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# UNIVERSITY-BUSINESS COOPERATION FOR FRUGAL INNOVATION:

# A CASE STUDY OF THE UNIVERSITY OF CAMPINAS

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# University-business cooperation for frugal innovation: A case study of the University of Campinas

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**Abstract**

Frugal innovation has gained prominence in recent years given its potential contribution to sustainable development and the new opportunities that it provides to low-income customers. However, the role of universities in frugal innovation remains largely unexplored. This paper looks into the different mechanisms through which university-business cooperation unfolds to foster frugal innovation. In addition to the conceptual discussion, the paper provides new empirical evidence based on a case study of the University of Campinas in Brazil. This case study serves as an illustration of how universities in emerging countries engage in frugal innovation in cooperation with business.

## 1. Introduction

Frugal innovation refers to the design and use of products, services and processes that are less complex and costly than prevalent alternatives, often providing smart solutions to meet the needs of low-income customers. The motivations to engage in frugal innovation are manifold. First, from a purely business perspective, it represents an attractive strategy for firms to profit from the opportunities offered by the vast and unsaturated markets of emerging countries (Prahalad, 2014). Secondly, frugal innovation also represents an opportunity to foster socioeconomic development by improving the quality of life of lower-income citizens. Therefore, frugal innovation is associated with "pro-poor innovation" (Lorentzen, 2010) and may be instrumental for closing income gaps, thus contributing to "inclusive innovation" (Chataway et al., 2014). Frugal innovation is also closely related to the notion of "social innovation", which refers to new products, services and processes that meet social needs more effectively and create new social relationships (Murray et al., 2010). However, frugal innovation is not always pro-poor, as it sometimes caters high-income customers too (Tran and Ravaud, 2016), while inclusive innovation and social innovation are broader processes that can unfold not only through frugal innovation but also by other means (Chaminade et al., 2018). Thirdly, frugal innovation has strong potential to foster a more environmentally sustainable economy and society, for example by using less natural resources or emphasizing the use of recycled materials within a circular economy framework (Basu et al., 2013). These different dimensions should be considered when analysing university-business cooperation for frugal innovation.

With regard to the different actors involved, the literature on frugal innovation has emphasized the role of locally-owned firms and entrepreneurs, which hold a better understanding of local

conditions and are capable of inspiring institutional change in their communities (Karnani, 2007). Another stream of research has evidenced the increasing interest on frugal innovation by multinational corporations from developed countries as a way to expand towards the large markets of low- and middle-income customers from emerging countries (Zeschky et al., 2011). As in other spheres of innovation, studies of frugal innovation have stressed the importance of collaborative networks or ecosystems.

Indeed, a strong consensus has emerged regarding the importance of inter-firm, user-producer and local-global networks for frugal innovation, which may be orchestrated by NGOs, local associations and cooperatives, international organizations (e.g. World Bank, WHO), or multinational corporations (Altmann and Engberg, 2016; Annala et al., 2018; Martínez et al., 2018; Tiwari and Herstatt, 2012). In the words of Leliveld and Knorringa (2018: p. 2), "the phenomenon of frugal innovation can most usefully be studied as a specific innovation practice, which can be found at different levels of society involving many and diverse actors, who interact in various configurations".

However, the role of university-business cooperation seems to be somehow downplayed in the existing literature on frugal innovation. A possible explanation for this relative omission is that, compared with other technological innovations, frugal innovation does not rely normally on new scientific knowledge that can be generated at universities, but rather on the recombination and adaptation of already existing technologies. In other words, while the transfer of scientific knowledge generated by universities is critical for state-of-the-art technological innovation, it is usually not perceived as a relevant trigger for frugal innovation. In this chapter, we will depart from this view, arguing instead that university-business-cooperation can play a critical role in promoting frugal innovation. Universities may foster frugal innovation by providing the necessary skills to firms' prospective employees, by supporting young entrepreneurs in the process of creating their start-ups, or by conducting applied research leading to new solutions that inspire frugal innovation initiatives. Universities can also link local systems with global networks and act as brokers that coordinate disperse networks of small firms and local communities, leading to a faster diffusion of frugal innovations.

There is a large body of literature on university-business cooperation (Galan-Muros and Davey, 2017; Guimón and Paunov, 2019; Kochenkova et al., 2016) and on the role of universities for inclusive and social development (Arocena and Sutz, 2017; Brundenius et al., 2017). But university-business cooperation in the particular case of frugal innovation remains largely uncharted. To address this, the general objective of this chapter is to explore the different mechanisms through which university-business cooperation unfolds to foster frugal innovation. In addition to the conceptual discussion, we provide new empirical evidence based on a case study of the University of Campinas in Brazil. This case study serves as an illustration of how universities in developing countries engage in frugal innovation in cooperation with business.

