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CROSS-MATCH: HOW TO IDENTIFY THE DAUGHTER COMPANIES OF A UNIVERSITY AND ESTIMATE THEIR ECONOMIC IMPACT?

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Fernando Guerrero Cunha[1], Roberto Ferrari Junior[2] and Andreza Aparecida Palma[3].

ABSTRACT

A university is evaluated by the people it trains, the knowledge it provides and, more recently, the companies and jobs it generates. "Daughter companies" of a university are those created by former students or by people with some connection to the university. The objective of this article is to provide a better understanding of how to map companies that are daughters of a university, and to evaluate their economic impact. By systematizing the literature, we found that the reported cases used the sending of questionnaires to former students – a method whose results depend on participation in the research, which never reaches 100%. So we proposed and tested a method based on cross-referencing university information with business information available in public databases. To test the proposed method, called Cross-Match, we conducted a study with former students of the Computer Engineering course at the Federal University of São Carlos (1992 to 2019). For the 792 names tested, 352 companies were found, 206 (58.5%) of which were active; 42.7% of Micro Size, 13.1% of Small Size and 44.2% of Other Sizes, making it possible to estimate an average revenue ranging from R$ 0.4 to R$ 27 billion, and to generate other indicators. This research contributes by systematizing information; by proposing and testing an unprecedented method in the literature, which does not depend on response rate, with the potential to automatically generate indicators on the impact of the university on society through its daughter companies. To advance the research, we suggest applying the method on an institutional scale, using government information, possibly in combination with consultation with former students.

Keywords: Daughter Companies. University Spin-Offs. Economic Impact of Universities. Mapping of Daughter Companies. University Entrepreneurship.

[1] Master's student in Science, Technology and Society
Federal University of São Carlos
E-mail: fernandoguerreiro@estudante.ufscar.br
ORCID https://orcid.org/0000-0002-8691-5660
LATTES: http://lattes.cnpq.br/6615516756375579
[2] Dr. in Computational Physics
Federal University of São Carlos
Email: ferrari@ufscar.br
ORCID https://orcid.org/0000-0003-3213-5084
LATTES: http://lattes.cnpq.br/1581806209106850
[3] Dr. in Applied Economics
Federal University of São Carlos
E-mail: drepalma@ufscar.br
ORCID https://orcid.org/0000-0002-0440-1683
LATTES: http://lattes.cnpq.br/0665252951411171

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INTRODUCTION

In Western Europe in the ninth century, the focus of teaching and academic training followed the demand of society, which, in the period, was a more generalist education, with a small set of courses. In the eleventh century, the first University in Europe appeared, and teaching was the main objective of the university. From the nineteenth century onwards, the insertion of research began as a goal of the University, especially in countries such as Germany, France and England. Only after the Industrial Revolution, the specialization of teaching began (Audy, 2017).

In the second half of the twentieth century, especially in the United States, another revolution emerged: the role of the University as a vector and protagonist of the process of economic and social development (Santos & Almeida Filho, 2008). With entrepreneurship being seen as a tool that helps in the economic and social development of a society, identifying the entrepreneurial culture as a driving force for change in society (Machado, 2017) and added to the Theory of Entrepreneurship by the Overflow of knowledge (Acs et al., 2009), it is recognized that the knowledge generated in universities is a source for the generation of new businesses and the commercialization of ideas not yet explored.

Based on the objective of fostering economic growth through entrepreneurship, universities adapt to society's need to create new businesses with technology and foster entrepreneurship. In this way, the vision of innovation in the University has also changed, moving from linear and long-term contributions, to a closer relationship between the university and society (Etzkowitz & Leydesdorff, 1997), possibly with short-term results. There is also the change in the generation of innovation that moves from a linear model to an iterative model, making the university an important actor in this process (Kline & Rosenberg, 1986; Mowery & Rosenberg, 1979; Rothwell, 1994). The very way students consider their Final Papers has also changed: in several countries, students are encouraged to develop topics that contemplate real processes and services, and can even generate startups (Valenti & Bueno, 2020). In addition, the university's relationship with startups and companies already established in the region is a catalyst for the development of knowledge-based technological innovation (Tosta, 2012) and the interaction between students and alumni creates an environment conducive to entrepreneurship, the generation of patents, the foundation of startups with technology licensed by the university, thus enabling the orientation of applied knowledge in the field and also the recognition by

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students of the potential of business and finance, of the knowledge generated at the university (Renner, 2017).

The municipalities that were more innovative and entrepreneurial according to the index used, had the highest Human Development Index (HDI). In these cases, Education was highlighted, emphasizing that the training of human resources and knowledge was a relevant asset for the promotion of innovation and entrepreneurship (Dos Santos, 2020).

In the United Kingdom, universities and the government collaborate to define research areas at each university, and the government acts as an auxiliary in connecting the university with industry, adapting and directing industries to use the academic potential of universities (Lambert, 2003). In Brazil, Caldarelli (2015) studied the relationship between the state universities of the state of Paraná and the economic development of the state. In Garnica's (2007) research, an exploratory and qualitative analysis was carried out, in which the following were studied: University of São Paulo (USP), São Paulo State University - Unesp, State University of Campinas (Unicamp), Federal University of São Paulo (Unifesp) and Federal University of São Carlos (UFSCar). In his study, Garnica (2007) concluded that the formal transfer of technology using intellectual property has been growing in public universities in the State of São Paulo.

