I think that companies have a responsibility to reduce the use of packaging and disposable articles	Gericke et al. (2019)	0.45	58%	0.6
	Gender Perspectives	1. Reinforcing girls' and women's rights and increasing equality around the world is necessary for sustainable development. 2. I think that women and men throughout the world must be given the same opportunities for education and employment	Gericke et al. (2019)	0.15	63%	0.5

APPENDIX III – SAMPLE DETAILED PER AREA

Business	Sample
Administration	169
Public Administration	75
Hard Sciences	**Sample**
Systems Analysis	7
Architecture	20
Information Systems	3
Agricultural Engineering	2
Environmental Engineering	13
Civil Engineering	102
Food Engineering	11
Control Engineering	5
Manufacturing Engineering	6
Production Engineering	25
Telecommunications Engineering	2
Transportation Engineering	3
Electrical Engineering	7
Mechanical Engineering	19
Health	**Sample**
Nutrition	11
Sports Science	5

DISCUSSION

The dissertation's main goal was to analyze the emergence of the so-called Knowledge Intensive Sustainable Entrepreneurship concept vis-à-vis an ecosystem perspective. An increasing number of authors focus on discussing how knowledge and technology are relevant to empowering sustainable entrepreneurship and its ecosystems (Cheng et al., 2024; Seclen-Luna et al., 2024; Wagner et al., 2019; Gerli et al., 2021; Ghazinoory et al., 2020), thus the material contributes to the advancement of KISE concept theoretically and practically. To accomplish this, the ‘readiness’ of the São Paulo entrepreneurial ecosystem was identified by comparing sustainable and conventional companies from PIPE-Fapesp. Next, a second layer of contributions was added by discussing the institutionalization of sustainability in an entrepreneurial university through a technology development and transfer perspective. Finally, the effects that the university may have on undergraduate students' main views, behaviors, and entrepreneurial intentions toward sustainability were identified. The findings suggest a need for advanced ways to combine knowledge, innovation, and entrepreneurship to foment new combinations and disruptive technologies addressing grand societal challenges. Moreover, the dissertation highlights the importance of government activity in conducting a more sustainable EE through formulating and implementing policies and programs, notably through research and innovation funding agencies and public universities.

Despite being a latent concept, KISE is developing with few or even without formal structures. Through PIPE Program analysis, this research indicates a high level of similarity between the KISEE configuration and the conventional entrepreneurial ecosystems. This can be interpreted as a positive situation since transitions towards more sustainable entrepreneurial ecosystems do not seem to be farfetched. Instead of developing an entirely new ecosystem focused on sustainable challenges, the findings propose an adaptation and reorientation to embrace sustainability in all ecosystem dimensions as a transversal strategy. The approach to orientate EE to support sustainable enterprises can be seen in some initiatives, such as the hub created by KAIST College of Business in collaboration with SK Group in Seoul, Korea. Under the mission to create, teach, and nurture for-profit sustainable ventures, the program has, among other initiatives, an incubator helping to boost KISE in the country (Kim et al., 2020). In turn, the Israeli ecosystem is using its high level of technological approach and investing in *social tech* or *social techpreneurship*, which is a new format of hybrid business looking for technological solutions to social and environmental issues (Manos & Gidron, 2021). The country is known as a *start-up nation* (Weinberg, 2019; Shachmurove, 2019; Fraiberg, 2017) and is now working on becoming an *impact nation* (Our Crowd Report, 2019). Nevertheless, it is crucial to emphasize that the strategies for adapting and reorienting may need particular structures to support the development of KISE. Examples of these structures include new forms of sustainable investment that combine different sources, such as donations, private funding, philanthropy, and blended finance. Additionally, specific incubators and accelerators focused on sustainable companies and their distinct characteristics, as well as sustainable innovation co-created with consumers/clients of the product or service, serve as excellent examples.