Brazil constitutes an interesting empirical setting to explore university-business cooperation for frugal innovation for various reasons. Within the context of the so-called "social outreach movement", since the 1990s Brazil has implemented new policies to integrate activities of extension into the teaching curricula and research activities of universities, with the aim of enabling a transformative relationship between university and society (Renault et al., 2017). Moreover, frugal innovation appears to be deeply rooted into Brazilian culture, as a function of its stage of development.

## 2. Frugal innovation as part of the third mission of universities

Beyond their traditional missions of teaching and research, universities are increasingly compelled to enhance their so-called "third mission" of contributing to socio-economic development (OECD, 2017). Under a narrow definition, this third mission is primarily associated

with the transfer of knowledge from universities to the business sector to promote innovation and economic growth. More broadly, the third mission is also associated with the wider contribution of universities to the social development of the regions or countries where they are inserted (Renault et al., 2017) and with their capacity to contribute to addressing the United Nations' Sustainable Development Goals (Durán-Romero and Laguna-Molina, 2017). Along these lines, Arocena and Sutz (2017) conceptualize "developmental universities" as those committed to social inclusion through the joint practice of teaching, research and cooperation for development with other institutions and collective actors, including not only firms but also NGOs, government agencies, and social groups. Becoming a developmental university requires strong efforts to expand access to higher education to socially disadvantaged groups, as well as to generate and diffuse socially valuable knowledge that contributes not only to generating economic growth and employment but also to addressing societal problems such as poverty, health or environmental sustainability.

A deeper university-business cooperation oriented towards frugal innovation could contribute substantially to this agenda. This would allow universities to modulate knowledge transfer towards the specific capacities of local firms and entrepreneurs and towards addressing grand societal challenges, with special attention to the needs of the most deprived groups of society. For frugal innovation to become embedded as part of the third mission of universities, an institutional strategic commitment is necessary, creating new processes, structures and incentives that reward researchers and students from different disciplines for engaging in frugal innovation projects in cooperation with firms and local communities (Matheson, 2008). Indeed, in order to instigate a cultural shift supporting university-business cooperation for frugal innovation, visible institutional incentives and support are critical. Such top-down approach to foster university-business cooperation for frugal innovation would complement bottom-up initiatives. In other words, the aim would be to provide more clear incentives and support to ad hoc frugal innovation projects undertaken by individual members of the academic community.

University-business cooperation can unfold in many different ways, including through direct channels (e.g. collaborative research, contract research, patent transactions, spin-offs, labor mobility, etc.) and indirect channels (e.g. publications, conferences, networking, facility sharing, etc.) (Galan-Muros and Davey, 2017; Grimpe and Hussinger, 2013). The more relevant channels are context-specific, considering the capabilities of the different actors involved, the type of technology transferred, the national context, etc. In the following sections, we dig further into the university-business cooperation mechanisms that appear to be most relevant for a frugal innovation agenda.

### 2.1. Fostering technology transfer for frugal innovation

Universities can engage in applied research in cooperation with industry to develop the technology required for frugal innovation. They may also develop such technology internally and then commercialize or share the results through different means including patent licensing, creation of spin-off companies, academic consultancy, or altruistic outreach and extension services. To promote frugal innovation, universities need to cooperate with a variety of firms, including start-ups, SMEs and large firms, either local or foreign-owned. The informal economy of entrepreneurs in developing countries represents a very relevant collective to consider when speaking of frugal innovation. In this sense, universities should aim at stimulating "grassroots" innovation developed by communities and civil society (Chaminade et al., 2018; Cozzens and Kaplinsky, 2010).

Beyond relying on the initiative of individual professors and researchers, those universities that wish to push frugal innovation as part of their strategic missions need to instigate institutional changes in their governance systems. Indeed, a barrier to frugal innovation may be the lack of incentives for researchers to engage in frugal innovation, since they are normally rewarded only

for more measurable outputs such as publications, patents, or research projects, which are not easy to achieve when focussing on frugal innovation. The institutionalization of frugal innovation can be pushed through intermediary organizations such as incubators, technology transfer offices (TTOs) and science and technology parks. For example, TTOs can identify existing research projects with possible implications for frugal innovation and ensure a proper disclosure of their results, searching for business opportunities in cooperation with private partners. Moreover, such intermediary organizations can be transformed to further include within their missions the need to link with poor communities as active agents of knowledge transfer in cooperation with businesses (Kruss, 2017).

An interesting example of these new forms of intermediary organizations is the Technological Incubator of Popular Cooperatives (ITCP) of the Federal University of Rio de Janeiro, Brazil. It was established in 1995 as an extension program focusing on developing new cooperatives among socially deprived groups (such as unemployed or underemployed workers; users of the mental health system; and recyclable waste pickers groups). This model later became an official program of Brazil's federal government, was replicated in more than 60 locations, and was elected as one of the country's ten most important programs to fight poverty (Renault et al., 2017).