A startup is a company in search of a profitable, repeatable and scalable business model, which is in a situation of extreme uncertainty (Blank & Dorf 2012). Universities with a strong emphasis on research usually consider as one of their results for society the creation of companies called spin-offs – companies created from the transfer of knowledge generated from their research (Miranda, Chamorro & Rubio, 2018). There is also another classification for companies: companies that are daughters of a university, which are defined as companies founded by students, alumni, professors, researchers, and active or retired technical-administrative staff; that is, a company created by people who have or have had some link with the university Gonçalves et al. (2022), Mori et al. (2017).

Daughter companies can be, therefore, startups that were incubated and graduated by the institution, companies that use university technologies, or other companies, created by people who, at some point, went through the university. Thus, academic spin-offs can be considered daughter companies, but not all daughter companies are academic spin-offs. Still, a startup can be a daughter company, but a daughter company does not have to be a startup. The concept of a daughter company covers all types of companies, created by people with some connection to the university.

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Thus, one of the contemporary ways that a university can use to measure its economic and social impact and its contributions to society is through indicators related to its daughter companies. In this way, mapping the university's daughter companies, building indicators, and analyzing the impact of these companies based on these indicators is a way to measure the economic and social impact of a university. The evaluation of the economic and social impact of a university can complement more traditional forms of evaluation, such as graduate students, scientific and technological production.

HOW HAVE UNIVERSITIES MAPPED THEIR DAUGHTER COMPANIES?

The Massachusetts Institute of Technology (MIT) conducted a first mapping of its daughter companies by sending a questionnaire to all its alumni and, later, a second questionnaire to those who identified themselves as entrepreneurs (Roberts et al., 2011). In 2001, a questionnaire was sent to the 105,000 MIT alumni as to whether or not they were entrepreneurs. The survey obtained 34,846 responses, in which 8,179 (23.5% of respondents) alumni said they were entrepreneurs. In 2003, another questionnaire was developed to be sent only to entrepreneurial alumni, with questions focused on the operation of the companies and the training of these individuals. In this second survey, 4,611 companies were identified, founded by 2,111 alumni. Through the answers to the second questionnaire, it was identified that 2.2% of the companies were duplicated, with more than one MIT alumnus in the corporate structure. Thus, duplicate companies were excluded. From the analysis of the responses, it was estimated that MIT had 33,600 daughter companies, 76% of which were active, employing around 3.3 million people and generating annual revenues of US$2 trillion (Roberts et al., 2011).

The research was later updated in 2014 by Roberts, Murray & Kim (2019). By e-mail, invitations were sent to approximately 104 thousand students to assist in measuring the impact of the University and a response was obtained from 19,730 students (19%). New indicators were generated, such as the percentage of former students who had created companies. In this2014 survey (Roberts, Murray & Kim, 2019) we extrapolated the data across 108 subgroups each separated by a different response rate. It was estimated 30 thousand active companies, employing 4.6 million people and with annual global revenues of US$ 1.9 trillion, being approximately the GDP of the 10th largest economy in the world in 2014. The number of companies that went through the IPO process was two percent (2%),

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and eight percent (8%) of the daughter companies were acquired by other companies. The number of serial entrepreneurs – that is, with more than one company – was 40%.

At Stanford University, researchers Eesley et al. (2018) conducted a study that also had a questionnaire as its starting point. 27,783 responses were obtained, with the concern of representing each of the seven schools of the University. To estimate the economic and social impact, data from a specific year were analyzed, and then the data were extrapolated. An estimated 39,900 active daughter companies were created, generating 5.4 million jobs and annual revenues of US$2.7 trillion. Twenty-nine percent (29%) of respondents said they were founding entrepreneurs, 32% indicated that they were investors, first employees, or board members of a startup at some point in their careers, and 25% of respondents have founded or incorporated a company at some point in their careers. A research with characteristics similar to Starford's (form submission) was conducted at the University of California (Charney, Libecap & Center, 2000).

Among Brazilian universities, at the State University of Campinas (UNICAMP), a first step was to conduct a survey with 47 responding companies (Lemos, 2008). Subsequently, the association of daughter companies was created, with about 130 companies (Mori et. al., 2017). The work of Gavira & Dos Santos (2013) presented suggestions for the improvement of the Unicamp survey. So, in 2016, a questionnaire was sent to all former students seeking to identify which graduates had created their own companies, and later also aiming to register these companies (Mori et. al., 2017). From the answers and a statistical extrapolation, 514 companies were estimated. Of these 514, 434 companies were active. Unicamp then began to prepare an annual report evaluating the impact of its daughter companies. The 2021 edition reported 1131 daughter companies, 1019 of which were active, generating 38,963 job positions, and R$ 16 billion in revenue (Unicamp Daughter Companies Report, 2021). In Unicamp's Daughter Companies Report (2022), reported revenues reached R$ 19.3 billion, demonstrating an increase of 20.6% compared to 2021. Of the total number of companies, 13 were large, with revenues of more than R$ 300 million. Of the 1,293 daughter companies registered, 1061 daughter companies were active, generating 44,624 direct jobs.

