

Entrepreneurial Impact: The Role of the Instituto Superior Técnico

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Dedicated to those who helped carve who I am.

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Resumo

O Empreendedorismo e a Inovação, numa economia e sociedade baseadas no conhecimento, estão a ser reconhecidos como os principais motores de um futuro de sucesso. Portanto, o foco dos *stakeholders* de uma sociedade moderna está voltado para a Educação Superior e como esta contribui para o mundo com profissionais capazes. Universidades, por estas razões, deixaram de ser apenas instituições de ensino superior, mas também os principais propulsores da economia.

Esta tese tem uma componente exploratória muito forte e é realizada com a mentalidade de que poderá se tornar a base de futuros estudos. Acima de tudo, tenta colocar em números e figuras a ideia pouco fundamentada de que o Instituto Superior Técnico (IST) é uma escola de empreendedores. Portanto, a grande questão que este estudo pretende responder é: Qual o impacto do IST nos alunos que se tornaram empreendedores, e qual o impacto das empresas destes na economia. Para fazer isso, o projeto focou-se primeiro na pesquisa do ecossistema do país e como ele tem vindo a evoluir. Posteriormente, a história do IST e dos seus serviços foram investigados com o intuito de apreender os paradigmas do empreendimento do passado e do presente, em que os alunos viveram e vivem.

Para responder à questão central do estudo e avaliar tanto o impacto do IST nos alumni empresários, como o impacto económico de 2020 das suas empresas, foi elaborado e divulgado um inquérito. Os resultados da difusão, para um tamanho desconhecido da população-alvo, resumem-se na identificação de cerca 500 empresários e obtendo quase uma centena de respostas.

A partir dos resultados obtidos no inquérito, inferiram-se várias conjeturas sobre os empreendedores e as suas empresas, como o volume de receitas, exportações e importações, os mercados e áreas de atividade preferidas e mais métricas descritivas.

Por fim, foram elaboradas algumas ideias e recomendações para dinamizar o espírito empreendedor dos futuros profissionais formados pelo IST, durante a sua vida académica na instituição. Algumas destas recomendações são a reintrodução de unidades curriculares no curso de Engenharia Informática e Computadores, a licenciatura com maior número de empreendedores (pelo inquérito realizado), e a possibilidade de criação de uma rede de incubadoras associadas ao IST.

Palavras-chave: Empreendedorismo, Instituto Superior Técnico, Impacto Económico, Alumni, Inovação, Inquérito, Portugal

Abstract

In a knowledge-based economy and society, entrepreneurship and innovation are being recognised as the main propellers to a successful future. Therefore, the focus of the modern society stakeholders has shifted towards Higher Education and how it contributes to the world with trained professionals. Universities, therefore, are no longer only institutions of higher learning, but the main propellers of the economy.

This thesis has a strong exploratory nature and is fuelled by the idea that future research could be built with these results as foundation. Above all else, tries to put into numbers and figures the anecdotal idea that IST is a school of entrepreneurs. With this in mind, the question that is tried to answer in this dissertation is: "What influence had IST on its students who became entrepreneurs and how did their companies impact the economy?" To do that, it first researched the country's ecosystem and how it is evolving. Afterwards, the school's history and services were investigated to grasp the past and present entrepreneurial paradigms that students were and are living in.

Furthermore, a survey was designed and disseminated to gather data to solve the question asked, by assessing and perceive both IST's impact on the alumni entrepreneurs and the 2020 Economic Impact of their companies. The diffusion results, knowing that the target population's size was unknown, were not very successful. A group of around 500 entrepreneurs was identified, and the survey achieved almost a hundred answers.

Several insights were inferred from the entrepreneurs and their companies working with what was obtained from the survey. A few examples of metrics are the overall revenues, exports and imports, selected markets and areas of activity and more descriptive metrics.

Concluding, some ideas and recommendations were devised to boost the entrepreneurial mindset of the future professionals graduated by IST during their stay at the institution. A few recommendations are the reintroduction of curricular units on entrepreneurship in the Computer Science degree's curriculum, and the possibility of an incubator network associated with IST.

Keywords: Entrepreneurship, Innovation, Instituto Superior Técnico, Economic Impact, Alumni, Survey, Portugal

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Acronyms

CAE Classification of the Economic Activities

CPIN Centre for the Promotion of Innovation and Business

DGEEC Direção-Geral de Estatísticas da Educação e Ciência

EI Entrepreneurship and Innovation

EIA European Innovation Academy

EITT Entrepreneurship, Innovation and Technology Transfer

EU European Union

FMUL University of Lisbon's School of Medicine

GDP Gross Domestic Product

GDPR General Data Protection Regulation

GEM Global Entrepreneurship Monitor

HEI Higher Education Institution

INESC Instituto Nacional de Engenharia de Sistemas de Computadores

INESC-ID Instituto Nacional de Engenharia de Sistemas de Computadores, Investigação e Desenvolvimento

IP Intellectual Property

IPN Instituto Pedro Nunes

ISEG Lisbon School of Economics and Management

IST Instituto Superior Técnico

MBA Master of Business Administration

MEPP2122 Teaching Model and Pedagogical Practices 2021/2022

NOVA NOVA School of Business and Economics

NPE Corporate Partnerships Unit

NPI Intellectual Property Unit

OEIST IST Graduate Employability Observatory

OPEN Business Specific Opportunities

PALOP Portuguese-speaking African Countries

PhD Doctor of Philosophy

RD Research and Development

SBA Small Business Act

SIFIDE II Tax Incentive System for Business Research and Development

SME Small and Medium-sized Enterprises

TAN Técnico Alumni Network

TBE Technology-Based Entrepreneurship

TPN Técnico Partner Network

TTO Technology Transfer Office

USA United States of America

UTEN University Technology Enterprise Network

Degrees

MEE Masters in Electronics Engineering

MEGIE Masters in Engineering and Management of Innovation and Entrepreneurship

MEEC Integrated Masters in Electrical and Computer Engineering

Chapter 1

Introduction

In an ever so advancing world, the demand and pressure to achieve better results in every subject of our existence are expanding accordingly. Entrepreneurship and the risk of creating a new technology/product and, ultimately, a company, have walked hand in hand as both of them push each other to go faster.

A society that wants to invest in its economy is now an entrepreneurial ecosystem due to the proven positive economic effects that startups and new employers bring to a nation [1, 2]. In a Portuguese society where failure implies blame, instead of being seen as the way to improvement, it seems that Portuguese entrepreneurs face a rougher environment than others. According to the most recent report of the Global Entrepreneurship Monitor (GEM) [3], in 2019, 72.74% of Portuguese people consider starting a business as a desirable career choice. Despite that, 52.59% of the population (18-64 years of age) who agree that they see good opportunities to start a business (53.52%) do not do so with fear of failure.

1.1 Motivation

At the time this study is being conducted, the pandemic outbreak of COVID-19 is in full force. The continuous confinements are setting the economy in a state of crisis almost globally, and people are adapting as fast as they can to this new reality. This situation seemed like the perfect time to take a step back and analyse what has already been achieved, what has been done to accomplish it, the current practices and future steps to reach taller heights. The topic of Entrepreneurship was both relevant and exciting to assess inside the university's context, and having the article from Roberts and Eesley [4] to serve as guidance, it started to make even more sense. Ultimately, the value proposition of a university is to educate and form the future generation of professionals who will disrupt the markets and provide a better future for society. Entrepreneurship is a natural consequence of these highly-trained persons. The ambition to create their path towards an impactful life brings them to create their businesses.

However, there is not an extensive study on the entrepreneurial side of IST alumni. To better accommodate the institution's services towards forming these students with an entrepreneurial mindset,

information about what was relevant in the past is crucial. The lack of a data-driven approach to this topic also led to creating a template that helps future projects assess the alumni's corporate economic impact throughout the next generations.

In a broader sense, if a Higher Education Institution (HEI) correctly promotes an entrepreneurial mindset and helps construct entrepreneurial-related skills, it will have a more significant positive impact on economic growth, technological innovation and job creation. If this study helps to achieve a slightly better picture of what path the university has to take, and helps to create a generation of better entrepreneurs, it makes the time spent worth it.

1.2 Objectives

The objectives of this study are very intertwined and dependent. Considering IST's always-present paradigm of focusing on innovation, it is clear that there is a need to create a method of assessment focused on the entrepreneurial alumni and their professional life. This problem of an unsystematic study of the students' entrepreneurial mindset is not singular in IST as it is referred to in Bennett et al. [5]. The consequence from this dearth of consistency is that, when entrepreneurship is inquired, the only information that IST has in this topic is assessed by IST Graduate Employability Observatory (OEIST), and it refers to recent graduates only.

Furthermore, there is a lack of data and documentation of the evolution of the entrepreneurial mindset of the IST alumni. The last report close to this topic was made in the early 2000s, made by students of a sociology degree, and only studied 7 cases [6]. By then, the internet was not widely available yet, resulting in a small dissemination of the study's inquiry and questions regarding the companies' access to the world wide web. That study had a more significant focus on the sociological profiling of the IST entrepreneurs than the present one. This study aims to better understand the repercussions in today's society, on an economic level, of the alumni.

It is also pretended to draw correlations between the college's various efforts to foment an entrepreneurial mindset with the actual results. These correlations will reveal and help evaluate better whether the time should be invested in those services or not.

To do all this, it will be important to better grasp the various concepts of entrepreneurship and how it evolved, the history of IST and the paradigm it lived in Portugal. Summing up, this dissertation has three clear objectives that go alongside with the question mentioned before ("What influence had IST on its students who became entrepreneurs and how did their companies impact the economy?"):

- Research the concept of entrepreneurship and its ecosystem's evolution, how IST fomented the culture through its services, and how impactful it was;
- Create a methodology and a survey for obtaining data on entrepreneurial impact;
- Describe the alumni entrepreneur's maturity and academic background, and depict the 2020 economic impact of their companies.

1.3 State of the Art

This section's purpose is to introduce the reader to relevant concepts mentioned during this dissertation.

Firstly, it will reflect on the concept of entrepreneurship and briefly describe what is an entrepreneurial university and its underlying education while giving some examples of impactful organisations.

Then, the reader is brought up to date and immersed in the Portuguese entrepreneurial paradigm. It will understand the current situation of Portugal in the topics of economical crisis, investment policies, enterprise revenues and institutional support growth.

1.3.1 Entrepreneurship

In its essence, entrepreneurship is the term used to describe the act of creating a business. Starting a new operation entails several risks and strenuous efforts in order to be successful. Notwithstanding, the keyword is "act", as actions move entrepreneurship [7]. Throughout the evolution of the concept, several "schools" of the concept were born. These "schools" could be grouped in six different approaches to the subject according to Cunningham and Lischeron [8].

Categories	School of Entrepreneurship	Assumption/Focus
Assessing Personal Qualities	"Great Person"	Innate ability and traits create an intuitive capacity for Entrepreneurship
	Psychological Characteristics	Unique values, attitudes and needs drive them towards Entrepreneurship
Recognising Opportunities	Classical	The process of doing and creating innovation
Acting and Management	Management	Can be developed. Able to organise and manage the risk of creating a company
	Leadership	Collective. Able to lead and adapt to others.
Reassessing and Adapting	Intrapreneurship	Development of the company from the inside

Table 1.1: Summary of the schools of Entrepreneurship (Adapted from Cunningham and Lischeron [8])

In its more abstract definition, an entrepreneur is a subject without whom the original idea would not be created [9]. In this study, the simplest ramification of this approach will be chosen, i.e. the "Management" definition. A person who founded and manages a company will be categorised as an entrepreneur. This choice derived from the fact that if one considers the more personal/intrinsic ones, those are more subjective, and that convolutes the creation of an assessment focused on entrepreneurship. One example of a challenging study is the impact of intrapreneurship. The creation of new projects or products within the already established organisation, sometimes overlooked sometimes due to its nature of not creating a whole business from the ground, is also an essential branch of entrepreneurship. However, due to the difficulty on the obtainment of data and its economic impact, it will also be disregarded in the study.