The digital transformation is also providing new opportunities to develop business models for frugal innovation. New digital platforms such as InnoCentive, IdeaConnection or Yet2 help to match supply and demand for technology by connecting firms with global networks of university research groups, individual scientists and freelancers to solve specific technological problems. New forms of open innovation have emerged including online communities of experts, tournaments, open calls and crowdsourcing (Dahlander at al., 2008). In addition, research results and data are becoming more easily and freely available through open data and open access practices, while the interactions of science and the civil society are being enhanced through open science. All of these trends have the potential to stimulate frugal innovation, for example by financing new technological solutions and ventures through crowdsourcing, by organizing disperse individuals and communities through digital platforms, or by linking universities and firms from different countries to solve common challenges.

### 2.2. Building skills for frugal innovation

In parallel to the generation and transfer of appropriate knowledge, a key objective of developmental universities is to encourage new employment and entrepreneurial opportunities in low-income countries through frugal innovation. Indeed, the flow of university graduates with the appropriate skills to industry is a critical channel of university-industry interaction. In developing countries, it becomes especially important to develop the capabilities required for frugal innovation, so that local businesses can emerge to profit from the opportunities available, rather than a situation whereby foreign multinationals end up reaping all the benefits. In addition to traditional university degrees, universities should also emphasize lifelong learning through continuing education programs on topics related to frugal innovation, targeted in particular to fostering social inclusion and addressing social challenges (Arocena and Sutz, 2017).

For this purpose, universities should collaborate with firms in curriculum design and delivery, in order to provide relevant skills on frugal innovation to students. In the fields of engineering, some of the frameworks and techniques that are relevant for frugal innovation include design for cost, design for manufacturing, value-sensitive design, or design for sustainability. In order to build the required capabilities for frugal innovation, universities should emphasize problem-based learning and entrepreneurship education. Such skills can be included across a wide range of scientific and social disciplines, and not only in engineering and business studies. Entrepreneurship education focusses on providing students with the necessary skills and incentives to set-up a new company. In this regard, a common approach is to support the development of bachelor and master theses as business plans for frugal start-ups. In addition, the example of start-ups should be used as part

of the learning experience and entrepreneurs should be invited to participate in teaching and mentoring activities of universities. The literature on "entrepreneurial universities" (Etzkowitz, 2016) can inspire new pathways for universities to promote frugal innovation through entrepreneurship. In particular, new developments in this stream of research point to the importance of university governance, leadership and contextual fit with the environment (Klofsten et al., 2018).

It is also critical to connect students with the social reality of low-income communities and with the most disadvantaged groups, not only through classroom learning but also through organized visits, fieldwork and structured internship programs. The aim would be to make students aware of the most pressing social needs and of the opportunities to address them through frugal innovation. This illustrates the importance of considering not only knowledge transfer from universities to business, but also the other way around, acknowledging the bidirectional nature of knowledge transfer. Indeed, universities need to reach out to low income communities in order to learn and become more effective in their teaching and their research.

Another means to foster frugal innovation through the teaching role of universities is by widening access of disadvantaged groups to higher education institutions. Besides narrowing inequalities, the presence of students from marginalized sectors of society could help to include more issues related to frugal innovation and social innovation in the teaching and research agendas of universities, and to build new types of connections between universities and businesses.

## 3. A case study of the University of Campinas

The selected case study deals with the University of Campinas, one of the leading universities in Brazil in most indicators related to research quality and technology transfer intensity. The objective is to illustrate how university-industry cooperation for frugal innovation unfolds in practice. Our research strategy begins with in-depth evaluation of public documents from the university that allow identifying agents of interest, as well as understanding the institutional profile concerning its orientation towards: (i) engaging in regional development processes, particularly via inclusiveness; (ii) other strategies to tackle inequality within the context in which the university is embedded; and (iii) establishment of linkages with firms in specific projects related to frugal innovation.

Subsequently, personal interviews were conducted by our research team with four categories of agents within the institution, namely: Institutional Representatives, Student Organizations, Research Centers & Groups, and Academic Spin-offs. An additional interview was held with a large multinational company that has a history of interactions with the University of Campinas in order to obtain a complementary perspective. This multidimensional character of agents represents an appropriate methodological approach for an exploratory study of an emerging research area, which might lead to useful insights and tentative propositions to feed a future research agenda. Nonetheless, as with any case study research, our findings are hampered by the risks of sampling bias and subjectivity, which limit the capacity to generalize to a wider population of universities and countries (Yin, 2003).

The profiles of interviewees are not presented in further detail to respect individuals' privacy[2]. We used snowball sampling to reach individuals of interest for our assessment, starting from the university's technology transfer offices. A total of 14 interviews were undertaken in the months of March, April and May, 2019. All interviews were recorded with the consent of participants,

[2] This procedure follows recommendations from the Research Ethics Committee from the University of Campinas. Interviews were approved under the protocol #89010418.2.0000.8142/Project 'Universities as Pivotal Agents in Innovation Ecosystems'.

fully transcribed by two research assistants and analyzed by the authors. Although with variations and adaptations according to interviewees' categories, scripts addressed:

a. Level of institutionalization of frugal innovation in scientific and technology transfer activities;
b. Dynamics of university-business collaborations and potential linkages with frugal innovations;
c. Future challenges concerning further contributions of university-business connections to the broader socioeconomic environment.