One of the commons and essential components that connects both conventional and sustainable ecosystems are Higher Education Institutions (HEIs). From the notion that education, entrepreneurship, and innovation are central elements to solving societal and environmental issues (Guerrero & Lira, 2023; Carayannis & Kaloudis, 2010), the research reveals that research universities, particularly those that become involved in collaborations with industrial partners, have an important role to play – a trend also observed in the case of KISE ecosystems. As outlined by prior assessments, leading academic institutions are pivotal agents in defining the socioeconomic agenda for entrepreneurship in the region (Thomas et al., 2023; Fischer et al., 2018; Cohen, 2006). Yet, the literature highlights the relevance of academic institutions as cradles for sustainable development (Nikolaou et al., 2023; Saha et al., 2022; Cai & Ahmad, 2021; Fischer et al., 2021; Dibbern & Serafim, 2021), the inquiries on how the technology produced is transferred and how the students are impacted by university sustainable engagement is still an open discussion. This dissertation made some efforts to contribute to this field and highlighted some considerations.

Firstly, through the University of Campinas (Unicamp) case study, a Brazilian public university, it was demonstrated that Entrepreneurial University behavior is slowly transitioning to a Sustainable Entrepreneurial University (SEU) model, implying a rotation in teaching, developing knowledge and technology, and spreading innovation (Karahan, 2024; Leal-Filho et al., 2023; Ramaswamy et al., 2021; Etzkowitz et al., 2021). A patent analysis suggests the existence of sustainable initiatives even without institutional frames positioning them, revealing that the science community is addressing sustainable challenges locally, nationally, and even internationally. While it is not the ideal scenario, it is worth mentioning that Unicamp is, in fact, contributing to sustainable development by providing sustainable technologies, especially in SDGs Second – Zero Hunger; Third – Good Health and Well-being; Sixth – Clean Water and Sanitation; Seventh – Affordable and Clean Energy; Tenth – Reduced Inequalities; Eleventh – Sustainable Cities and Communities; Twelveth – Responsible Consumption and Production;

and Thirteenth – Climate Action. SDG 12 is the most common goal among intellectual properties, followed by SDG 3.

It can also be emphasized that similarities between the dynamics of technology development and IP rights between sustainable and conventional technologies were identified. Sustainable technologies involve slightly more external interactions among researchers than conventional ones, mainly developed inside university institutes and departments. In both cases, technological development in terms of researcher interactions seems to derive more from university collaboration (internal or external groups) than university-industry. Interestingly, private companies' participation as co-assignees demonstrates fruitful results, with almost one-third of sustainable technologies patented in partnerships and almost half in the conventional group. Nevertheless, to effectively contribute to sustainable development, an SEU must transform its institutional arrangements and be rooted in sustainable values from the integration of campus infrastructure, teaching, collaboration, cooperation, and science and technology production. Universities must go beyond traditional research and commercialization approaches to develop a comprehensive socioeconomic growth agenda. This involves actively participating in policy development and implementation processes and building stronger relationships with communities and partners (Thomas et al., 2023). Knudsen et al. (2021) suggest that these shifts in perspectives and activities create new opportunities for technology transfer, with academic involvement driving the development of innovative technology transfer models.

Secondly, the university's effects on students were also explored. As an SEU at the initial stage, Unicamp's students may experience some effects from interaction with the university environment. The exploratory factor analysis employed in the assessment revealed that university entrepreneurial support has no direct effects on student's entrepreneurial intention toward sustainability. This demonstrates that the institutional background must be improved, and students, as relevant actors in sustainable development, do not drive their actions or intentions according to the university's commitment. Other authors (Dagliute et al., 2018; Nejati & Nejati, 2013) also identify that institutional actions may not have the potential to influence students' actions or entrepreneurial intentions. Nevertheless, non-structured initiatives seem to have impacted more individuals and may have the potential to influence their abilities to create a sustainable company.

Student-university engagement, that is, being actively involved and taking part in social and environmental activities, being knowledgeable of strategic documents, implementation reports, and university commitment, and participating in student organizations positively affect sustainable entrepreneurial engagement. The most relevant finding points out that formal activities to foment entrepreneurship (i.e., courses and training) are less effective than those that promote organic interactions among students and the university ecosystem (Farias et al., 2024; Moraes et al., 2023; Fischer et al., 2019). In this sense, some suggestions arise as a pathway to improve sustainable mindset and entrepreneurial intentions: volunteering programs, community projects (Hockerts, 2017), participatory and citizenship behaviors (Monavvarifard et al., 2019), teamwork, real-world learning, problem-solving, social collaboration activities (Ripollés & Blesa, 2024), and sustainable practice-oriented activities in partnership with private and public sectors to intensify students' interests (Leal-Filho et al., 2019). Participating in student organizations is an effective strategy to integrate students around common goals and promote entrepreneurial engagement by the university, as the estimations also showed.