Regarding economic growth, innovation leads to economic growth and its economical impact is proportional to the level of disruptiveness [10, 11]. To add to this, Wong et al. [12] concludes that even though the higher percentage of new business ventures are the ones with fewer employees, the high growth potential startups are the ones that provide a significant impact on the economy. Essentially, every firm is important, but the ones who are able to develop and employ more people end up being more impactful. Entrepreneurship is everywhere, behind every enterprise and innovation. The act of creating a business itself brings competition, and competition translates into better and more complete products (and markets), and does not let the economy enter in a conformist ideology (natural in monopolised countries). Other than the competition, the job creation and boost in productivity [13] sides of entrepreneurship are also essential. The fact that a new company is improving the purchasing power of the population end up creating a healthier economic cycle while the boost in productivity brings better products faster to the markets.

Translating the act of entrepreneurship into numbers is a difficult task, dividing the literature until today, but looking at the values obtained by [4], in a conservative estimation, if the entrepreneurs from MIT were considered as a nation, they would be positioned as the seventeenth economical power (in terms of revenue of the companies created) of the world. This estimation model was considered by the author as the best one available in the literature. Therefore, it will be adapted to the current study and used in various topics such as elimination rules for the target population and in the results section.

Regarding organisational structures that support entrepreneurial ideas, Business Incubators and Acceleration Programmes are two examples. It's important to understand their ideas as further in the study, they will be mentioned. Therefore the next two topics will be focused on them and how they work.

Business Incubators

Business Incubators, or only "incubators", were one type of organisations that were born with the uptrend of the concept of entrepreneurship. These are organisations whose primary focus is helping in the process of developing a new business enterprise [14, 15]. They facilitate the translation of ideas into profitable ventures by providing mainly office space and consulting services. In addition, they also provide a great network of investors and logistic-focused companies. According to several studies [5, 16–18], this last service is the most crucial aspect of a business incubator.

Recent reports have gathered some interesting insights about the effect of incubators on startups and universities (when university-based). In the case of university-based incubators, although they seem like a step towards helping the students successfully kick-start their entrepreneurial ventures [19], the effects on the school hinder in comparison. A study by Kolympiris and Klein [20] suggests that, after thorough research in the United States of America (USA), university-based incubators end up cannibalising the university's resources, usually directed for the Technology Transfer Office (TTO). Likewise, it is shown in the study that the licensing income decreases with the implementation of an incubator. Still, some intangibles can be taken into account, for instance, the increase in marketing potential and the prestige that brings people to the institution.

Business Acceleration Programmes

Before referring to the existing acceleration programmes, there is a need to grasp what these consist of and their differences to incubators. Accelerators (short for "Business Acceleration Programmes") are a recent business model. Their definition is still divergent amongst researchers due to their diverse areas of impact [21]. So, to explain the concept of an accelerator, a parallelism with the definition of an incubator will be used. From the article by Zajicek [22], the following table (Tab. 1.2) summarises the differences and similarities.

	Accelerator	Incubator
Purpose	Expedite the growth of established new companies	Support during the beginning stages
Duration	Set time frame	Open-ended timeline
Application Process	Classic and strict (highly competitive and looking for excellent growth potential)	Relaxed and usually regional/local (not focused on the quick growth or scalability,)
Environment	Both provide collaborative spaces and mentorship	
Investment Capital	Invest capital in exchange for equity in the company	Generally, do not provide capital and do not take an equity stake

Table 1.2: Comparison between Accelerators and Incubators [22]

Concluding, accelerators offer a more serious environment for the growth of companies, focus on small teams of founders (and not individually) and provide pre-seed investment in exchange for equity (usually).

Regarding one of the best examples of an accelerator, "Y Combinator" was one of the first organisations that provided the service of acceleration [23]. Their methodology focuses less on the money invested and more on the work developed alongside the startups. Their philosophy is simply helping the entrepreneurs focus most of their time on building their idea and less on how they'll manage it. The accelerator first creates a small investment fund for the startups selected. Then, due to their maturity and history in the development of startups, they take the small business idea presented to them and show a path for the founders to take in order to best scale the company.

After presenting their views on the direction the startups in the acceleration programme should take, they then focus on the later stages, namely, dealing with investors and acquirers. This way, they make sure the future is set for the startups present in the programme.

"Y Combinator" presents a unique portfolio due to its size and number of impactful companies. Some are the archetype of a company in their sector like: "Airbnb", "Doordash", "Dropbox", "Coinbase", "Gitlab", "Reddit" and many others. Their numbers present 2000 active companies; around 300 were acquired, and 500 are considered inactive. These results show how impactful a well-managed accelerator is in the world .

1.3.2 An Entrepreneurial University

Summarising this topic would be to write that an entrepreneurial university is an HEI in which entrepreneurship is encouraged, the mindset and the skills are provided throughout the education of the students. Services are available to help kick-start, and initiatives are ready to guide the entrepreneurs into a successful venture [24]. This synopsis would be a correct assessment, but it would also be a disservice to not mention the shift in mindset that occurred worldwide in which academia started to ac-

cept that entrepreneurship could be learned [25–27]. Over the years, the concept of entrepreneurial university mutated several times, and Volkmann et al. [28] arrived at a set of important characteristics, adapted and resumed in the scheme in Dominginhos et al. [29] (Fig. 1.1).



Figure 1.1: Characteristics of an Entrepreneurial HEI (Adapted from [29])

This pyramid contains much information about the structure of an HEI focused on implementing an entrepreneurial mindset and providing the necessary tools to develop it. The degree of importance goes from the bottom to the top but every step is important as the pyramid wouldn't be complete without it.

Starting from the bottom, the foundation of this implementation is a structured management body, willing to innovate the institution with a clear vision and keen on developing a plan with goal-oriented actions. One of those actions should include a pedagogical study about the best ways to execute the transfer of knowledge to educators and students. It is expected that having a unified faculty will result in a more consistent and approachable education. Consistency in entrepreneurial education was one of the more influential factors mentioned in Volkmann's work. Moreover, the education itself revolves around developing a mindset for entrepreneurial ventures and a skillset to act on them [30].

With all this in mind, the next two steps in the pyramid could be on the same level. However, the authors decided to structure like it is presented in the picture because having a more diverse educational or extra-curricular background is vital and broader than its orientation. This step also includes cross-campus/cross-school activities that broaden the network of the student, also a major factor in the ecosystem of entrepreneurship.

Finally, regarding the last step and the top of the pyramid, it is fundamental to have the market always present in mind. If the market is not interested in the knowledge created in the university, that knowledge will not produce an economic impact. Conclusively, entrepreneurial ventures that do not please the market do not succeed.

Curricular Entrepreneurship

As it was mentioned, the topic of entrepreneurship in education is In Europe, education on entrepreneurship is a very recent topic when compared with other more well-known subjects. However, when the Atlantic is crossed, it is remarkable to understand that the issue of creating and managing new busi-

nesses remounts back to 1947, when the course “Management of New Enterprises” was established in the Master of Business Administration (MBA) taught at Harvard Business School. After that implementation, several study programmes and books were created throughout the USA [31]. By the year 2000, more than 700 different programmes were being offered in the United States.

This development in Europe was not evident at such a large scale, as the different societies approached the topic with a cultural bias inherent in the various regions. The divisive beginning promoted by this friction would bring a slower implementation of education on entrepreneurship in Europe. The first European countries developing and adopting an entrepreneurial education were from the Scandinavian region. The lack of a structured entrepreneurial education in Europe led not following the development in other countries as in the USA and Israel. These two countries are the contemporary images of entrepreneurship with the well-known Silicon Valley, MIT (regarding the first), and the Israel Institute of Technology.

Regarding the Israel Institute of Technology, more commonly known as Technion, is based in Haifa's southeast area. This institute produces highly skilled professionals, having 25% of its alumni created a company after graduating. Furthermore, Technion graduates won four Nobel Prizes, and alumni of this institution created 67% of the Israeli companies listed on NASDAQ.

Throughout its history, the school always thrived to bring to their society what was needed from an engineering standpoint. From its foundation, to give an engineering education to Jews; to the aftermath of the First World War, where it was needed aeronautical engineers to nourish an Israeli aircraft industry now composed of 5000 Technion graduates (every single engineer came from the institution); to the opening of the micro-electronic institute, that provided Israel with the semiconductors that were becoming scarcer after the war with France [32].

Technion provides its students with facilities that promote research and innovation. On these subjects, Technion provides services on four fronts:

- Commercialisation, through their Research and Development (RD) Foundation, TTO and the MIT-Technion Link;
- Industry, again through the R&D Foundation;
- Research Resources, by providing research equipment and infrastructures;
- and Innovation, through t-hub, their Knowledge Centre for Innovation, Bronica Entrepreneurship Centre and Biztec Entrepreneurship Challenge.

Nevertheless, the main focal point that shines brighter is the administration's clear mission of providing everything necessary for their students to start their businesses and create an ecosystem of innovation. This example presents a strong argument for the beneficial effects of an entrepreneurial university and the overall impact of entrepreneurship in a nation.

In the current days, entrepreneurial education is present everywhere, from business schools and engineering universities to private academies and online courses. Universities everywhere present to students the ability to register in Masters Programmes that focuses solely on the subject and various

curricular units that tackle the subject from several fronts. There are numerous initiatives to bring the entrepreneurial mindset to the younger generation as society, in general, finds entrepreneurship (education) the way to an improved economical stance.

However, the impact on the students is a research topic that was scarcely studied, which is somewhat expected due to the recent implementation of entrepreneurial measures. The acquisition of data on the matter of education on entrepreneurship is also quite challenging to obtain as every education provider structures their programmes differently. Therefore, there is an inherent difficulty when benchmarking the results obtained.

Nevertheless, some studies from different countries conclude that people who had an academic background in entrepreneurship are more inclined to devise a business venture in the future, generate higher revenues, employ a more significant number of people, and extensively contribute to overall economic growth Charney and Libecap [33], Jena [34], Lee et al. [35], Castro et al. [36].

The topic of Doctor of Philosophy (PhD) theses in the creation of companies, and therefore entrepreneurship, has also been brought up by the literature. If PhD theses are aligned with nation-states' economic development and interest, governments and businesses will be more inclined to finance the research [37]. In Europe, there has been an increased pressure to improve and grow the collaborative doctoral education due to the focus on innovation through R&D.

This effort shows the tendency for the economy to advance to a more knowledge-based one. It displays the importance of creating a direct correlation between doctorates and careers outside academia [38]. A study conducted by Malfroy [39] in 2009 regarding the relationship between university and industry concluded that it is usually beneficial to create a partnership between HEI and industry/government for a doctoral education programme. It tightens the bond between them and creates knowledge that is applicable to the economy. Anyhow, it is still complex to create such bonds due to the alignment of logistics and bureaucracies.

However, a PhD and the start of a company contain intrinsic structural similarities in a simplistic approach because both have three very characteristic but similar steps [40]. Both have:

1. Problem Identification;
2. Pursuing a solution;
3. Solution Communication.

Nevertheless, a good PhD thesis does not necessarily create a company. (New) Knowledge only has value if someone is willing to pay for it. This dissertation won't go into detail

1.3.3 The Portuguese Landscape

Even though this project is leaning over the impact of IST on the economy through its alumni, it is important to reflect on the general state of the country. This studious exercise is relevant to comprehend the climate alumni faced when they finished their degrees.

Traditionally, Portuguese entrepreneurship has evolved from the necessity of the population to earn money to support themselves. This situation made the entrepreneurs of the past, people without higher education and limited them to markets like textiles, cork and footwear. However, recently, these Portuguese markets found a technological boom and now are at the top of their technological paradigm [41, 42].

Nevertheless, Portugal has been focusing many resources on Entrepreneurship and Innovation (EI) policies, activities and services for many years and it grew to be considered an ecosystem still in its development phase, but already appealing. The start of the rise in the acknowledgement of entrepreneurship in politics could be found in different ages but in 2008, the member states of the European Union (EU) recognised the importance of Small and Medium-sized Enterprises (SME) in the growth of the economy through the Small Business Act (SBA). Based on the European Charter for Small Enterprises [43] and current SME policies, the SBA aims to tackle the global approach towards the global policies of entrepreneurship. This act has ten principles that seek the and sustainability of SME, but all of them could be clustered under a single idea: *"Think Small First"* [44].