A key challenge in this empirical assessment concerns the use and precise comprehension of the term frugal innovation for the Brazilian academic context. First, this concept is not widespread in Brazil, so most interviewees were not familiarized with it. In order to tackle this issue, we prepared a brief introduction based on relevant literature that offers a comprehensive perspective on our research goals (Lorentzen, 2010; Chataway et al., 2014; Murray et al., 2010; Tran and Ravaud, 2016; Chaminade et al., 2018; Basu et al., 2013). While effective, this approach still caused some confusion, as many interviewees were researchers more closely connected to scientific advancements than to innovation *per se*. For these cases, we adopted a more open strategy for conducting interviews, extracting aspects that could be associated to the notions of frugal and social innovations during the analyses of transcripts.

### 3.1. Context

Brazil is an interesting empirical setting to explore university-business cooperation for frugal innovation, since the country's universities have a long tradition of engaging in social development and extension services. In particular, since the 2000s, new policies have been launched to achieve a more inclusive higher education system (Renault et al., 2017). Furthermore, the institutional changes that took place over the last two decades have had significant impacts on the connections established between academia and other agents, including indigenous and multinational firms (Dewes et al., 2015; Fischer et al., 2018b; Santos & Torkomian, 2013).

In this study we focus on the case of the University of Campinas (also known as Unicamp), one of the leading Higher Education institutions in both Brazil and Latin America. Illustratively, roughly 10% of Brazilian indexed scientific articles have at least one co-author from Unicamp (Guerrero et al., 2014). Its faculty consists of over 2,000 lecturers and professors, predominantly with a PhD degree (99%), and nearly 20,000 graduate and undergraduate students, spread across 6 campuses, 24 institutes, 21 research centers and 3 hospitals. Beyond its basic functions of teaching and research, Unicamp is also acknowledged as one of the most prolific Latin American institutions in terms of technology transfer (Dias & Porto, 2018).

The University of Campinas is a public university attached to the government of the State of São Paulo. It was originally instated in 1966 as part of a strategy to respond to demands of the industrialization processes taking place in the country, considering not only the lack of qualified human resources, but also the need for establishing stronger connections between scientific and technological developments and the activity of firms. At its inception, the organizational design of the University of Campinas counted with a close collaboration with the state's Federation of Manufacturing Industries (FIESP) in order to take into account the needs of the regional productive system (Nascimento, 2016).

Following these developments, the University of Campinas established a Technology Center in 1972, to provide services and technological assistance to firms, as well as applied research and training of technicians and engineers. Other governmental initiatives followed, strengthening the capabilities of the Campinas region, while also sowing the seeds for a thriving ecosystem of innovation and entrepreneurship. Illustratively, because of the research competences in optic fibers available at the Institute of Physics, the Federal Government decided to place two research

facilities in the field of telecommunications in the campus neighborhood: the Center for Information Technology (CTI) and the Center for Research and Development in Telecommunications (CPqD). These connections were translated into intense collaboration between academia and government, also fostering the attraction of multinational firms to Campinas (such as IBM, HP, Texas Instruments, Lucent Technologies, Motorola and Samsung) and generating conditions for a friendly environment for academic spin offs. These conditions also led to the creation of Brazil's first synchrotron in Campinas, in 1997 (Nascimento, 2016). Funded by the federal government, this facility functioned as a mainstay for the National Research Center in Energy and Materials (established in 2010), a complex infrastructure located just outside the main campus of the University of Campinas, and which stands as a key node for university-business cooperation in this ecosystem.

Currently, Campinas represents one of the most thriving areas in innovation and entrepreneurship in Latin America (Fischer et al, 2018a). However, the city still faces large inequalities and pockets of poverty; typical maladies faced by metropolitan areas throughout Latin America. Illustratively, the most recent estimation of income inequality in Campinas points to a Gini index of 0.578, indicating a high concentration of wealth. At the same time, Campinas is undergoing a process led by the Inter-American Development Bank to become a digital ecosystem with full integration with smart city concepts and promotion of initiatives related to Industry 4.0. These dual characteristics of Campinas illustrate its main challenge: to achieve higher levels of *inclusive* development. Thus, the third mission of the University of Campinas needs to embrace broader social goals rather than focusing only on economic growth, which translates into supporting not only technological innovation but also other forms of social and frugal innovation. This is reflected in the university's current strategic plan[3] with a strong focus on social responsibility and inclusiveness from a transversal perspective, i.e., involving teaching, research and outreach activities. Hence, a key organizational goal is expressed as "*To generate knowledge in all fields of science and disseminate it through teaching and other diffusion mechanisms […] leading the definition of innovative agendas that express institutional commitments to society*" (quote from Unicamp's 2016-2020 Strategic Plan). Accordingly, as an envisaged future, Unicamp foresees a deeper integration between its academic role and social demands from society, fulfilling its developmental goals that date back to its foundation.