The São Paulo State University (UNESP) initially identified its daughter companies through prospecting, visits and contacts, reaching a number of 1365 companies. So a form was sent to these 1365 companies, aiming to identify their impact on society. 307 responses were obtained and 70% of those who responded reported the average annual

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revenue. It was possible to estimate the annual revenue of R$2.5 billion, area of operation, location, among other information about the companies (Daughter Companies, Startups and Spin-offs of UNESP, 2020).

In addition to these mappings, USP has on its website a Registration Form for USP's Daughter Companies (2023). On the UFSCar Innovation Agency website (2022) there is also a questionnaire for registering daughter companies. UFRGS, PUC-RS, and FGV monitor companies linked to their technology parks and/or acceleration programs, and Insper has initiatives to monitor venture capital investments made in companies owned by their graduates (Parque Zenit UFRGS, 2023; PUC-RS -TECNOPUC Technology Park, 2022; FGV Entrepreneurship Center, 2023)

The Association of University Technology Managers (AUTM) builds indicators of spin-offs of universities affiliated to this association (Astebro & Bazzazian, 2010). Similarly, in Brazil, the National Forum of Innovation and Technology Transfer Managers (FORTEC) conducts annual surveys among its members, verifying the number of spin-offs in each university (Base Year Report, 2021). But this information refers to spin-offs, and not to the whole set of companies that are daughters of universities.

Chart 1 summarizes the main initiatives of universities and university associations to map daughter companies and their impact on society. The AUTM and Fortec associations only monitor spin-offs, which leaves out other types of companies. The other initiatives – MIT, Stanford, Unicamp and UNESP – identify companies and evaluate their impact on society based on information provided by the respondents in the questionnaires, and statistical extrapolation. None of the initiatives was based on exhaustively searching public databases for how many of their students and alumni had registered companies, as well as the economic and social impact of these companies.

Chart 1 - Summary of the mappings of daughter companies

Institutions and Universities	References	Ways of Mapping
MIT	Roberts et al. (2011); Roberts, Murray e Kim (2019)	Questionnaire to former students and second questionnaire focused on daughter companies, for those who said they were entrepreneurs.
Stanford	Eesley et al. (2018)	
Unicamp	Lemos (2008); Mori et. al (2017)	
Unesp	The mapping of Daughter Companies, Startups and Spin-offs of UNESP (2020)	Prospecting of companies, and sending a questionnaire to them, to confirm and characterize the daughter companies.
AUTM	Astebro & Bazzazian (2010)	They monitor spin-offs, but not other types

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FORTEC	Base Year Report (2021)	of companies.

Source: Prepared by the authors

CROSSMATCH METHOD FOR IDENTIFYING THE DAUGHTER COMPANIES OF A UNIVERSITY, AND CHARACTERIZING THEIR ECONOMIC AND SOCIAL IMPACT

Databases were listed and described in which information on Brazilian companies can be searched, such as: Treasury Revenue Solution (2023); Legal Entity Consultations (2023); CNPJ.info (2023); and Consult CNPJ Online. For each company, information can be obtained such as: Year of opening of the Company; Company Registration Status (Active; Suspended; Unfit; Baixada); Reason for registration status; Company City; Federative State of the Company; National Classification of Economic Activities (CNAE); Qualification of the Person in Charge; Share capital; Company size; Option for the simple; Option for MEI; Name of the entrepreneur; Excerpt from the Entrepreneur's CPF.

These mechanisms allow you to search for the company's CNPJ, the name of the company, and in some of them it is also possible to search for information about the partners – name or CPF. Thus, considering that a university has the list of names (and CPFs) of all its students and alumni, it would be possible to search by the name of each of the former students and identify each of the daughter companies of a university, created in Brazilian territory. In addition, through the registration information of each company, listed above, it would be possible to identify whether the company is active or not, its area of operation, the size of the company, and (by the size of the company) it would be possible to estimate the revenue, which is an objective indicator of the economic impact of the university's daughter companies.

Despite recording the size of the company, these business registrations mentioned do not record the number of people employed. However, once the CNPJ of the daughter companies is in possession, it is possible to use the Econodata platform (2023) or even the Annual Report of Social Information - RAIS (2023) to find the number of jobs generated, which is an indicator of the social impact of the university's daughter companies. Figure 1 illustrates the process of identifying the daughter companies of a university, and the characterization of their economic and social impact, by the Cross-Match method.