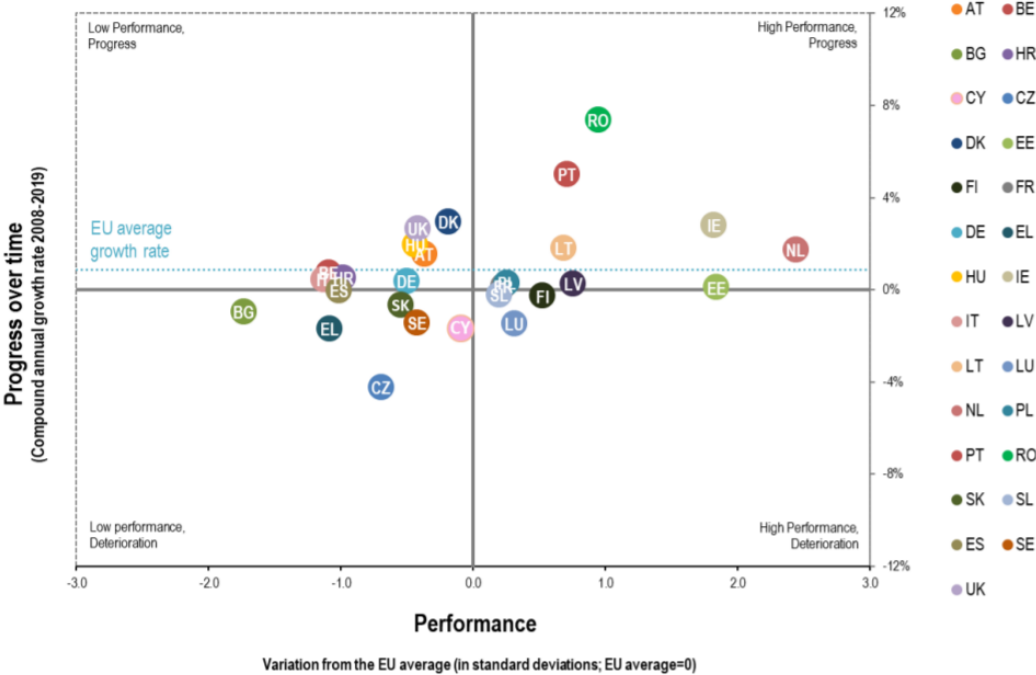


Figure 1.2: Positioning of each EU-28 Member State in terms of their performance and progress over time for entrepreneurship (2008-2019) (Source: European Commission)

In that year, 2008, the great global recession occurred and profoundly affected the country (and the world). Not long after, the Portuguese economic crisis of 2011 through 2014 also brought down numerous companies. The unemployment rate increased significantly, mainly due to the overall job destruction. Moreover, the number of jobs with the minimum wage increased and the constraints in contracting credit imposed a taller barrier to reinsert people in the market [45].

Notwithstanding, since then, the country has seen an above-average growth (Fig. 1.2) in the entrepreneurial chapter compared to other EU member states (Country codes are present in Tab. B.1). In

this figure, it is possible to observe a matrix in which the "Compound Annual Growth Rate (2008-2019)" is paired with the "Average EU Variation". Portugal is inserted in the "High Performance, Progress" cell alongside countries like Romania, Ireland and the Netherlands. On the lower left side, Czechia, Bulgaria and Greece negatively stand out. Moreover, one of Portugal's initiatives towards entrepreneurship, "Capitalize 2018", was one of the highlighted proposals by the report [46] due to its innovation and possible positive impact.

Entrepreneurial Education

The Portuguese evolution on this topic resembles and follows the European trend previously referred. In Portugal, by 2003, there were already nine courses dedicated to entrepreneurship in some of the Management under-graduate programmes and six post-graduate degrees in this field of studies [47]. Table 1.3 represents the opportunities to study entrepreneurship aforementioned.

University	Under-Graduate Course	Post-Doctorate Degree
Autónoma University of Lisbon	–	Business Management, Entrepreneurship and New-Ventures Creation
Catholic University of Lisbon	Business Initiatives	–
ISCTE/ISCTE-INDEG	Entrepreneurship and Organisations	Entrepreneurship and New-Ventures Creation
Lusíada University of Lisbon	–	Management and New-Ventures Creation
Minho University	Entrepreneurship	–
Moderna University	–	Micro-Firms Creation and Small Business in XXI century – Management Tools
Nova University of Lisbon/ Faculty of Economics	Entrepreneurship	–
University of Aveiro	Leadership and Entrepreneurship	–
University of Beira Interior	Entrepreneurship	Entrepreneurship and New-Venture Creation
University of Évora	Entrepreneurship	Entrepreneurship and Innovation
University of Trás-os-Montes and Alto Douro	Theory and Practice of Entrepreneurs	–

Table 1.3: Entrepreneurship in Higher Education, Portugal 2003 [47]

Nowadays, there is an immense offer of entrepreneurial education in Portugal. There is a clear mindset of providing everything an entrepreneur needs to prepare its ideas for the market. Almost every university has available curricular units on entrepreneurship, TTOs, complete degrees on the topic have emerged in business and engineering schools, and academies that provide extra-curricular training were established in the country (Ex: European Innovation Academy (EIA)). These core changes in society have brought enormous pressure in the education for entrepreneurship to be successful. As mentioned in section 1.3.2, it is studied that, with the correct innovation on education, a clear positive response will generate an innovative and prosperous society.

Incubators and Accelerators

In Portugal, the number of incubators has grown significantly in the past years. From the year 2002, when they were only 23, the number grew to 72 [48, 49] in 2014. In 2020, there were counted around 100 certificated incubators (Tab. B.2). This growth in offer of incubators in Portugal is regarded as a good sign of the entrepreneurial ecosystem.

Regarding one of the more iconic incubators in Portugal, Instituto Pedro Nunes (IPN)'s incubator is one of the best examples. Since 2002, the incubator headquartered in Coimbra has focused on providing support for new innovative business projects that are technology-based or advanced services. IPN was awarded the world's "Best Science-based Incubator" in 2010. The award is judged by a panel of international scientists and specialists, based on the analysis of a combination of performance indicators and the startups incubated, made by the Centre for Strategy and Evaluation Services. Over 330 companies were under the IPN's incubator, and 75% survived the early stages. Over 2600 highly skilled jobs were created during the time frame, and a total of €190 million of annual business turnover was accounted for in 2014, with an export rate of 65%. Two of the companies under current or previous IPN incubation are "Askblue" and "Feedzai" [50]. Regarding accelerators in Portugal, some of the incubators present in the table mentioned above also provide the service of an accelerator. However, the more established accelerators are:

- Energia de Portugal;
- Lisbon Challenge;
- Building Global Innovators;
- Founder Institute;
- Startup Braga Accelerator;
- IEUA Play;
- UPTEC Accelerator;
- inRes - Entrepreneurship in Residence;
- Indico Capital Accelerator Programme.

From this list, one of the organisations that should be highlighted is UPTEC. The organisation's mission is to promote entrepreneurship in the fields of arts, technology and sciences through the link between the university and the market. UPTEC has several programmes to help develop startups and are focused on a diverse field of work spectrum (from agriculture to healthcare). Their portfolio counts with more than 630 companies impacted. Some of the IST alumni founded companies were integrated into their programmes, namely: "Landing.Jobs", "SiliconGate", "Probely", "TEKEVER", "Do It Lean", among others. Therefore, this institution had, and has, a profound impact on the entrepreneurial movement in Portugal.

Investment in R&D

It is relevant to situate the evolution in this topic alongside the country's to understand the growth in investment in R&D in the last years. The fact that part of this expenditure is made in HEI makes it fundamental to understand its intricacies. If a university has the financial freedom of providing its students with an innovation culture, the product will certainly be better than if monetarily constrained.

Now, to better understand the investment in RD, a recent timeline was created. The unit measure used in the following graphs describing the Portuguese expenditure in this sector of innovation will be the percentage of Gross Domestic Product (GDP). This way, it will mitigate the inherent changes in the economy of the country. Fig. 1.3 presents data collected from Direção-Geral de Estatísticas da Educação e Ciência (DGEEC)'s reports on the investment made in R&D from 2014 until 2019 [51–56]. Adding to these values, to make a comparison with Europe's expenditure in R&D, the average volume of investment in the percentage of GDP is also inserted.

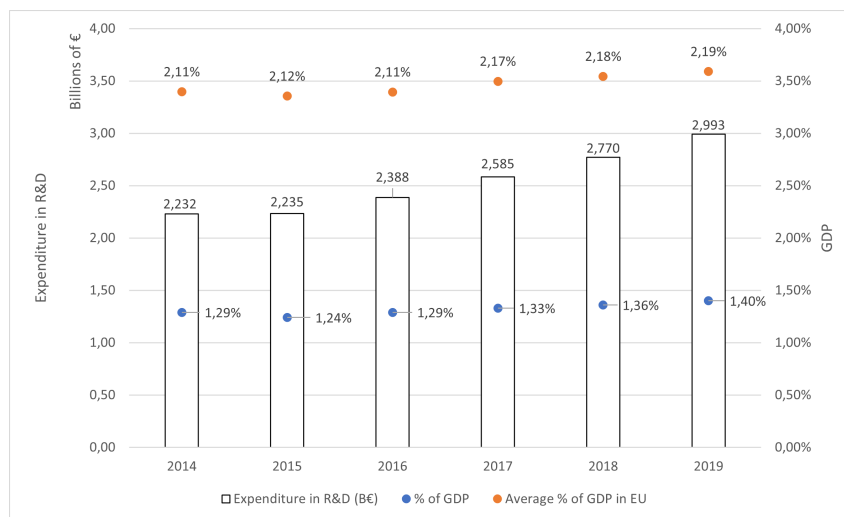


Figure 1.3: Expenditure in R&D vs Europe (Source: DGEEC)

In this graph, it is possible to observe a trend for a positive growth in investment that accompanies Europe's. However, the percentage of the GDP is still, on average, 0.83% below. To better understand how Portugal compares to the other European countries, Fig. 1.4 demonstrates how the average from the previous figure was distributed. The main precursors of this value are the Scandinavian countries accompanied by Germany and Austria. These values go in accordance with economic power these countries possess, and how focused they are on technology-based ventures, being some of the more industrialised nations in Europe. In terms of investment in R&D, Portugal clearly isn't on the same level.

The most significant chunks of these 1.4% of the GDP are almost evenly distributed across corporations and HEI (around 93%). Companies have been getting a larger percentage lately (in 2019, 52.5% in companies vs 40.5% in higher education) and it is relevant to point out that most of this investment is spent on personnel (55% on average).

If discriminated by the entity (Fig.1.5), there is much insightful information. Companies and HEI are the most prominent investors, which is expected from the information above. Still, it is possible to

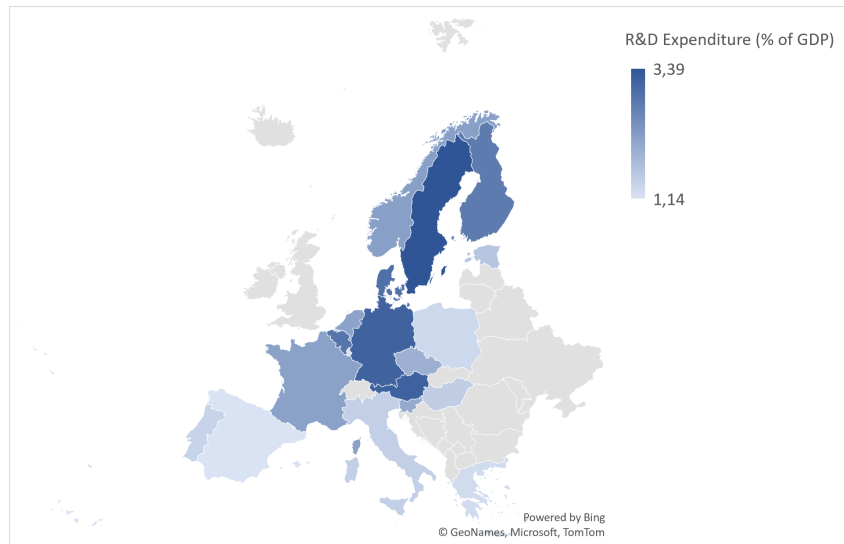


Figure 1.4: Expenditure in R&D in Europe

observe an increase in the percentage of investment from corporations, from 46.4% in 2014 to 52.5% in 2019. This growth implies that companies are the main actor for the investment in R&D and the trend is to create a more substantial distance from the other ones. HEI are the entity that has lost the more notable percentage of investment and this fact is correlated with the decrease (in percentage) in investment verified in the last paragraph. Going more in-depth, in 2019, the companies that invest more are telecommunication companies ("NOS" and "Altice") followed by banks ("Banco Comercial Português" and "Banco BIC Português"). Only after come technological institutions like "Hovione" and "CEIIA". However, these expenditures do not necessarily translate into automatic investment in the R&D sector.