### 3.2. Fostering technology transfer for frugal innovation

Taking into account its historical background, as discussed in Section 3.1, the University of Campinas is a pioneer in the Brazilian context considering technology transfer activities. In the 1980s, it was among the first universities in the country to launch managerial strategies for its intellectual property portfolio, aiming at administering its technological potential and licensing it out to industrial partners. Accordingly, its first Technology Transfer Office (TTO) was inaugurated in 1990, facing the ubiquitous challenge of circumventing the mistrust between academia and firms (Hertzfeld et al., 2006). Unicamp has become one of the most active patent assignees in Brazil and is also characterized by an above average propensity to cooperate with industry (Fischer et al., 2018b).

Following the evolution of academic embeddedness in firms' activities that took place over the 1990s (Etzkowitz, 1998), the existing structure became obsolete in face of the university's needs and orientation. Consequently, in 2003, the TTO was absorbed by a proper Innovation Agency, INOVA, with a multi-sided, proactive and long-term orientation. This step preceded the Brazilian Innovation Law in 2004 – which, among other items, installed the requirement for public universities to establish TTOs in their respective organizational structures. This new institutional environment for technology transfer activities represented an important step forward in the Brazilian dynamics of university-business interactions (Santos & Mello, 2009).

[3] http://www.prdu.unicamp.br/areas2/planes/planes/arquivos/planes-2016-2020 (in Portuguese)

The University of Campinas played the role of nationwide leader in this process. Inspired by the experiences of Yale, Massachusetts Institute of Technology and the Association of University Technology Managers (AUTM), INOVA served as a benchmark for TTOs across Brazil. Currently, the staff of INOVA consists of about 35 full time employees and it manages the intellectual property portfolio of the University of Campinas (available online), R&D partnerships with companies, licensing activities, the university's Science Park, a business incubator and entrepreneurship policy at the institutional level. More recently, in 2017, INOVA founded *Vértice*, a venue within the Science Park to harbor both startups and incumbents, offering a physical space that aims at strengthening ties between academia, new firms and large companies.

In terms of R&D collaboration, the main areas of specialization within the University of Campinas include health sciences, electrical engineering, computing, mechanical engineering, biology, chemistry, energy and petroleum. Some relevant partnerships involve Royal Dutch Shell and Petrobras, the Brazilian State Oil Industry. In this regard, it is interesting to notice the role played by Unicamp's Center for Petroleum Studies, a research facility that was created in a joint effort with the federal government to address technological barriers in the oil and gas industry. According to our interviews, all of this joint research ultimately translates into a better quality of training for students.

A case of interest for the purposes of our assessment concerns the research and development of frugal innovation from natural resources typical from Brazil, such as polyurethane from Açaí and derivation of biomaterials from sugarcane molasses for applications in plastic surgery. This latter project has the potential of exponentially aggregating value for this raw material, generating wealth for those communities involved in harvesting this crop. Also, the São Paulo Power and Energy Company (CPFL, part of the Chinese Group State Grid) has strong ties with the university with specific focus on energetic efficiency and sustainability. In this latter case, the geographical proximity also allows for a strong flow of students to the firm. Following these experiences, Unicamp has been involved in a broad initiative to establish an International Hub of Sustainable Development, together with other universities, companies and governmental bodies. This is mirrored in its technology transfer mission, which aims at "*fostering research, teaching and outreach activities from Unicamp that focus on sustainable socioeconomic development*" (quote from an Institutional Representative).

However, even though these actions are attached to a strong scientific and technological activity via publications and patents with frugal and societal orientation, the university has yet to develop mechanisms to map these outputs. A main challenge identified by Institutional Representatives of the university concerns the difficulty, for instance, in concatenating institutional interests with the autonomy of researchers. This is particularly critical since the latter are mostly involved with state-of-the-art technologies that do not necessarily translate into cost reduction in products and processes in the short term. Hence, although there is plenty of information available to assess university-business links in general, the aim is to focus on the still unexplored issue of cooperation for frugal innovation. This leads to the empirical challenge of isolating the role of the university in fostering frugal innovation, since sometimes this is masked within broader initiatives, and not necessarily referred to as frugal innovation in official documentation. This viewpoint is also shared by researchers: if some of the technologies can be *cheaper* than available standards (and thus frugal), they are not necessarily affordable for disadvantaged populations. It should also be pointed out that they represent potential opportunities for technology upgrading, as they substitute imported goods that are not currently produced in Brazil.