Therefore, considering the abovementioned, this dissertation argues in two complementary directions to foster the KISE ecosystem. The findings suggest that improving sustainable entrepreneurship with high knowledge intensity requires bottom-up and top-down initiatives. Top-down means policy development at the governmental level implemented by funding agencies such as sustainability as criteria of selection to receive investment; facilitating support mechanisms such as incubators, accelerators, and sustainable investment access; partnerships not only with the private sector but also with public ones and non-governmental organizations (NGOs); teaching, research, and technology transfer focused on real challenges connected with triple bottom line issues; and universities institutional changes to embrace sustainability in a transversal way. In turn, bottom-up initiatives include cataloging what the individuals are already doing that effectively contributes to a positive change and boosts them. For example, it was demonstrated that sustainable ventures have already been applying knowledge and technology in their business; researchers are committed to sustainable problems through knowledge creation, research groups, and creating cleaner technologies; there are sustainable patents; and students are motivated through university engagement, which flexible mechanisms can improve. Notably, integrating all these endeavors will result in a *sustainable culture* that utilizes KISE's contributions to foster sustainable development, recognized as a vital asset for future generations.

CONCLUDING REMARKS

This dissertation conceptualizes and describes the KISE phenomenon through different but complementary lenses. It outlines the ecosystem characteristics, central areas of practice, and maturity levels. The findings described an entrepreneurial approach focused on reorientating the ecosystem, with government, universities, researchers, and students as fundamental transformation vectors. It also highlights how entrepreneurship, technology development, and transfer support sustainable transition. The three articles and their objectives, taken together, postulate that the phenomenon of knowledge-intensive sustainable entrepreneurship is latent and developing even with few policies and actions to encourage it in the analyzed context. KISE is essential in achieving sustainable development; it already has a developed structure and needs policies to develop and expand its impact potential. We highlight that each component of the sustainable ecosystem is essential to its effectiveness and interconnection not only in structural but also in functional ways (Suguna et al., 2024). In conclusion, the study emphasizes the emergence of KISE and its main components, arguing that there is room to develop and effectively address social and environmental challenges.

In doing so, some streams of literature have been advanced. First, a new conceptualization, Knowledge-Intensive Sustainable Entrepreneurship, has been developed, emphasizing knowledge and technology dimensions to achieve sustainable growth through entrepreneurship. Then, we contributed to the entrepreneurial ecosystems, presenting the configuration of an emergent arrangement. Thirdly, the study strengthened the literature on sustainable entrepreneurial universities (SEU), describing how a university is upgrading to a new stage, contributing to knowledge and technology development, and adding the role of government through funding agencies. Finally, the sustainable entrepreneurship stream, once the research revealed how the university affects the intention of the potential entrepreneurs and the main strategies to boost it.

Yet, despite some efforts, the dissertation is not without limitations. Due to the availability of data, the analysis of the KISE was concentrated in the São Paulo region, one university (Unicamp), and a small group of students. Since Brazil is a country with a continental area, this may offer a narrow approach, causing difficulty in understanding the whole phenomenon. More research approaches in other regions, both national and international, are encouraged, as well as the inclusion of other ecosystem perspectives such as sustainable incubators and accelerators, technological parks, special investment calls, and funding access. These aspects will offer new pieces of knowledge to delve into the topic of sustainable ecosystems properly. Other interesting research topics are the tensions in KISE companies, considering their triple role in achieving social, environmental, and profit goals. Evaluating sustainable ventures helps refine their characteristics and identify their practical contributions as sustainable companies. This will allow researchers to build a big picture of KISE development.