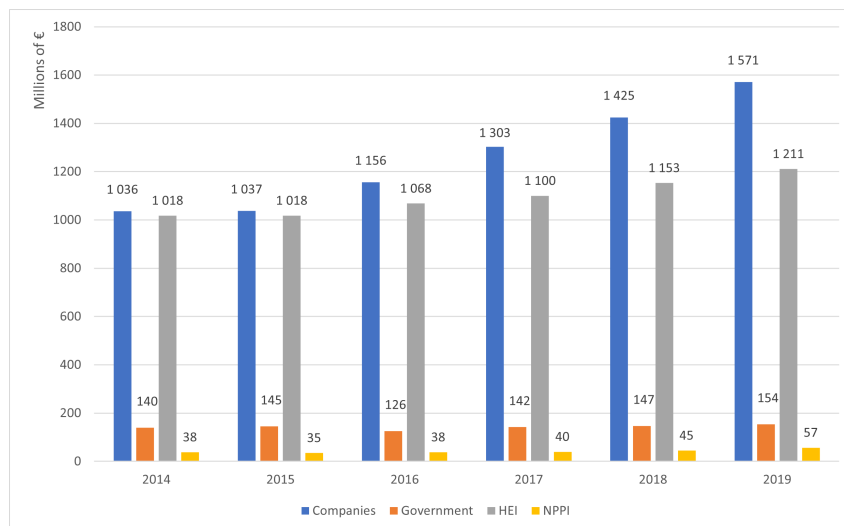


Figure 1.5: Investment in R&D per Entity (Source: DGE)

Tax Incentive System for Business Research and Development (SIFIDE II), the Portuguese policies for the assignment of fiscal benefits for companies that engage in R&D activities also promotes the expenditure in investment funds. These would then translate into an investment in a company that was involved in the sector. This last strategy was very attractive, promoting an increase in the expenditure

demonstrated in the figures shown. Nevertheless, these investments do not translate in a proportional evolution of the R&D sector in Portugal, leaving some questions on where the investments were being applied.

Due to this problem, the State Budget for 2021 tackles this issue by enforcing stricter rules on SIFIDE II's fiscal paradigm. Companies that apply to these benefits have to present their numbers more regularly, R&D institutions are subject to a more intensive background check, and investment funds have a fixed schedule to apply their funds in order to be deductible on the companies that trust them. The impact of these changes will change the paradigm of the fiscal incentives on the R&D, and their evolution would be a relevant topic for future research [57, 58].

One example of the great investment practices in technology-based solutions in Portugal is Portugal Ventures. This institution was formed in 2012 from the merger of three societies: "AICEP Capital Global, SCR, SA", "Turismo Capital, SCR, SA" and "InovCapital, SCR, SA". In 2020, Portugal Ventures integrated the "Grupo Banco Português do Fomento".

The institution was born from the eagerness to propel the competitiveness of Portuguese companies to global standards through their three core values: Commitment, Transparency and Excellence. These values then frame the strategy of the organisation. Portugal Ventures invests only in Portuguese-based companies, adding value to what the country has to offer, in the digital, engineering and manufacturing, life sciences and tourism fields (in the Pre-seed, Seed and Series A stages).

Portugal Ventures' portfolio counts more than 175 companies, and some of them are "Science4you", "Probely", "PETsys" and "HiJiffy" (these last three founded by IST alumni). In total, since 2012, the Venture Capital institution has realised almost €147 million in investment [59]. Concluding, the impact that this organisation has had is remarkable for the Portuguese ecosystem.

Understanding investment from the perspective of the investor is also relevant. On the one hand, due to the stage Portugal's ecosystem is now at, there is still a relatively small number of startups being born in the country. On the other hand, the number of technology companies that already have grown past the prototype stage and are already doing marketing and sales is diminutive. Furthermore, the number of investors is also quite underwhelming when comparing to the likes of the USA, where investors, once entrepreneurs, are now trying to help the newer generation.

These points will take time to be solved and will reveal an evolution of the Portuguese ecosystem's maturity. In the meantime, companies with great potential get investments from investors from other geographies. Consequently, these startups end up changing their headquarters to other countries due to the investors not wanting them in a country with different laws and quite volatile economically. Furthermore, the dimension of the Portuguese market is small for a potential global technology. There will be a need for the national ecosystem to mature and more venture capital to support companies to reverse this trend.

Revenues from companies

Regarding one of the key aspects of the study, the revenues obtained by the alumni-founded companies, it is crucial to first swiftly situate the content on what the current Portuguese companies' paradigm is, as

they are one of the main shareholders of an entrepreneurial ecosystem. Figure 1.6 shows the evolution of the revenue from 2004 until the beginning of the pandemic, 2019 [60]. It is possible to observe that the volume was rising steadily until the recession of 2008. During the three years after, SME were the ones more affected by this, showing a greater decline until 2012 (an economic crisis effect). However, the large enterprises continued to decline until 2016 while the SME were growing. In 2019, both the SME and large enterprises had recovered from the recession, hitting an all-time high total of almost €440 billion.

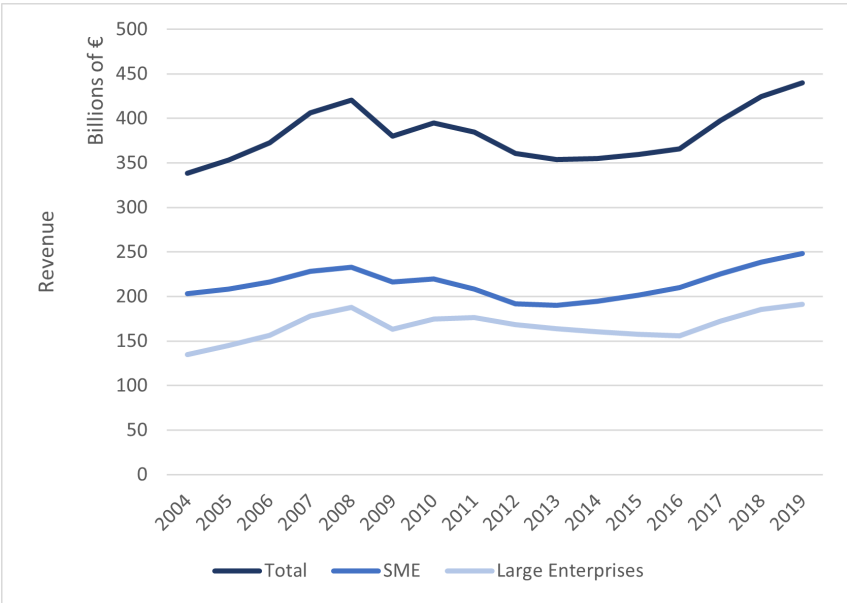


Figure 1.6: Revenues by Enterprise Dimension (Source: INE and PORDATA)

This outcome leads to the belief that the enterprise ecosystem was healthy before the pandemic, and companies were steadily increasing their revenues through the years. The values obtained show an economy that can prosper and accommodate new SME.

External perspective

According to factors mentioned above and the more recent editions of the "Portugal StartUp Outlook" [61, 62], an annual extensive study on the Portuguese startup ecosystem, it is understandable that the country is on the right path to an entrepreneurial future. It is internationally recognised as a great startup hub due to the government's efforts. Portugal's geographical location helps on the startup internationalisation, and investors (domestic, in an earlier stage; and foreign in an advanced one) are willing to support new companies. There is also an abundance of educated working-force available at a great price, which is attractive to more established businesses.

This funding, notwithstanding, lags behind other European countries (due to the dependency of foreign investors), and the bureaucracy associated with creating and maintaining a new company are also making the lives of the founders more difficult. Certain industry sectors are thriving under the pandemic outbreak like the IT, Healthcare, FinTech and Agriculture & Food, accumulating some of the most considerable value in startup exits.

1.4 Thesis Outline

The outline of this thesis tries to create a seamless interaction of the research conducted, how the implementation of the methodology was created and what the results were. So, after this chapter, in which core concepts were brought up and personal ideas from the author were explained, the second chapter will be focused on IST's past and brief surrounding paradigm. There is no student without a school, and its inherent environment guides the student to a successful future. After briefly understanding the environment in which the students were being brought upon, it will be understood the different services and projects provided by not only IST but also students' nuclei and companies.

Later, in the third chapter, the reader will be provided with the structure used to acquire data. From the "Target Population", "Dissemination" and the structure of the survey.

In the fourth chapter, it will be presented the insights created to paint a complete and thorough picture of the evolution and current state of the alumni's entrepreneurial mindset and the economic impact their companies have made in the peculiar (but important) year of 2020.

Finally, to conclude this thesis, the fifth chapter will summarise the key topics and results from the work developed. It will be accompanied by a collection of ideas that could act as recommendations to provide the students with a better and more prosper entrepreneurial environment. This final chapter will leave some future work proposals to further and ameliorate future reports and the continuation of this important study.

Chapter 2

IST and the creation of an Entrepreneurial Mindset

IST was founded 110 years ago, and since then, engineers from all fields have been educated to create and improve society's way of living and the world as we see it. Moreover, it is necessary to create a timeline of IST's policies and services that make the idea of creating one's own company a reality. The academic environment in which the entrepreneurs were educated is crucial for their success in such an uncertain world.

2.1 Foundation

The historical and political environment before the foundation of IST is outside the scope of this study. Therefore, the thesis starts with its foundation. Alfredo Bensaude was appointed by Brito Camacho, a minister in the First Republic's provisional government, to be the first dean of IST. Alfredo was very keen on creating a school of excellence from the beginning by fomenting a "school spirit" and an innovation mindset. The degrees were six years long, divided into two segments of three years each. The first was focused on basic engineering concepts, while the second regarded five different fields of studies available (Civil, Electrical, Industrial Chemistry, Mechanical and Mining Engineering).

Until then, the political and economic elite of the monarchy was not centred around the industry (according to the census created in 1900, 79% of the population was illiterate, and only 1% was working in an industrial environment [63]), placing Portugal in the very back regarding education and innovation in Europe.

This paradigm led the first graduates of IST to become instrumental in rearranging the industry and seeking innovation by establishing numerous new companies. From the first 80 graduates, 12 founded their own company, and three became factory directors immediately [64].

In 1927, Bensaude stepped down and Duarte Pacheco, former IST student, takes charge as director. During his mandate, with three other institutes and already 20 years of history, IST is integrated to constitute the Universidade Técnica de Lisboa. Under his mandate, the Alameda campus is also built (Fig.

2.1), and notorious other feats of engineering were made. Duarte Pacheco later became a significant minister due to the approval of numerous civil engineering projects that profoundly improved the state of the country.



Figure 2.1: Alameda Campus

2.2 Evolution of an Established Institute

After the Second World War, IST was already an established Institute and, from the 1950s to 1972, it started to host three Portuguese study centres, from a group of 12. Those were focused on Chemistry, Geology and Mineralogy, and Electronics. Due to the establishment of these centres, IST provided better training and acquired the right to grant the Doctorate Degree. It was also in 1967 that the first computer was installed. This fact shows how IST was focused on being in the forefront of innovation and how it sought for bringing the best technology available to its students.

In the 1980s, another profound internal restructuring occurred in IST, due to the Complexo Disciplinar and the inherent creation of autonomous research groups. The university faculty's statutes were published for the first time, and there was a push to integrate IST into society by creating partnerships with various institutions and companies.