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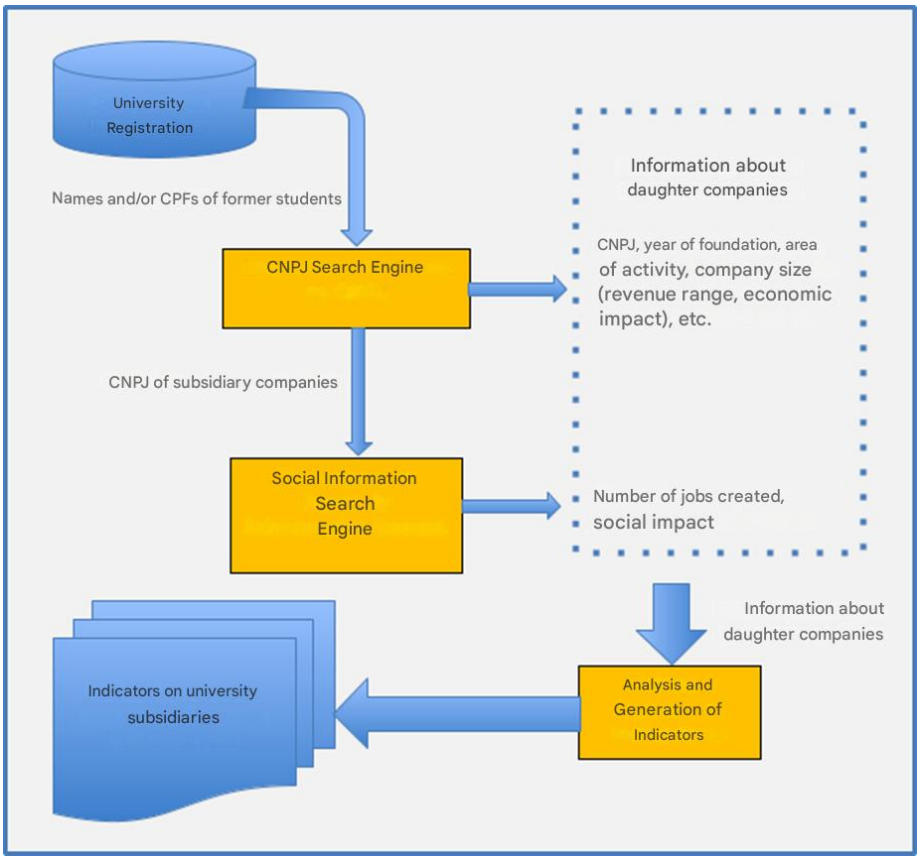
Figure 1 - Identification of daughter companies and characterization of their impact by the Cross Match method



Source: Survey data.

Some information can be collected from the construction of several indicators on daughter companies, including:

- Number of daughter companies: total number of daughter companies, number of active child companies, number of companies opened per year and/or set of years; percentage of active companies, percentage of companies in each registration situation;
- Area of operation of daughter companies: number of active companies per area (CNAE), number of active companies in CNAEs linked to technological areas;
- Geographic impact of daughter companies: number of active companies by area – municipality, state, region;
- Economic impact of daughter companies: number of active companies by company size, percentages of active companies by company size, percentages opting for simple/MEI, estimate of the total economic impact of active daughter companies;
- Social impact of daughter companies: total number of direct jobs generated by daughter companies;

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- Serial Entrepreneurship Indicators: number of former students who created companies, percentage of former students who created companies, quantity/incidence of companies created by each student, percentage of former students who created companies, per year.

By consulting other records of the university, it is possible to generate even more detailed analyses, as well as extension of the analysis to professors and employees of the university.

EXEMPLIFYING THE USE OF CROSS-MATCH

The Cross-Match method can be used by the university itself, as an institutional action, to identify daughter companies and characterize their impact on society. In this case, the university can use the CPFs of its former students in the search. The Cross-Match method can also be used by an independent research. In this case, as it is an independent research, it will be necessary to use the names of former students in the search, and not the CPFs, because the CPFs are not public information.

To test the Cross-Match Method and evaluate its functioning, we conducted an independent survey with part of the former students of the Federal University of São Carlos - UFSCar. We took as the research universe freshmen of the Computer Engineering course at UFSCar, from the years 1992 to 2019, information publicly disclosed by the Department of Computing at UFSCar (DC UFSCar, 2023). We identified a total of 792 students and alumni of the computer engineering course at UFSCar.

We tested the names of each of these 792 students/alumni on the CNPJ.Info search engine (2023) and identified that (of these 792 names) 441 had no business registrations in their names. The other 351 were part of the corporate structure of at least one company, as indicated by the records. As the search was carried out by name and not by CPF, it is possible that some of these companies actually have in their corporate frameworks people who are homonymous with former students of computer engineering at UFSCar. We set out for a mechanism to eliminate homonyms. To this end, we sent the names and excerpts of the CPFs (obtained in the CNPJ.Info) to UFSCar, using the citizen information service Fala.Br (CGU, 2023), request for information N. 23546.032664/2023-71, and requested UFSCar to confirm that the names/excerpts of CPF that we sent had in fact been students of the University's computer engineering course. Among the 351 people with companies