Policy Implications and Recommendations

Relevant efforts to develop the KISE ecosystem must consider long-term goals interconnected with environmental and social perspectives, venture support, collaboration, government participation, funding agencies, university mission, and student behavior. Policies designed to enhance the ecosystem should consider these factors to ensure the intended impact. Government policymakers could implement these findings in various ways once policies and regulatory instruments on KISE are central pillars. Creation of legal frameworks and standards to enable sustainable ventures to function correctly, provision of financial support, creation of public-private partnerships with them, and finally, the creation of endorsing statements, media campaigns, national registers for sustainable companies, and labels in support of KISE are all initiatives that government can derive (Bozhikin et al., 2019).

Moreover, offering financial assistance through public funding sources and public-private partnerships, such as Unicamp's International Hub for Sustainable Development and Sustainable Campus initiatives, can enhance the ecosystem, ensuring the intended impact and facilitating the development of activities. This initiative may be implemented by funding agencies through public calls to invest in sustainable ventures, training, events, and promote citizenship debates. Likewise, to enhance KISE ecosystem, incubators, accelerators, and mentors can also be specific for sustainable entrepreneurs as they can be seen as agents oriented to stimulate connections and to facilitate action amongst social impact firms, private and public agents (Purkayastha et al., 2020; Guerrero et al., 2020; Pathak & Mukherjee, 2020; Villegas-Mateos & Vázquez-Maguirre, 2020; Pandey et al., 2017). These organizations, also known as intermediaries, facilitate the flow of resources, the building of capabilities, the access to social networks, and the connection with funding sources.

The university, as a natural place for the development of KISE, has the mission of disseminating and including sustainability not only theoretically but also practically in transversal strategies. This positive influence on students leads to them becoming catalysts for the transformation process, given that they have the necessary tools and interests. It is essential to understand their behavior and habits to design methodologies and approaches that can promote the emergence of this type of entrepreneurship. The results of the dissertation suggest specific actions that could be taken to enhance university engagement and commitment. These actions may include, but are not limited to, on-campus activities (i.e., hackathons, events organization, physical spaces to interaction organically), teaching, actionable research, sustainable entrepreneurial training for students, fostering student organization, and building partnerships with other organizations (public and private) to utilize the knowledge and technology generated in university labs and classes to address the grand challenges.

Teaching activities must go beyond traditional approaches and evolve students in sustainable issues using real challenges. From a transversal perspective, for example, this could be combined with public and/or private institutions selecting a specific social or environmental problem to solve. Nevertheless, the academic community must recognize the relevance of these institutional actions by recognizing sustainability as a university mission. Embracing this poses challenges in critically analyzing the university's activities in all areas and proposing new approaches. For example, one can cite the creation of specific prizes as incentives for sustainable undergraduate projects and master’s and doctorate research that contribute to addressing social and environmental issues.

Technology Transfer Officers (TTO) have a distinguished place in this new configuration once they are strategically positioned to take the knowledge produced by the university and connect it with the market needs. Therefore, TTOs must rebrand their activities to include a sustainable view beyond the traditional agreements, including the positive impact the technology may have on society. To properly embrace sustainable entrepreneurship, TTOs can develop flexible transfer mechanisms that consider the technology's impact on society and take risks alongside the enterprise. A specific policy for sustainable ventures seems a reasonable path to potentialize technology transfer and knowledge flow outside universities.

Despite the findings not presenting significance for gender issues, the literature has demonstrated that equality is indispensable to sustainable development. Therefore, some practical actions can also be embedded as general policies, including support for the LGBTQIAPN+ community and women's equity. This can be reached by intensifying the access of LGBTQIAPN+ individuals in universities through quotas and financial support for retention and participating in committees to take their perspectives of inclusion. Women may be empowered as leaders in faculties and schools, having offered equal conditions to participate in national and international events, research practices, and civil service examinations to access academic positions. Both groups are fundamental axes in a Sustainable Entrepreneurial

University. Indicators and metrics must accompany all initiatives mentioned above to assess and measure their success.

Based on extensive research, outcomes confirm that science and technology play a crucial role in sustainable development. Information and research are already available and can positively impact society. They can be used by companies, non-governmental organizations, public organizations, and communities to improve people's lives, protect the environment, strengthen public policies, and drive the next generation forward. Knowledge, innovation, entrepreneurship, and technology are all worthwhile allies that can be utilized to shape new policies and as strategies for achieving sustainable development.

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