Figure 2.2: Alameda Campus nowadays

The start of the last decade of the XX century marked the introduction of new courses and post-graduate degrees. In 1994, IST's north and south towers were inaugurated (Fig. 2.3), creating the conditions to boost the number of students to 8000 in that decade.

The last two significant additions to IST's installations were the Taguspark (Fig. 2.3(a)), in 2000; and Tecnológico e Nuclear campi (Fig. 2.3(b)), in 2013. Taguspark aims to connect the university and its students to the industrial polo present in the area. At the same time, the Nuclear campus objectives revolve around advanced and specialised scientific and technological research, mainly in radiological protection and nuclear safety.

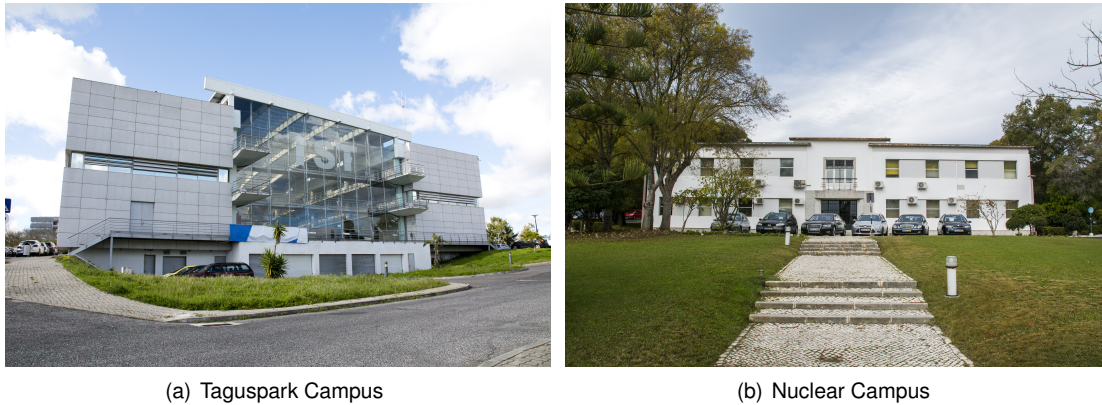


Figure 2.3: Recent IST Campi

Nowadays, IST counts with over 10000 students distributed by these three campi.

2.3 Introduction of Education on Entrepreneurship

In IST, the first curricular units focused on technology-based Entrepreneurship started to be taught with the profound restructuring that occurred in 2006, with the implementation of the European Higher Education Area defined by the Bologna Process. Portugal signed this accord in 1999 alongside numerous other European countries. There were several objectives in mind when signing this accord, but the main ones were:

- Create a European standard for Higher Education;
- Boost the international attractiveness and competitiveness between institutions;
- Tighten the relationships between universities and countries;
- Improve the easiness of mobility exchange and employment [65].

One of the key points in implementing the Bologna Process that favoured the introduction of the entrepreneurship courses was the one that mentioned acquiring broad skills. The result was the introduction of courses on Technology-Based Entrepreneurship (TBE) or Entrepreneurship, Innovation and Technology Transfer (EITT). Nowadays, there are six Master-level courses (outside of the Masters in Engineering and Management of Innovation and Entrepreneurship (MEGIE)) and three PhD-level ones available (Table 2.1) [66].

After observing Tab. 2.2, some concerning issues could be raised from the data made available by IST. The first topic relevant to be discussed is how inconsistent the entrepreneurship courses have been.

Degree	Graduate Course	PhD-Level Courses
MEBiol	Entrepreneurship in Bioengineering	Research Seminar I & II
MEAer and MEEC	EITT	iTeam
MEGE	TBE	Innovation Studies
MEGI	TBE	
MEMec	Product Development & Entrepreneurship	
MEQ	EITT	

Table 2.1: Curricular Units on Entrepreneurship in IST, 2020

This concern could be the result of an undecided IST management body, could stem from the number of registrations in those courses or even the availability of faculty to host them. Also, it is essential to refer that some degrees lost the entirety of their registrations in this kind of curricular units, namely Masters in Electronics Engineering (MEE), MEIC(-A & -T) and METI.

Degree	Course	Academic Year									Total
		2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/2020	
MBiotec	Entrepreneurship in Bioengineering	3	10	4	3	17	6	20	3		66
MBiotec	EITT		11	1	8			3		6	29
MEAer	EITT							35	38	62	135
MEAmbi	EITT	1	11	4	13	4	7	7	2	1	50
MEBiol	Entrepreneurship in Bioengineering	12		21	20	23	34	16	25	36	187
MEBiom	TBE	7	9								16
MEE	Entrepreneurship		10	6	2						18
MEE	TBE					10	3	7		4	24
MEEC	EITT	130	175	245	158	175	208	277	260	226	1854
MEGE	TBE		8	11	13	10	25	14	22	30	133
MEGI	Entrepreneurship	35	31	24	15						105
MEGI	TBE					19	28	24	31	37	139
MEGIE	Product Development & Entrepreneurship									11	11
MEGIE	TBE									12	12
MEIC-A	TBE	27	35	29	25						116
MEIC-T	Entrepreneurship		15	8	4						27
MEM	Product Development & Entrepreneurship	3	4	2	2	4	13	10	23	11	72
MEMec	Product Development & Entrepreneurship	32	23	29	45	64	65	68	50	25	401
MEQ	EITT		29	15	40	23	23	26	27	22	205
METI	Entrepreneurship		6	14	4	4	3	2	4		37
Total:		250	377	413	352	353	415	509	485	483	3637
Percentage Change:			51,00%	10,00%	-15,00%	0,00%	18,00%	23,00%	-5,00%	0,00%	

Table 2.2: Registrations in Entrepreneurship-Related Courses

Disregarding these observations, there has been a steady climb in students enrolled and interested in entrepreneurship from 2011/2012 until 2017/2018. From that academic year on, the number stagnated just below 500 enrolments. The degree that contributed the most is Integrated Masters in Electrical and Computer Engineering (MEEC) due to the compulsory nature of their course and the overall number of students accepted per year.

Another pertinent observation is the fact that students are willing to register in courses on entrepreneurship outside of their degree's curriculum. This conjecture presents an organic demand in curricular units that provide the students with practical knowledge on how to start their own businesses.

2.3.1 Masters in Engineering and Management of Innovation and Entrepreneurship

The MEGIE is the most recent significant step of IST to bring a more entrepreneurial mindset to its students. In its first year, ten students enrolled in the masters, while in the second year of existence, this

number jumped to around 30. This growth in applications proves the existence of a demand for the field of entrepreneurship.

MEGIE is a 2-year program in which the students are provided with a range of courses dedicated to the training in "innovation management, design thinking and development of new products and services" [67]. The final project for the conclusion of the masters is atypical when considering the other programmes as it can be a group project in which the students have well-defined positions in a professional setting.

Unfortunately, it is impossible to assess the impact of the MEGIE program in the time frame of this thesis dissertation. However, it would be an intriguing development to observe in the future.

2.3.2 Restructuring of IST's Pedagogy in 2021/2022

While writing this dissertation, all the preparations and assortments for the curricular year of 2021/2022 are almost finalised [68]. IST decided to revamp its education system and summarised this immense effort in the Teaching Model and Pedagogical Practices 2021/2022 (MEPP2122) report. MEPP2122 was structured and discussed to place IST in the forefront of the educational systems. Its principal aim is to situate the school with the present-day learning practices that better prepare the students for the contemporary technological challenges. In that respect, several necessary adjustments can be summarily enunciated:

- The calendar year of activities will change;
- There will be no more Integrated Masters;
- The second cycle will be restructured;
- The attitude towards teaching (less theoretical and more project-oriented).

This topic will not be thoroughly discussed in this study due to still not being implemented.

Nevertheless, it is imperative to mention it and to remark that, among several ambitions, one is to improve the "Entrepreneurship and Innovation training programmes". It will be interesting to follow how this point will be addressed.

2.4 Services to promote Entrepreneurship

Most of the history and the paths paved by the generations of IST's management councils referred to in the previous sections could be considered efforts towards an entrepreneurial alumnus/a. Despite that, this section will discriminate between partnerships and services that evolved through time, solely focused on innovation and access to entrepreneurial knowledge. Some services, however, will be omitted (like Centre for the Promotion of Innovation and Business (CPIN), UNIVA or Business Specific Opportunities (OPEN)) considering that they are not actively working alongside IST anymore.

2.4.1 Laboratories for R&D

To this day, IST has only grown and matured as an institution. It has developed several partnerships with companies, other universities and academies, but in this particular case, with several research centres. Regarding the number of institutions, IST shelters 55 divided per the following fields:

- 12 on Basic Sciences;
- 8 on Applied Life Sciences;
- 12 on Energy, Environment and Mobility;
- 6 on Engineering and Production Technologies;
- 4 on Technology Management and Entrepreneurship;
- 7 on Materials, Microtechnology and Nanoscience;
- 6 on Information and Communication Technologies.

Nevertheless, IST does not stop there. It also grants the statute of an associate laboratory to seven different laboratories focused in R&D closely intertwined with IST's research fields. Most of them have (or had) a significant influence on the entrepreneurial mindset of their researchers. Instituto Nacional de Engenharia de Sistemas de Computadores, Investigação e Desenvolvimento (INESC-ID), one of the associated laboratories, will be highlighted due to its history alongside IST's and impact it had on several researchers from the academic institution.

Instituto Nacional de Engenharia de Sistemas de Computadores (INESC) was founded in 1980 as a non-profit association dedicated to education, research and consulting in the diverse fields of science and technology. Since their early beginning, IST was one of the entities associated with this institution. During its numerous years of partnership, various IST students and faculty members became researchers and innovators at INESC. This environment blossomed and nourished new tech-related companies (like "Priberam") when support for startups was scarce or non-existent.

Due to a structural reorganisation of INESC, it was founded in the year 2000 INESC-ID. This institute is also a non-profit, officially declared of public interest, R&D institute, privately owned by IST and INESC.

In the time frame of this study it hosts more than one hundred PhD students and two hundred post-graduate students. The research topics can be divided into eleven scientific fields and these four thematic lines: Communications, Electronics, Energy and Information Technologies.

Regarding the entrepreneurial mindset created by this institution, seven spin-offs were created (Tab. 2.3) throughout the approximately 20 years of life. Furthermore, in a recent study conducted by Ioannidis et al. [69], nine INESC-ID researchers were distinguished among the top 2% of the most-cited scientists in their respective areas. This results presents an example of the impact INESC-ID has in Portugal and the world.

Companies Founded in INESC-ID	Year of Establishment
CoreWorks	2001
Voice Interaction	2008
PETsys	2008
NWC Network Concepts	2008
SiliconGate	2008
HeartGenetics	2013
Magnomics	2013

Table 2.3: Spin-offs from INESC-ID 2020

2.4.2 Technology Transfer Office

The TTO was established in 2009 to fill the existent gap of connecting the school with society. The implementation of this office stems from an initiative started in 2007 called University Technology Enterprise Network (UTEN). UTEN was a programme created by the Portuguese government in partnership with the IC2 Institute of the University of Austin. Its mission was to gradually build a professional, highly competitive and sustainable network of TTOs. IST's TTO is the contact point with the entrepreneurial and corporate world and helps the Executive Board of IST by contracting, protecting, managing and exploring IST's intellectual property. This office has been evolving and growing over the years, adding numerous tasks and responsibilities while fulfilling the needs of its stakeholders.

Traditionally, an office dedicated to technology transfer revolves around Intellectual Property (IP) protection and IP licensing [70]. However, it was decided that the approach to this office would be different. The office tackles a wider variety to be more thorough and to aim to address every need.

In Fig. 2.4, it is possible to understand the overall scope of the office. It includes the Corporate Partnerships Unit (NPE), the Intellectual Property Unit (NPI), Técnico Alumni Network (TAN) and the Entrepreneurship & Innovation Working Group (E&I). In the following sections (from 2.4.3 through 2.4.5), two of these will be discussed and analysed more in-depth (NPI and E&I), while the other two will only have a small mention since their missions are somewhat far from the projects' scope.