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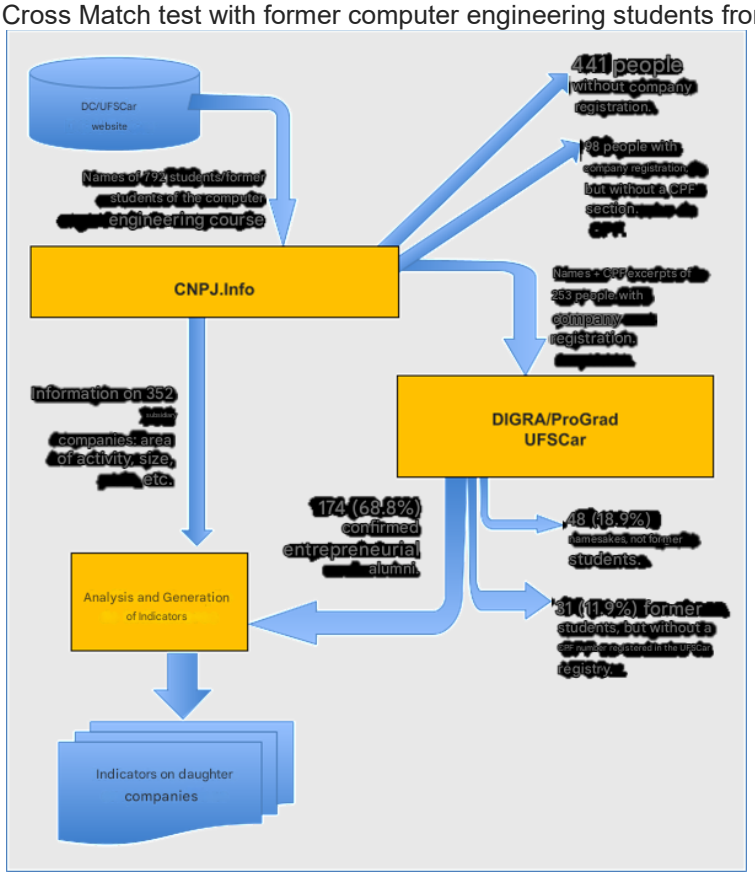
linked to their names, the CNPJ.Info had a record of the CPF section of only 253. Thus, we sent UFSCar the names and excerpts of the CPF of 253 people. UFSCar responded to the request, through the Division of Management and Academic Registration (DIGRA/ProGrad/UFSCar).

Of the 253 names sent, 174 (68.8%) were confirmed as students or alumni of the computer engineering course at UFSCar, 48 (18.9%) had not been computer engineering students at UFSCar, and for another 31 (11.9%) it was not possible to confirm it because, despite having computer engineering students/alumni with these names, the CPFs of these names were not included in UFSCar's records.

Thus, indicators were generated for 352 companies whose corporate structure had at least 1 of the 174 students or former students of the computer engineering course at UFSCar, with identity confirmed by their CPF, by the University itself. Figure 2 summarizes the step-by-step adopted to test the Cross-Match method for identifying and characterizing UFSCar's daughter companies, based on students and former students of the computer engineering course.

Figure 2 – Cross Match test with former computer engineering students from UFSCar



Source: Survey data.

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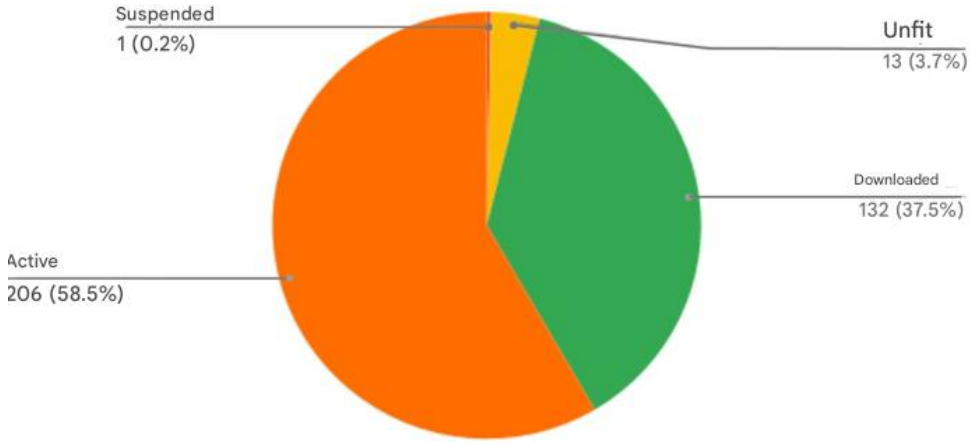
It is possible and likely that the number of entrepreneurial students/alumni and daughter companies is higher, as part of the names could not be confirmed as students/alumni, due to the absence of information about the CPF, either in the CNPJ.Info or in the University's records. In this way, a search made directly with the CPFs has the advantage of not needing a confirmation step, but may not cover all former students, excluding those for whom the University does not have the CPF in its records.

In the analyses and indicators presented below, only companies linked to students or former students with identity confirmed by their CPF were considered.

NUMBER OF DAUGHTER COMPANIES

Of the three hundred and fifty-two (352) companies with students or former students of the computer engineering course at UFSCar in their corporate boards, 206 (58.5%) were active at the time of the survey, 132 (37.6%) were listed as written off, 13 (3.7%) as unfit and 1 as suspended (0.2%), as illustrated in Figure 3.

Figure 3 - Registration status of companies created by students or former-students of the computer engineering course at UFSCar



Source: Survey data.

AREA OF ACTIVITY OF ACTIVE DAUGHTER COMPANIES

The CNAE (National Classification of Economic Activities) codes of the main activity of each of the 206 Active Companies at the time of the survey were identified. Eighty-one (81 – 39.3%) of the 206 active daughter companies had CNAE of the main activity directly related to the area of the Computer Engineering Course, with the creation of the company and application of the knowledge of the course in the company/society. The CNAEs of these 81 companies, and the incidence of each CNAE, are indicated in Figure 4.