One specific challenge in this respect is the lack of incentives for undertaking frugal innovation initiatives in Brazil. This is a concern expressed by both researchers and entrepreneurs from spin-off companies, which is mainly associated with the lack of market demand for science-based products in the country and the consequent scant access to lines of funding (for researchers) and venture capital (for entrepreneurs). Given the nature of applicable knowledge produced by the university, its evolution towards standardized products that can reach enough scale to become

accessible for a wider market seems to hamper a further integration of academia into the dynamics of frugal innovation.

From the perspective of university-industry joint projects, interviews with Institutional Representatives highlighted that the fact that companies have been establishing social and environmental responsibility policies has impacted on their demands in terms of interactions with the university. However, from the perception of a Research Group, this is not necessarily the case for multinational firms, which do not seem to engage in such sort of R&D collaboration in Brazil. On the other hand, the broader institutional framework in which these linkages are embedded has been facilitating these connections. As addressed by another Research Group involved in a large project on environmental sustainability and energetic efficiency, sectoral policies that promote joint R&D projects involving firms and public universities represent strategic mechanisms to strengthen ties with industry.

In addition, interviews with Research Center members and entrepreneurs belonging to spin off companies have stressed the importance of Unicamp's strong technology transfer structures. According to their perceptions, the Innovation Agency not only facilitates approximation with industry, but it has actively promoted a stronger entrepreneurial culture in academics. In parallel, the updated Science and Technology Regulatory Framework is expected to improve these conditions by facilitating exchanges between academia and industry. As expressed by a Research Group leader, "*in the past, collaborating with companies was frowned upon, in the public university you could only do research. Then one day, we ran out of money and people started asking 'how we are going to fund research now? Now we have to resort to private firms […] younger researchers and faculty are also renewing the environment with fresher ideas*" (quote from an interview with a Research Group leader).

However, these processes do not take place easily and they take time to reach maturity. A manager from a large firm described the evolution of relationships with the university as moving from initial informal contacts that usually take years to translate into actual joint projects. In this regard, what the firm notices is "*complementarity […] Unicamp offers strong conceptual and academic knowledge […] when you bring in an academic partner, with a different perspective […] it is there where a new technology comes to life, a new concept, that is going to be applied further down the road"* (quote from the interview with a large company's innovation manager). On the other hand, the perception from companies also points to barriers associated with the slowness of internal processes at the university-level, which makes signing contracts and agreements a lengthy process.

Additionally, another critical form of integration consists in the extensive flow of undergraduate and graduate students to occupy positions at firms, an aspect that is perceived as a relevant source of input for further interactions with the academic environment, reinforcing the idea that this shared research environment can improve the quality of teaching.

### 3.3. Beyond science: the university as a cradle for entrepreneurs

Another area of technology transfer emphasized by the University of Campinas excels consists in the generation of spin-offs, once again highlighting the pivotal role of this institution in the business and innovation ecosystem. During our interviews, academic entrepreneurs have clearly expressed that the culture of the university promotes entrepreneurship through dedicated policies and initiatives. In this regard, the strategic importance of business incubators was highlighted, offering managerial support and access to networks that enhance the capabilities of these new ventures.

Unicamp not only offers an incubator for high-tech ventures, but also an incubator dedicated to support social technologies, oriented towards promoting inclusion, and generation of income for vulnerable groups. Projects include cooperatives that deal with basic sanitation and

agroecological techniques. Interestingly, this environment is strongly connected with research activities and several undergraduate and graduate students have been involved in training and research focusing on the dynamics and impacts of these businesses.

Notwithstanding, the main focus of Unicamp's spin-offs is still related to technical fields involving different areas of engineering and health sciences. Most of these companies are located in the Campinas Metropolitan Region, while the State of São Paulo as a whole absorbs over 90% of these ventures. This is consistent with recent studies which posit that high-tech clusters are mostly located in the surrounding areas of academic campuses (Isaksen and Trippl, 2017). An offspring of this movement was the creation in 2006 of the Unicamp Ventures Community, a structure that seeks to thicken entrepreneurs' connections with other agents – such as the financial system – and to offer mentoring to newcomers. Such conditions underscore the typical regional dynamics of feedback loops that reinforce the competitiveness of the geographically bounded innovation ecosystem (Audretsch and Belitski, 2017).

Accordingly, the exchanges that take place through academic collaboration with the outside environment – including firms and research institutes – have been pinpointed by interviewed academic entrepreneurs as a key pillar for achieving technological development, indicating the role of a dense ecosystem. In practical terms, these linkages were translated, for example, into technologies that allow early detection of breast cancer that can be applied at significantly lower costs than existing apparatuses used for mammography. Other spin-offs achieve similar cost reduction results for physical rehabilitation of medical patients and bioengineering techniques. These serves to illustrate the results achieved in terms of frugal innovation.

Close ties with companies in a large research project for environmental sustainability and energetic efficiency also resulted in a number of spin-off companies, as reported by a Research Group leader. In this regard, the project functioned as a field of tests for developing new technologies, while networking activities with large incumbent firms opened up market opportunities for students to pursue entrepreneurial career paths. Again, the entrepreneurship-friendly culture of the university simplified these processes. In addition, the financial support provided by the São Paulo Research Foundation (Fapesp), a public entity, for R&D in small companies has proved strategic to leverage these startups.