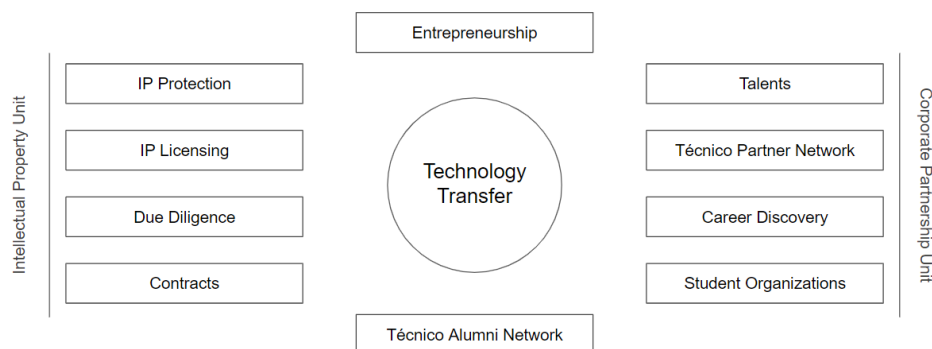


Figure 2.4: TT's Framework Approach

2.4.3 Intellectual Property Unit (NPI)

NPI is the unit inside TTO responsible for the management and protection of IST's IP. Part of the management also includes disseminating the service, available to anyone in IST's sphere. The Unit plans from 15 to 23 clarification sessions per academic year and, with the human resources available, looks through an average of 400 contracts per year. Putting into numbers their achievements (until 2020):

- 284 National Patents;
- 13 Patent Cooperation Treaties;
- 30 National Phases;
- 110 Brands;
- 10 Licensing Procedures;
- 10 Utility models.

NPI is critical in supporting start-ups as part of their procedure of protection of intellectual property also includes the encouragement for the commercialisation of the IP through the creation of a spin-off [71].

The actual magnitude of the effect that these numbers had on the economy or even society in general weren't possible to study and create factual considerations. However, it is remarkable that, with an office populated with small faculty numbers, it was able to assess 400 contracts per year. If this number is multiplied by the years the office is active, it amounts to 4400 contracts analysed in approximately 4000 days.

2.4.4 Entrepreneurship & Innovation (E&I)

Throughout the years, TTO promoted several initiatives that focused solely on the spirit of innovation within the community. Summarised below, the reader will find the four different subareas - Business Acceleration Programmes, Contests, IST Spin-off Community and Participation in Tech fairs (Web Summit in particular) - and what were their concepts and achievements.

One of the main absences in the structure of IST and TTO's services, and present and prevalent in other universities is the lack of an established incubator. This might be the result of an already great pressure of incubator in the geography of Lisbon, or the lack of funds to invest on an initiative of such scale.

Incubators and Accelerators

As it was mentioned in IST's history, one of the most recent campi is based in Taguspark. Taguspark was created in 1992 through a governmental initiative to promote technological development and innovation. IST is a shareholder of the structure with a 12.64% share percentage. Taguspark's mission is achieved

through, but not uniquely, the presence of an incubator that houses 20 companies and has 2000 square meters of offices and laboratories. In fact, the incubator is the only one in the south of the country prepared with specialised laboratories to assist chemical, bio-engineering or life-science startups [72]. All of this shows the importance IST has been giving to the promotion of innovation and entrepreneurship. Indeed, "Talkdesk", one of the first unicorn companies coming from Portugal, was nurtured in Taguspark.

In respect to IST's accelerators, there are two available programmes: Lab2Market@Técnico and EIA.

Lab2Market is an acceleration program organised by IST partnering with Everis and i-Deals. The teams selected from the pool of applicants win 250 hours of mentoring in technology and market assessment, revenue and costs, investors and feedback. Only professors, researchers, and doctoral and masters students from IST can apply [73]. This acceleration programme does not insert itself in the usual concept of an accelerator as it is designed to accelerate an idea into reality. Instead of accelerating a company. Nonetheless, it also does not comply with the concept of incubator due to the contest-like application method and strict deadlines.

On the other hand, as the name suggests, EIA is not only a school for future entrepreneurs but also an accelerator of companies' digital growth. The organisation has six different headquarters spread across the world, and one of them is Portuguese. This geographical position made possible the contact with IST. The organisation presents several services but the focus is on the following two.

The first service is non profit and counts with professionals from top institutions (like Stanford University, U.C. Berkeley, and Google) as mentors. It is a 3-week experience in which the students find themselves sharing and creating ideas, forming teams, designing a prototype, establishing a marketing plan, launching their idea, and pitching it to a panel of experts. This is the service that IST partnerships on, by giving a scholarship to its students sponsored by "Santander".

The second service from EIA however, is a full-fledged accelerator, following the classical concept designed to enhance a company's growth, innovation and culture [74].

In conclusion, these two accelerators partnerships don't show the same results as the incubator due to the fact that students usually aren't truly committed to starting a company.

Contests

The TTO also organises two innovation competitions: E.Awards@Técnico and Technov.

Both competitions are focused on IST's academic community. E.Awards, on the one hand, are only for projects developed under the curricular units of Entrepreneurship. Technov, on the other hand, is focused on projects whose developers are mainly from IST, which constitutes a big difference.

In terms of prizes, the two competitions also defer from each other. Due to its degree of seriousness, the first one has a symbolic monetary prize usually sponsored by "Santander" and "Armilar Venture Partners". In Technov, on the other hand, the applications must be precise on what type of support and quantity would be beneficial and necessary for the company. Then a committee evaluates how many teams receive said support and how much. This contest, over the years, was sponsored by "Banco BPI", "Thales" and "Santander" [75, 76].

These competitions are still active and being organised in 2021. However, during the academic year of 2018, IST partnered with Junta de Freguesia do Areeiro to create the AreeiroEmpreende Programme. This programme was a one-time contest for entrepreneurial ideas that could be implemented in six months, and they aimed to ameliorate the quality of life of the local community [77].

IST Spin-off Community

IST Spin-Off Community is a registered brand created by IST to create links between alumni-found companies, tightening their relationships with the institution and stimulate entrepreneurship among students.

This community already counts with 58 companies associated (Tab. 2.4), and it usually organises one big member's reunion yearly.

Fields of Work	IST Spin-off Members				
IT and Computers	Action Modulers	ANDITEC	Bana Consulting	C2C New Cap	Chilltime
	Codacy	Gatewit	GetSocial	Infortucano SI	Infoistema
	iNok	Landing.Jobs	Link Consulting	MAEIL	MIND
	NWC	PPL	Priberam Informática	Prodsmart	Seedrs
	SIQuant	SISCOG	Talkdesk	Thought Creator	Unbabel
	VoiceInteraction	Tradiio	Xpand IT	Quidgest	Heptasense
Robotics, Automation, Electronics and Computer Vision	Albatroz Engenharia	Coreworks	FrontWave	IdMind	Life Emotions
	AGORA Systems	Reverse Engineering	SelfTech	SiliconGate	Tecmic
Biotechnology and Biomedical Engineering	Bioteca	Biotrend	CardioID	Cell2B	HeartGenetics
	Magnomics	PETsys	Plux		
Environment and Clean Energies	Hidromod	Off7	Terraprima	Waterways	WS Energia
Aeronautics and Space	Lusospace	Omnidea	Spin.Works	TEKEVER	UAVision

Table 2.4: IST Spin-off Community Members

This group of companies shows that there is a greater percentage of companies in the IT and Computers field. The rest shows that there is space for new state of the art technologies to emerge.

Participation in Technological Fairs and Web Summit

IST and the TTO also promoted the participation of its students in technological fairs like Web Summit and Landing Festival.

Web Summit, in particular, is an event focused on creating a bridge between philanthropists, entrepreneurs and investors. Founded in 2009, it started as a 400-person convention about technology and businesses. Over the years, it has grown into the epitome of technological fairs creating a platform with tens of thousands of attendees for networking, learning and developing ideas that end up in successful entrepreneurial ventures [78].

In 2016, Web Summit chose Lisbon to be its host city due to the "quality of life, a welcoming community and world-class talent" [79]. Considering that IST is known to graduate world-class professionals, Web Summit and IST joined forces to provide free tickets to students since then.

However, when it comes to the actual impact of the event on an entrepreneurial level, it is complicated to make any conclusions as the lack of data impedes any analysis. Nevertheless, Domingues and Nunes [80] mentions that the direct impact (from startups attending the event) might be lesser than previously thought, while the indirect impact on the economy is greater (from the accommodation and catering sectors). These outcomes conclude by stating that Web Summit made the world look at Lisbon (and Portugal) as a good ecosystem for all kinds of startups and entrepreneurial opportunities.

2.4.5 Técnico Alumni Network (TAN) and Corporate Partnerships Unit (NPE)

TAN and NPE are slightly outside the scope of the project. Nevertheless, it is still relevant to mention some aspects of their work due to their contact with students associations and the alumni of IST.

Regarding TAN, this working group of TTO is focused on the promotion and encouragement of a connection between IST alumni and the institution. This objective is achieved by creating a platform of lifelong learning, knowledge sharing and updating, and combining a group of highly trained professionals oriented towards scientific and technological production.

This mission brings an group of interested people back to its institution while showing what accomplishments one student can make after finishing their degree in IST. It can also create a bridge with these people by maintaining contact with them. As it will be further explained and mentioned several times during this study, the contact with alumni of IST is preponderant for the success of the dissemination and assessment made in chapters 3 and 4.

Changing the topic to NPE, this is the Unit in the TTO that, as the name suggests, takes command over the relationships and partnerships with companies. These responsibilities include having to manage:

- The "Career Discovery" activities (which can be divided into ten different fields, from Técnico Job Bank to Técnico Business Cards);
- Student's nuclei and clubs (sponsors, logistics, regulations...);
- The Técnico Partner Network (TPN);
- Merit awards and scholarships.

Regarding the TPN, it is a symbiotic partnership between institution and companies, focused on the students, innovation, social responsibility and IST's strategic management. It counts with 16 partners (during the writing of this dissertation) [81], and most of them are world top firms in their fields (Accenture, A.T. Kearney, Boston Consulting Group, Capgemini, McKinsey & Company, Vodafone...).

From all of these services, the ones that may impact the entrepreneurial mindset the most are students organisations (46 in total) and clubs (eight due to being a more recent possibility). Knowing that most of them have an inevitable component of entrepreneurship, JUNITEC and SystemsGroup are the ones that stand out the most. Therefore, the next two topics will briefly describe their objectives and work.

JUNITEC

JUNITEC is a non-profit junior enterprise headquartered in IST. A junior enterprise is a company where the workforce is a collective of students and inserts itself in a business landscape. Since its foundation in 1990, the main goal is to create the link between the knowledge obtained by students in their respective degrees and the correspondent market. Every year, JUNITEC receives project applications and works towards the fulfilment of its clients' needs.

Throughout its history, JUNITEC has consistently grown not only on the financial aspect but also through their human resources. The junior enterprise not only has its projects with clients but also organises a competition called TecStorm. TecStorm is a hackathon focused on cultivating new and disruptive business ideas, which grew exponentially through its three editions. Higher education students from all over the country can compete in this competition to win monetary and material prizes and contact entrepreneurs and investors. Due to the growth in scale, Pavilhão do Conhecimento was the host for the last two editions.

This competition, aggregated with the work developed with their clients and the recent startups created by its members (Clynx, MyNutriScan, POGG and Servido), elevated the junior enterprise to new heights. In 2020, the organisation won the award for the most Entrepreneurial junior enterprise in Europe. It is clear that since IST accepted the application for the creation of JUNITEC, and helped along the way towards their growth, entrepreneurs and entrepreneurial-minded people have come out of this organisation [82].

SystemsGroup

SystemsGroup shares the same ambition as JUNITEC. This junior enterprise was founded in 2009 as a private non-profit association by virtue of the demand of the students of TagusPark. Its mission is similar to JUNITEC's as it strives to allow the students to work in a real project-based environment to complement their academic education.

They are focused on four kinds of services: Web Development, Mobile Development, Prototyping, Outsourcing. As a recent junior enterprise, these services provide a broad spectrum of activities, translating to diverse partners for the students to develop their skillset outside their education [83].