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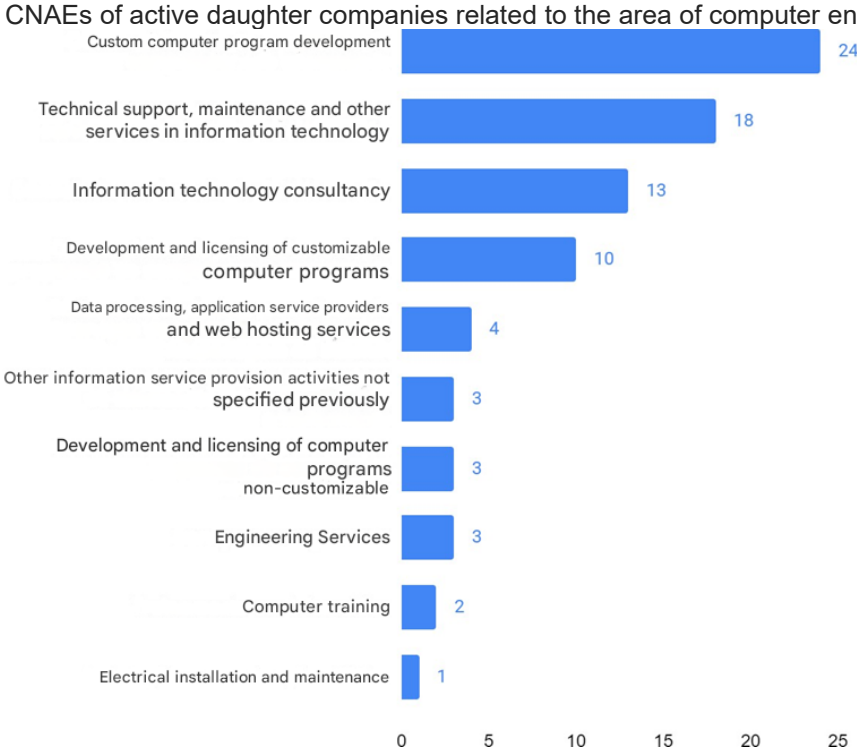
Figure 4 - CNAEs of active daughter companies related to the area of computer engineering



Source: Survey data.

In addition to the 81 (39.3%) active daughter companies with main activity related to the area of computer engineering, the remaining 125 (61%) active daughter companies indicated as their main activity areas such as retail trade of construction materials (20 companies), Clinical laboratories (14 companies); Holdings of non-financial institutions (7); Investment agents in financial investments (7); Combined office and administrative support services (7), and other areas, all with a lower incidence. It is possible that these companies have CNAEs related to Computer Engineering registered in their secondary activities. However, the analysis of the area of operation was carried out only in the CNAE registered in the company's main activity.

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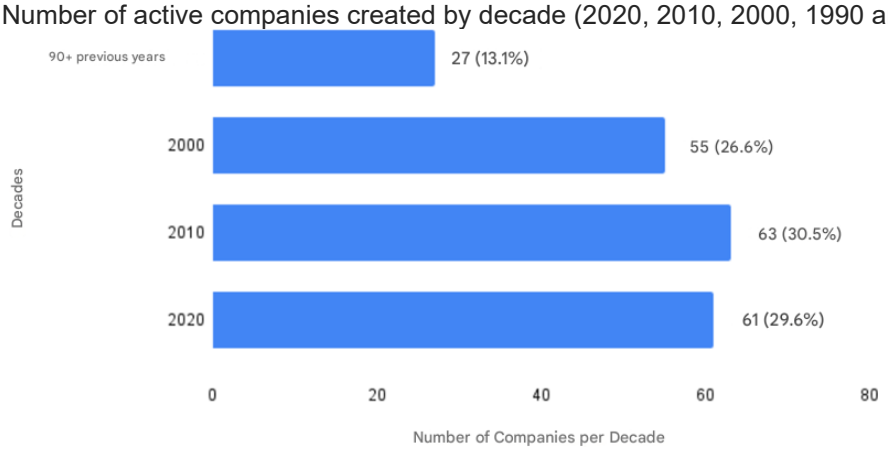
Figure 5 - Number of active companies created by decade (2020, 2010, 2000, 1990 and earlier)



Source: Survey data.

In the case of companies that were founded in 1990 or earlier, that is, before the student's entry into UFSCar, it is possible that they are examples of existing family businesses, whose shares were transferred to graduates of the Computer Engineering course at some point. Thus, these companies continue to be daughter companies, because the concept used in this research verified the existence of a link between the founders and/or partners of the company and the university, regardless of the year of creation of the company. But, of course, it is possible to adopt a different definition, which considers as daughter companies only those companies founded after entering the university.

Figure 5 indicates that the number of companies created increased decade by decade. In the 90s (+ previous years) 27 companies were created. In the 2000s, 55 companies were created. In the 2010s, 63 companies were created. And in the 2020s, in which only 3 (three) full years were computed – 2020, 2021 and 2022 – and part of the year 2023, 61 (sixty-one companies) were found, which projects a much larger number of companies, when 10 years are computed.