But Unicamp's connections with entrepreneurship also faces important challenges. This can be attributed to the overall regulatory framework and macroeconomic conditions of the Brazilian economy, as well as a lack of training for entrepreneurship in STEM fields. A Research Center leader emphasized these barriers: "*where are the spin offs? It is all very difficult in Brazil […]We are not trained to become entrepreneurs. It is only now that this model has become known […] in doctoral theses I start to perceive a context of market orientation and innovation, aiming at generating products or processes, and that the student is no longer dependent on finding a position as faculty member in a university, he now can become an entrepreneur*".

An additional aspect of interest in this discussion refers to the bureaucratic requirements for entrepreneurs to remain connected to the university's laboratories and research infrastructure. One entrepreneur highlighted that the documentation and procedures he has to go through in order to formalize a partnership with the research unit he came from are excessive for a small firm. While large corporations can dedicate resources and people to navigate through these processes, it becomes hard for a startup to dedicate time for this. As a result, there is a lack of incentives for spin-offs to collaborate more closely with academia once their company is created. As a public university, Unicamp has to abide to overarching regulations that are attached to federal and state-level laws, thus not leaving room for the institution to be flexible in this respect.

### 3.4. Building skills and widening access

The University of Campinas has established entrepreneurship as a key area in its educational portfolio. Besides offering traditional entrepreneurship courses for students from different disciplines, a strong institutional support exists for junior enterprises, involving undergraduate students in business activities from an early stage of their formation.

From a different perspective, Unicamp presents a strong commitment with the inclusion of low-income students. A cornerstone initiative in this regard is the Program for Higher Interdisciplinary Education (ProFIS). This pioneering program in Brazil favors students from public high schools in Campinas facing situations of social vulnerability and allows them to have an interdisciplinary education for a period of two years before deciing if they wish to pursue a formal university degree. Additionally, Unicamp has long been including social and racial quotas in its entry exams, aiming at reducing opportunity inequalities. Its latest action in this regard was the engagement with indigenous communities, selecting students from tribes in the Amazon region. Most importantly, these programs are complemented with strategies to reduce dropout rates, with the provision of financial assistance through the implementation of research and administrative scholarships, psychological services, and access to housing facilities.

To dig deeper into these processes, our interviews included contacts with student organizations and institutional representatives associated with outreach initiatives. In this regard, we could identify that these student bodies represent a relevant part of the educational development, going beyond the classroom and laboratories, promoting social entrepreneurship and linkages with vulnerable communities. However, students notice a lack of engagement of faculty members in their initiatives, an aspect that has been improving with the inclusion of research and mentoring projects for these organizations. Linkages with companies are still scarce, a problem that limits the availability of funds for undertaking larger projects.

For the case of outreach activities, interviews underscored the need to build solutions together with target communities – not only through direct transfer of academic knowledge. However, although a larger engagement of researchers and faculty in these dynamics, they do not necessarily – and often do not – involve technological innovation. In this case, organizational forms of innovation are more common, although some identify cases that do in fact rely on the application of cost-effective technologies. An example of such type of frugal innovations includes the development of tents designed to assist populations from areas affected by natural disasters, resulting in products that are affordable and simple to assemble.

Other forms of student engagement with frugal, social and environmental innovations involve active learning in research projects. For instance, a new course for undergraduates has its focus on the development of a pipeline for household energy generators, starting from technical feasibility studies and reaching the stage of prototypes by the end of the program. As mentioned by a Research Group leader, when this kind of initiatives are embedded in joint projects with industry, there are often offerings of scholarships funded by companies. In any case, the University of Campinas has incorporated students as a key part of its developmental activities.