2.5 Técnico+

Técnico+ is the solution that IST found to address a need for advanced training in a post-graduate and professional environment. The mission for Técnico+ is to educate and update people and organisations with the broad spectrum of knowledge and experience that this HEI has. It offers pre-established programs and courses for individuals along with a service for organisations to conceive and adapt training to their needs. The courses provided usually have a short period of "classes" that, aggregated, occupy less than one day of work.

Withal, the people who've participated in these courses won't be considered as part of this study's target population due to being formatted to an already professional environment and do not coincide with the type of students intended. This information about the target population will be presented in section 3.1.

Chapter 3

Methodology of Data Acquisition

This chapter focuses on the framework used to obtain relevant data for the study and explains the intricacies of each step. It will be a roadmap of every idea and path followed to arrive at the result.

After studying and understanding the current paradigm of entrepreneurship and IST's history, it's time to obtain the relevant data to structure our results and conclusions. All the thoughts present in this chapter were formulated with the information presented in the previous chapters in mind. This way, it will create a seamless framework of information from research to data acquisition, and presentation of results.

Structure-wise, there will be a thorough analysis on the topic of the target population. It discusses how and why the population for this survey was selected, creating a conservative estimation. After this, the means of diffusion will be explained, bringing up every possibility considered. Finally, the form's structure and body will be presented, accompanied by its intrinsic liabilities.

3.1 Target Population

Well-defined criteria define the target population. These criteria are focused on the founder and the company itself, and can be summarised in the following: Type of Education, State of the Company, State of the Founder. The inspiration behind the construction of these rules was the work of Roberts and Eesley [4]. The main focus is to create a realistic but conservative estimation of the entrepreneurial impact from the studied population.

3.1.1 Type of Education

This study focuses only on IST alumni that started and finished a cycle of studies (either the first cycle, Bachelor's Degree; the second cycle, Master's Degree; or the third cycle, PhD). If a person did not complete one of these educational marks, it would not be considered in the study. This criterion, in particular, leaves the people who have dropped out in the middle of their cycle. However, a person who has finished a cycle but abandoned the following one (for instance, if it has completed a Bachelor's Degree but quit in the middle of the Master's) still is of the scope of the study.

As briefly explained in section 2.5, people would not be considered if they have frequented IST's education outside of the scope of the three cycles mentioned above (Técnico+). The professional/advanced education provided by the school might be relevant to create an entrepreneurial mindset; nevertheless, due to the time frame of these programmes and target population, it does not fit the objectives.

3.1.2 State of the Company

The state of the company was a crucial factor to enter the target population. If a company, for any reason, was closed until the end of 2020, that business did not enter the study. Only founders that had a company that became inactive, but still had other active businesses until the end of 2020, were considered. This rule prevented unnecessary information to the study due to the focus on 2020's economic impact.

Another necessary rule is that the company has to be born after the founder completed a study's cycle. Therefore, a business is excluded if the founder created it, and only after enrolled in IST or finished the cycle of studies.

Furthermore, if a company was acquired or merged during its lifetime, it will not be considered as external factors were added to the initial founder's value proposition. This rule has an immense effect in the Portuguese paradigm due to being a common path followed by entrepreneurs in Portugal. This rule creates an intense undervaluation of the companies' impact.

In addition, if a company was founded after October 2020, it was not considered due to its short time in the market (it had less than a quarter of the year of activity). Moreover, if a company from 2020 did not present any economic numbers, it would be disregarded from the study. This rule was applied because it had to stay consistent for all companies. If a company founded before 2020 did not present any value, the rationality was that the founder did not want to disclose important information. The same idea was extended to companies from 2020.

3.1.3 State of the Founder

The person who has founded the enterprise must be alive. This factor may skew the results to have more recent companies.

The founder, too, must still be working for the company/companies that have started. This criterion is essential because "inside information" of the company will be inquired, and if the founder does not have hold of them, their answer may be invalidated.

These rules will bring the total impact of the companies down and skew the data to have more recently created businesses (and create an estimation by default, as said before), but they are necessary due to the means of dissemination detailed below (section 3.2).

3.2 Dissemination

Regarding the dissemination of the form, the peculiar nature of the study and its target population made it challenging to find a customary way to obtain responses. Three options were considered:

- Through the Alumni Network of TTO;
- Through the OEIST;
- Through LinkedIn.

The first approach would be comprehensive, and that was the first unsuccessful attempt to send the form to every alumnus/a possible. The form, if this approach was selected, would then filter and separate the people that were important for the study from the ones who were not. This method was quickly dismissed when it was understood that IST no longer had permission to contact the alumni due to the General Data Protection Regulation (GDPR) implementation in Europe. This regulation created the inability to send an email without the previous consent of the receiver.

Regarding the approach to OEIST, it was possible to understand that some alumni could be reached, but when meeting with the faculty member, it was understood that the third option (LinkedIn) was the more favourable to reach better results.

This method would require more work during the diffusion of the form. Nonetheless, there are significant favouring points to this method of dissemination. This peer-to-peer methodology gives a personal touch to otherwise bland communication in a professional and intimate setting. It provides a greater sense of closeness in an otherwise far contact. Moreover, filtering could be imposed before sending the form by inspecting the profile of those who were deemed significant for the study.

3.3 Survey Creation

The primary purpose of this survey is to acquire data from the entrepreneurs and their companies. This information will provide the study with a solid factual foundation for the economic impact pretended and possible suggestions to improve it.

The survey is designed to be as terse as possible to impede dropouts. The following three fields summarise the main focuses of the survey concisely to go by the objectives of the study:

1. Description of the founder (without compromising the anonymity);
2. Characterisation of the company;
3. Identification of IST's impact.

The platform used, from the numerous online platforms available for inquiries (for instance: SurveyMonkey, Typeform, Qualtrics), was Google Forms. The seamless integration with Google Sheets and the author's previous experience with the platform made it the most trustworthy choice.

3.3.1 Structure

When it comes to the survey structure, it is simple to understand that it was very fixated on the objectives mentioned, leaving the inquiry with a small margin for its answers. In the end, structure-wise, the end

goal was to get three different tables of data: personal identification, company information and IST's impact.

So, the survey started with a small introduction referring to the dissertation and the survey's objectives. Then to be in line with the GDPR, it mentioned that the person would always be anonymous, and its data would not be used to identify them.

After this, four **Personal** questions were asked:

1. Age?
2. Gender?
3. Degree?
4. Year of the conclusion of the degree?

The reason behind these questions is simple, to create a brief personal and academic profile and to understand when he/she entered the professional working life. Subsequently, the person entered in a section denominated **Entrepreneurial Profile** that was used as a filter to end the survey to those who didn't create a company.

This section had three questions:

1. Have you created a company?
2. If yes, how many?
3. How many of them are active?

These three questions, apart from filtering the unwanted population, already present a quick perspective of the founder: if it was a "one and done", quit after an unsuccessful venture, was resilient or a serial entrepreneur.

The answers to these questions would end up sending the person to the respective section:

- If the person had not created a company, it would end the survey;
- If it had founded a company (or several), but it was not active anymore, the survey would also finish;
- If the person created one, two or three active companies, it would loop the section focused on the companies the same amount of times, to input the information from each company;
- if the founder had more than three active companies, it was prompted to choose the three with bigger revenues in order to avoid dropping out of the survey due to its extent and repetitiveness.

Now, advancing to the **Company** loop, the founder would be prompted with the following questions regarding Support/Funding, Activity and Economic Impact for each company:

- Year the company was born?
- Support/Funding:

1. Did the company get any support?
 2. If yes, from whom? (choices were given)
- Activity:
 1. Main Area of Activity?
 2. The Service/Product's base of knowledge? (IST Technological Knowledge/Outside Technological Knowledge/Not Technological)
 3. Principal Market? (National/Foreign)
 4. If it worked with foreign markets, which? (Presented with some choices. It was decided in those answers to create a distinction between Africa and Portuguese-speaking African Countries (PALOP) due to the Portuguese colonial past and different relationships with those countries.)
 - Economic Impact:
 1. The number of employees? (in an interval)
 2. Revenues in 2020? (€)
 3. The volume of Imports in 2020? (€)
 4. The volume of Exports in 2020? (€)
 - (Loop if there are companies unmentioned)

The objective of these questions was to get the most information possible with the least amount of questions. There are many opportunities to pair up answers to find interesting insights (for instance, pairing up the year the company was born with the year the founder graduated IST brings up the maturity of the founder when it started its entrepreneurial venture). In the one hand, the support section was devised to understand if the companies created had a support structure that helped them thrive. On the other hand, the activity section was designed to show where the companies found their ideal market and how they structured their service around it. Summarily, if there was a certain incline to a specific region.

The economic impact section was not extensive to maintain the survey brief and somewhat uncomplicated. It was asked the number of employees, to be able to discriminate the companies' revenue by number of employees, and try to find interesting insights on the matter. The volume of revenues, imports and exports was one of the most summarised way to try to depict how much a company was able to sell, and what was the inflow and outflow of money from the country. One critique could be made about the import question. How would a company track this value? This question might create some confusion as the company, for instance, could have bought an imported product from an intermediary. This would not be considered a cost through imports. However, what was asked, in its core, as mentioned before, was the outflow of money from the company to outside of Portugal.

The second to last section of the survey reflects on **IST's influence** on the business's creation. The founder was prompted about the following aspects:

1. Did you register in a curricular unit of Entrepreneurship during your academic life?
2. If yes, what was its impact? (scaled from 1 to 5)
3. Did you participate in any of these events or services provided by IST? (Provided with a plethora of choices)
4. How do you measure the impact of IST in the creation of your company? (scaled from 1 to 5)

Again, this section was very succinct but straight to the point. It was focused on finding if the entrepreneurs had some academic background in the field and if the knowledge obtained in IST helped when establishing their business. The question regarding the registration in entrepreneurial courses is expected to be skewed to a younger generation of entrepreneurs due to the recent implementation of said curricular units.

Lastly, it was asked for feedback on the survey. This component is fundamental to improve the questionnaire and to understand the point of view of the user. It brings some attention to what they believe is vital to change and, therefore, a "happier customer".

Counting the number of questions (without the Feedback section), the entrepreneur would find that:

- If they had **one** active company, it would answer a total number of questions between 19 and 22;
- If they had **two** active companies, it would answer a total number of questions between 28 and 33;
- If they had **three** active companies, it would answer a total number of questions between 37 and 44.

3.4 Liabilities

One of the main flaws of the overall study is the lack of knowledge of the global target population. This dilemma indicates that the results obtained in the next chapter (Chapter 4) may not represent the reality of an IST entrepreneur. Coupling that with the dissemination framework presented, the results of this study rely on the goodwill of the inquiries. There are several trust factors associated with the survey, namely:

- Inaccurate educational background on LinkedIn. People may omit the fact that they did not complete their education at IST;
- False professional background. Individuals could fabricate false professional backgrounds and generate false information about the foundation of a company;
- Incorrect input of the values in the survey. It is possible that, while filling the form, mistakes happen and invalidate the response;
- Unwillingness to respond to the section related to the company's numbers. It is understandable that the founders may not entirely trust the author and therefore omit the more confidential features of the company.

Chapter 4

Results of the Survey

This chapter will approach both the pre-processing of the data acquired via the survey and insights obtained.

Regarding the insights, the three focus points attributed in the previous chapter will be mentioned, namely: a description of the founder, the economic impact of the companies founded by IST alumni and the overall impact of IST in the establishment of said companies.

4.1 Dissemination Results

Throughout the time allocated for disseminating the inquiry, 513 persons were contacted via LinkedIn (or email, in some instances) through the connection request. From those, 221 accepted the invite (which represents a 43.9% ratio) and 96 responses were registered (Fig. 4.1). This ratio means that 43.4% of the people that accepted the invite filled the form. Moreover, a total of 19.1% of the request population that was contacted filled the form.



Figure 4.1: Dissemination Results

Therefore, with the amount of data gathered, it is believed that the following results may not truly represent the reality of the impact caused by the IST entrepreneurs. If the values are proportional to the

number of answers obtained, the results below could be multiplied by five to estimate the total impact of the target population.