SIZE OF ACTIVE DAUGHTER COMPANIES

The size of the companies, according to the CNPJ.Info database, has three classifications, Micro - average revenue from R$ 0 to 360 thousand, Small - average revenue from R$ 360 thousand to 4.8 million and Others, covering Medium sized companies - average revenue from R$ 4.8 million to 300 million - and Large - average revenue above R$ 300 million. Based on this classification, 88 (42.9%) of Micro Enterprises, 27 (13.1%) of Small Enterprises and 91 (44.3%) of Other Sized Enterprises were identified.

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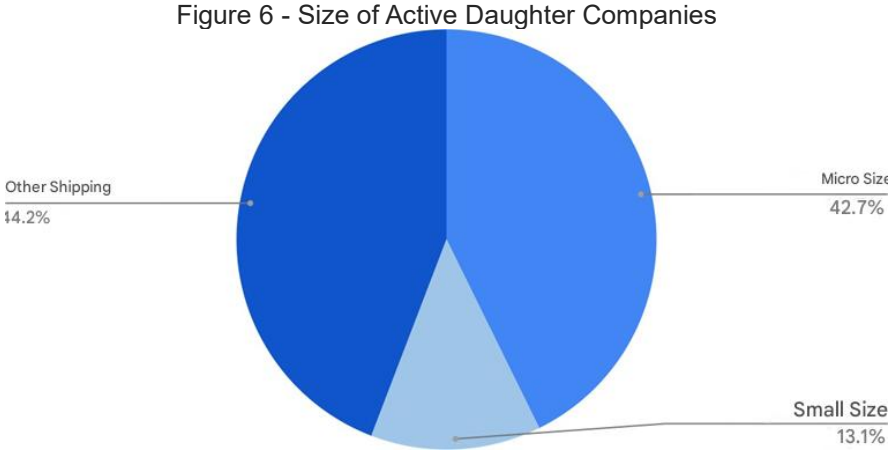
Figure 6 - Size of Active Daughter Companies



Source: Survey data.

ESTIMATED REVENUE OF ACTIVE DAUGHTER COMPANIES

From the information on the size of the company, it was possible to calculate the minimum and maximum average revenues of the 206 active daughter companies. The minimum average revenue can be calculated if we adopt the revenue of the 88 Micro Sized daughter companies as zero, the revenue of the 27 Small Sized daughter companies as R$360 thousand, and the revenue of the 91 Other Size daughter companies (Medium and Large) as R$4.8 million (i.e., the minimum values of each range). In this case, the minimum average revenue of the 206 active daughter companies would be R$ 446.52 million.

The maximum average revenue of the 206 daughter companies can be calculated if we adopt the maximum values of each range: average revenue of the 88 Micro Sized daughter companies as R$360 thousand, the average revenue of the 27 Small Sized daughter companies as R$4.8 million, and the average revenue of the 91 daughter companies of Other Sizes (Medium Size and Large) as R$300 million (although, in this range, the revenue may be even higher than R$300 million). With these values, the maximum average revenue of the 206 daughter companies of the Computer Engineering course at UFSCar would be R$27,461,280,000, or R$27.461 billion.

Thus, based on the size of each of the 206 daughter companies of the Computer Engineering course at UFSCar, we can conclude that the average annual revenue of these 206 companies is between R$ 446.52 million and R$ 27.461 billion.

SERIAL ENTREPRENEURSHIP STUDY

In Chart 2, it is possible to verify the number of daughter companies founded per entrepreneur, considering the 174 entrepreneurial alumni of the Computer Engineering

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course at UFSCar, confirmed by their CPFs. Of the total of 174 entrepreneurial alumni, 104 (59.77%) entrepreneurial alumni had active companies registered in their names. These 104 were ranked in relation to the number of founded companies that were active at the time of the survey.

Chart 2 shows that, of the total of 104 former students of Computer Engineering who owned active companies, 66 former students had a single company registered in their name, another 17 owned 2 companies, 8 owned 3 companies, 6 owned 4 companies and 2 had 5 active companies registered in their name. Another 4 entrepreneurial alumni owned 6, 8, 14 and 20 active companies registered in their name. It is worth remembering that due to the fact that some names have been excluded because it was not possible to confirm their identity by their CPFs, it is possible that the number of entrepreneurial alumni is higher.

Chart 2 - Serial Entrepreneurs in the Computer Science Course

Number of Daughter Companies	Number of Entrepreneurs	Percentage of Entrepreneurs Serials/ Number of Companies
1	66	63,46%
2	17	16,35%
3	8	7,69%
4	6	5,77%
5	2	1,92%
6	1	0,96%
8	1	0,96%
14	1	0,96%
20	1	0,96%

Source: Survey data.

GEOGRAPHIC DISTRIBUTION OF DAUGHTER COMPANIES

In the geographic impact survey, the municipalities with the largest number of active daughter companies were identified. Of the 206 active companies, 61 (29.75%) are located in the city of São Paulo - SP; 15 (7.3%) are headquartered in Campinas - SP; 14 (6.8%) are in São Carlos-SP; 10 (4.8%) are in São José dos Campos – SP, and 60 in other cities, from 13 Brazilian states and also from the Federal District. It is important to note that the consulted business registry (CNPJ.Info) holds information only from Brazilian companies, and it is possible, therefore, that there are other daughter companies registered in other countries.