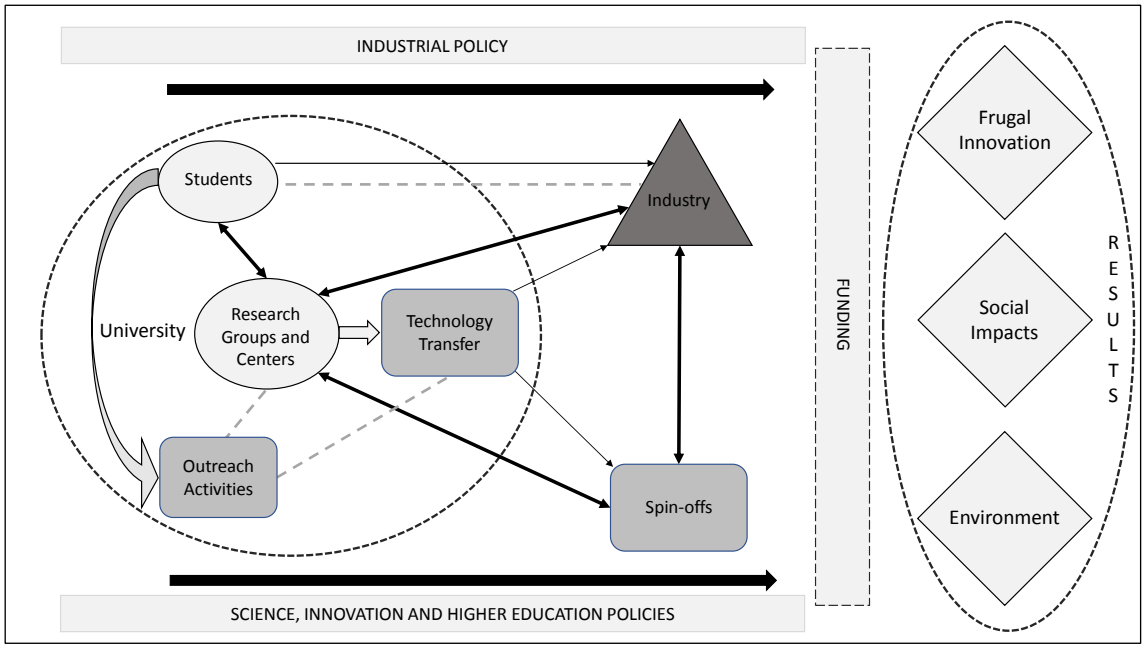
## 4. Conclusions

This chapter has addressed the interplay between the pivotal role of academic institutions in the context of innovation ecosystems and the relevance of frugal and social innovations for the reality of the developing world. For this purpose the case study of the University of Campinas, Brazil, sheds new light on the dynamics behind such processes and derives some exploratory remarks that can guide future research in this critical topic.

Based on our interviews and documental analysis, Figure 1 establishes a simple analytical framework to understand how relationships take place in order to promote frugal innovations, social and environmental impacts through university-industry connections. These linkages are

embedded in a broader context of industrial policies and science, innovation and higher education policies. A main identified hurdle for these dynamics to effectively translate into more noticeable results is the scarce availability of funding opportunities for such endeavors. The density of connections in the university-industry system can still be improved, as some relationships are still of a unidirectional nature or present only weak ties.

**Figure 1. Relationships Leading to Frugal Innovation, Social and Environmental Impacts**




**Notes:** Unidirectional and bidirectional arrows identify the flow of relationships. Dashed lines represent weak ties. For example, students are connected to industry through supply of human resources and (weak) ties between student organizations and firms.

In this regard, our assessment carries lessons for universities, firms, policymakers and researchers. First, for higher education institutions, our findings point to various challenges associated with translating scientific and technological developments into accessible, inclusive and sustainable innovations, building on a closer internal connection between research, teaching and outreach activities. The institutional coordination mechanisms that are necessary to drive the actions of autonomous researchers in these directions are far from simple and they may require structural shifts in the way evaluation and incentive systems are designed. Still, these mechanisms should not harm institutional capabilities of producing frontier knowledge. This is where the strategic importance of organic engagement from researchers and faculty lies, not relying on a top-down, centralized policy – as proposed by an Institutional Representative during our interviews. Balancing such perspectives can be tricky, but it also represents an opportunity to further integrate academia and society within the framework of broader socioeconomic development agendas. .

Second, the results of our analysis suggest that firms can also benefit from establishing linkages with universities based on frugal innovation dynamics. While academic institutions in Brazil are often perceived as potential sources of advanced R&D (Fischer et al., 2018b), contributions could be enhanced by a focus on cost-effective, sustainable products and processes. As our interviews demonstrate, academic spin-offs often face barriers associated with the difficulty of achieving scale – a hurdle that could be overcome through closer cooperation with incumbents. By reaching out to large, untapped markets, firms could achieve higher levels of competitiveness through joint initiatives with universities, ultimately generating higher levels of social welfare.

Third, such aspects raised for universities and firms justify why policymakers should play a role in promoting these types of connections. Facilitating the establishment of linkages through more flexible and simple regulatory frameworks – particularly for small ventures – could represent a significant contribution for strengthening ties in innovation ecosystems. This is of particular interest in developing countries, where academia concentrates human capital and technological prowess (Ryan, 2010). By advancing in this front, technology upgrading processes could be coupled with more immediate needs associated with vulnerable communities and the natural environment. Also, our case study highlighted the eminent role of the São Paulo Research Foundation (Fapesp) in promoting university-business interactions through funding of research projects and also through initiatives that explicitly target technology transfer.

Lastly, while studies on the third mission of universities abound, the context of developing countries is still poorly understood. As a consequence, policies and assessments often mirror trends observed in the developed world. This is unfortunate, as universities' connections with industries in laggard nations could provide more meaningful outcomes if better connected with the local environment. Further analyses in different contexts through qualitative and quantitative studies could explore the effective contributions of university-business linkages for frugal innovation, sustainable development and social inclusion.

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