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SOCIAL IMPACT

In the present research we did not calculate the number of jobs generated by the daughter companies. As already mentioned, business registries such as CNPJ.Info do not record the number of people employed. However, once you have the CNPJ of the daughter companies, it is possible to use the Econodata platform (2023) or the Annual Report of Social Information - RAIS (2023) to find the number of jobs generated.

ANALYSES AND CONCLUSIONS

The way the university operates over the centuries has evolved, starting with a focus on more generalist courses, then moving on to specific courses. In a second moment, in addition to the training of people, the expectation for the university began to include the generation of knowledge, through research. More traditional indicators to evaluate the impact of the university on society are, therefore, the number of graduates, the number of dissertations and/or theses, the number of publications, the number of research projects, etc.

More recently, society has been considering the university as capable of generating economic and social development. The first academic indicators focusing on economic and social development were those depicting the development of new technologies, the generation of patents, and the creation of academic spin-offs. Some institutions and associations such as AUTM and FORTEC, for example, conduct regular surveys to identify the number of patents and the number of spin-offs generated.

More recently, some universities have begun to measure the university's daughter companies, and their economic and social impact. Daughter companies are those that the founder or partner has or had some link with the university, either as a student or employee. The concept of daughter company therefore includes spin-offs, but also includes other types of companies, such as startups or companies of another nature.

How have universities calculated the number of daughter companies generated, as well as their social and economic impact on society? The literature reports, for example, the cases of MIT and Stanford University, and in Brazil the case of Unicamp and Unesp. These institutions identified their daughter companies through prospecting, sending emails to their alumni, sending forms, and estimating the number of daughter companies and their economic and social impact based on the responses obtained.

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We did not find in the literature any institution that has identified its daughter companies by crossing information from the alumni database, and databases containing information about companies. In order to verify the feasibility and potential of a method for identifying daughter companies based on the crossing of information, we developed a conceptual model, called Cross-Match (Figure 1), through which, in summary, we took a list of names (and/or CPFs) of former students of a university, and searched, name by name, in databases of business information. Thus, we can identify, theoretically, all daughter companies – companies with an alumnus in their corporate structure, regardless of a response rate, and without the need for statistical extrapolation. It is also possible to identify the size of the company and, with that, estimate its economic impact. Also, by searching in complementary databases, it is possible to identify the number of jobs generated at each of the daughter companies.

To evaluate Cros-Match in a real situation, we conducted a test with graduates of the Computer Engineering course at the Federal University of São Carlos. Of the 792 former students surveyed, 253 had company registration in their names. As we searched by name, it was necessary to confirm the identity by the CPF. Eliminating the homonyms and names for which the University's database did not have the CPF, we arrive at 174 entrepreneurial alumni, confirmed by their CPF. These 174 entrepreneurial alumni owned 352 companies registered in their names, of which 206 were active at the time of the survey. Based on the size of each of the 206 daughter companies of the Computer Engineering course at UFSCar, we can estimate that the average annual revenue of these 206 companies is between R$ 446.52 million and R$ 27.461 billion.

We were able to point out some limitations in the test carried out: by consulting a Brazilian business database, only companies registered in Brazil were identified. Another limitation occurred due to the fact that the University's database did not contain the CPFs of all its former students. Another limitation is that the economic impact was calculated by the size of the company, indicating a minimum value and a maximum value, and not the revenue effectively calculated by each company. We have not yet calculated the number of jobs generated by each company. It is possible to try to overcome these limitations by complementing the search of foreign business databases, in databases that record the number of employees of each company, and/or by sending forms to former students, to complement the information obtained in the business databases.

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Despite the limitations, the test showed that the use of Cross-Match is viable. Regarding the calculation of daughter companies and their economic impact exclusively by forms and spontaneous participation, the use of Cross-Match can be advantageous due to its potential to generate objective indicators, calculated automatically, if a software solution is developed for this purpose. Once entrepreneurs and companies have been identified by Cross-Match, and once the indicators have been calculated, it is possible to complement the research with the methods already used, such as sending emails and/or forms.

We were also able to identify some points of discussion, which can be better studied in other research. One of them is the very definition of a daughter company, whether or not it should include companies in the name of former students, created before their entry into the university.

This research had as a contribution the systematization of information and the proposition of an unprecedented method in the literature (Cross-Match) to identify companies that are daughters of a university, as well as to evaluate the economic and social impact of these companies. It was also a contribution to test and evaluate the operation of the method in a limited universe – former students of a course at a Brazilian university. The survey also pointed out limitations, and points of discussion.

To more adequately evaluate the use of Cross-Match, or other approaches based on cross-referencing information, it is suggested to advance research with an institutional-scale survey (all alumni of a university), using government databases, possibly complementary databases, and possibly also complementary surveys via e-mail/form with entrepreneurs and/or companies. We also suggest evaluating the development and/or use of software tools for automatic or partially automatic calculation of indicators.

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