Furthermore, the sections below will present the insights achieved by processing the data collected.

4.2 Pre-processing

The raw data obtained via the form was automatically transformed into a Google Sheets sheet. One of the reasons why the Google Forms platform was chosen. Then, it was transferred into a Microsoft Excel file in order to be worked offline.

The first steps were to translate the information to English (as the form was written in Portuguese) and change the questions to variable names. After that, the companies' principal activity was clustered to accommodate the study better and per the Classification of the Economic Activities (CAE) code.

The CAE gives a code and title to every economic activity. When in the process of registration, a business has to insert itself under one of those areas. There was some reluctance when considering the triplet Consulting/IT/IT Consulting during the clustering part, but it was decided to continue having those separated.

It was also tested if there were any repeated companies, as some of the founders contacted worked together in their entrepreneurial lives, showing that the network or friendships made during their degree transited to their professional lives and were very important.

4.2.1 Companies Considered

From the 96 answers recorded on the form, six were actually from people who had not created a company. Furthermore, another six people did not have an active company at the time of the survey. Therefore, 84 entrepreneurs had active companies. From the answers recorded of the 90 founders, at least 189 companies were created. The number is uncertain due to the "6+" answer, which omits a person who has founded, for example, seven companies. From those 189, at least 133 were active during the year 2020.

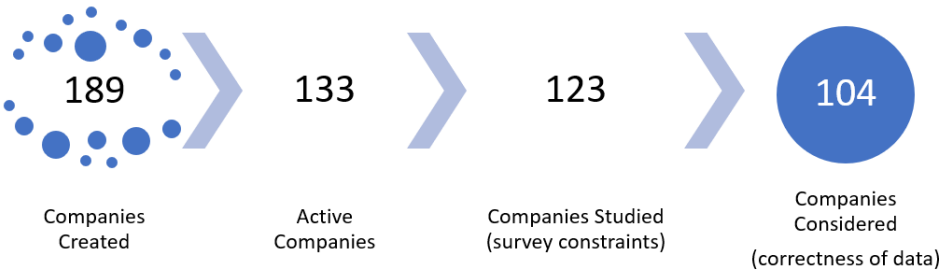


Figure 4.2: Pre-Processing of Companies

Due to the constraint of only assessing a maximum of three companies per person, only 123 were considered in the study. After that, 19 companies had the "Economic Impact" section zeroed (9 of them

were established in 2020 and 2021). Therefore, from 189 total companies created by 90 people, 104 were active during 2020 and had their data correctly filled (Fig. 4.2).

4.2.2 IDE & Programming Language

Then, these tables were saved as .csv (UTF-8) files and transferred to the Visual Studio Code ("VS-Code" in short) to obtain insights using Python (3.8.5 in Anaconda) as the programming language in a notebook-like structure (using the Jupyter kernel). The result achieved was three *pandas Dataframes* (id, companies and ist) with the structure available in Appendix B.4. Through the programming phase, new variables were created like the maturity of the entrepreneurs that combined two variables present in those data frames.

To work with the data and achieve the graphs and images presented in this chapter, the list of packages needed to import were:

- *NumPy*: for mathematical work;
- *Pandas*: for dataframes and data work;
- *Matplotlib* and *matplotlib.pyplot*: to create colour maps, graphs and figures;
- *Squarify*: for unique graphs called treemaps;
- *Seaborn*: to present the figures more cleanly.

The reader can find the Python code for the data processing in GitHub [84].

4.3 Description of the Entrepreneurs and their Companies

The percentage of male entrepreneurs is 92.22% and consequently 7.78% are female founders. This result was expected as the number of female students in IST has been minuscule in relation to male students. However, in recent years, this trend has been countered, and more and more female engineers are being graduated year by year.

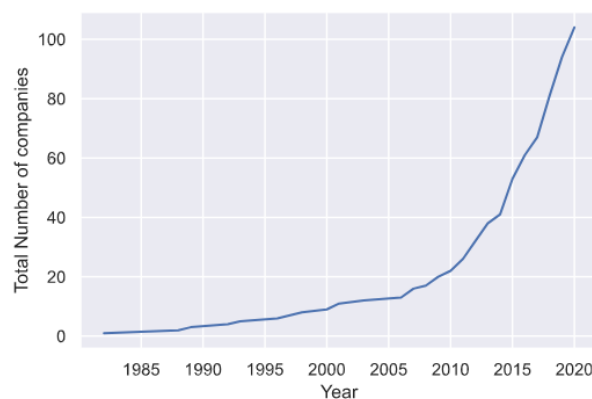


Figure 4.3: Evolution of the companies created by IST alumni

Even though the report made by "Startup Portugal" [62] indicated a decrease in startups created from 2015 to 2020, the data collected suggests the contrary (Fig.4.3). This outcome might be influenced by the rules applied in the dissemination phase (section 3.2) that promoted a more juvenile target population and companies. Despite that, it is still observed that nearly half of the companies were created in that time frame. However, there are two clear trends available in the figure. The first is a small slope from the beginning until early 2008, and another slope, with an increased trend of companies created per year. The change of pace could be result of self-employment out of necessity due to the global recession. From 2015 and onward, the end of the 2010-2014 Portuguese financial crisis brought a climate of hope and companies started flourishing from those years of recession and austerity. Furthermore, this insight could be the consequence of the integration of new services and curricular units on entrepreneurship.

Moreover, it is important to state that, from the results achieved:

- 39% of the founders are considered resilient, as they have created more companies than are active now;
- 7% had at least one unsuccessful entrepreneurial venture and did not create an active company afterwards;
- 26% are serial entrepreneurs, people that started at least three different businesses.

Degrees and Base of Knowledge

Fig. 4.4 refers to the degrees that graduate a superior number of entrepreneurs. It is possible to observe that, as expected, the more numerous degrees (considering the number of students) get the majority of the entrepreneurs. It is interesting that Aerospace Engineering, one of the more recent degrees lectured in the institution, appears with 5.56% of the sample size, above many other degrees lectured for a longer period.

Although these courses produced many entrepreneurs, it is relevant that not everyone used the technological knowledge obtained in IST to constitute their company. Only 51% of the companies' base of knowledge is from IST according to the data gathered. The rest is distributed to the other choices almost evenly: 26% were based on "Outside Technological Knowledge" while the remaining 23% are for businesses with no technological background.

Maturity

The average maturity of the entrepreneur recorded is approximately 12 years (Fig. 4.5). This value means that after finishing their studies, the IST graduate usually takes their time in the professional market. In some cases, after a certain period of time, the founder seeks education for business management, like an MBA, and only afterwards explores entrepreneurial ventures. During the dissemination period of this study, even though it was not questioned if the entrepreneur sought another academic degree, it was observed that a good portion had graduated in business management. This remark might

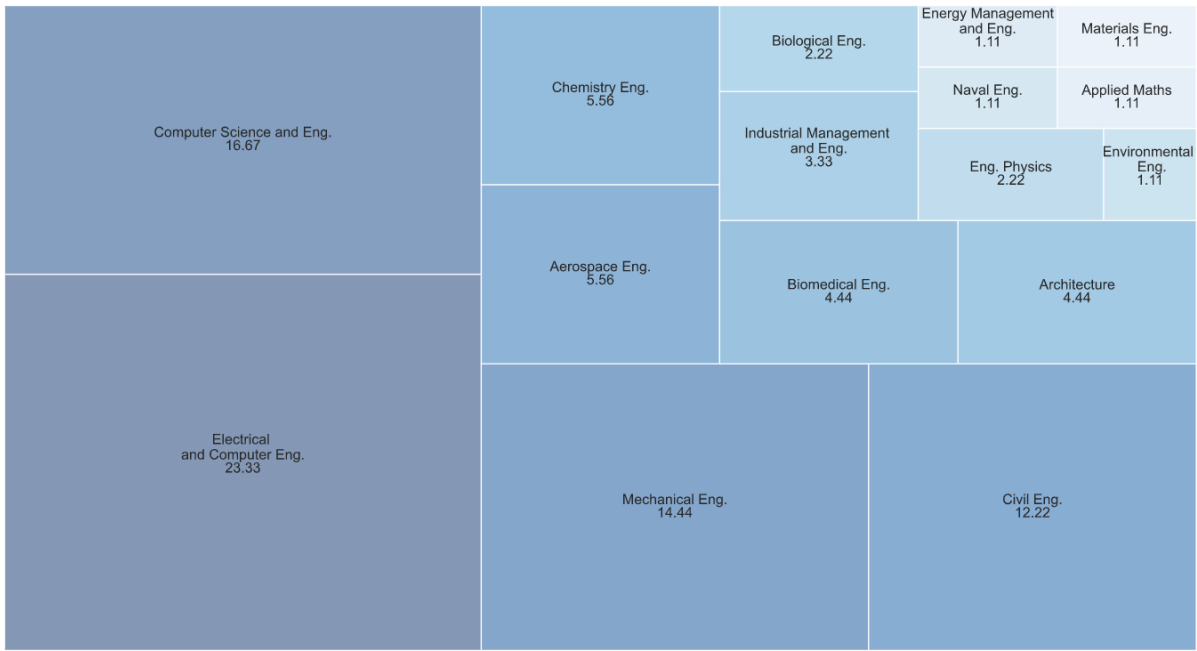


Figure 4.4: Percentage of Founder's Degree

be relevant in the result assessed from the IST impact in the company's creation, where the founders answered an average of 2.86 out of 5.

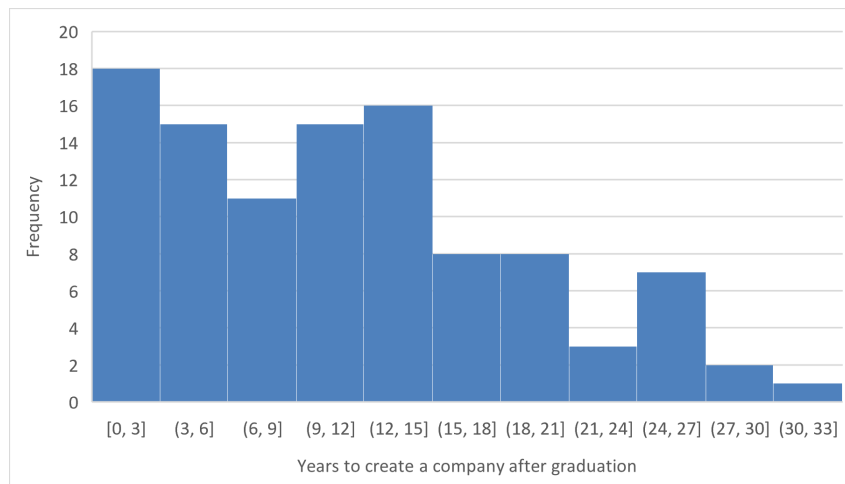


Figure 4.5: Maturity of the Entrepreneurs

Observing the graph, a clear downwards trend is observable for people to venture into creating new business opportunities as time passes. There is a clear predisposition to have a riskier approach during the first years after graduating. Moving forward, a hump is present in the 9-15 maturity age that is representative of a person who is seasoned in the market, understood the need for a new product, and developed said product under a new company.

IST's Impact

Regarding the answers to the question assessing if the founder had registered himself in a curricular unit on entrepreneurship, 20% of the answers were positive. However, knowing that the average year of the degrees' conclusion is 2003 and taking out all the answers from before 2006 (adoption of the Bologna Process), the percentage only grows to 23%. The expected number would be closer to 50%. The disparity encountered indicates that people that concluded the course before the restructure of 2006 had classes on Entrepreneurship. These answers could indicate that:

- The question was dubious (they could have had courses outside IST on Entrepreneurship (like an MBA), or regular project-oriented courses that touched slightly on the topic of entrepreneurship were considered);
- IST provided courses on Entrepreneurship before the restructure (going against the research made).

In a quantitative perspective, the entrepreneurs that filled the form did not consider too significant both the curricular units on entrepreneurship they frequented and IST's impact on the foundation of their company. As it was mentioned in the "Maturity" topic, the overall impact was just below average and the entrepreneurship course had an average importance. These outcomes show that even though IST has made several integral changes to their structure, the effect on the students is not proportional. Still,

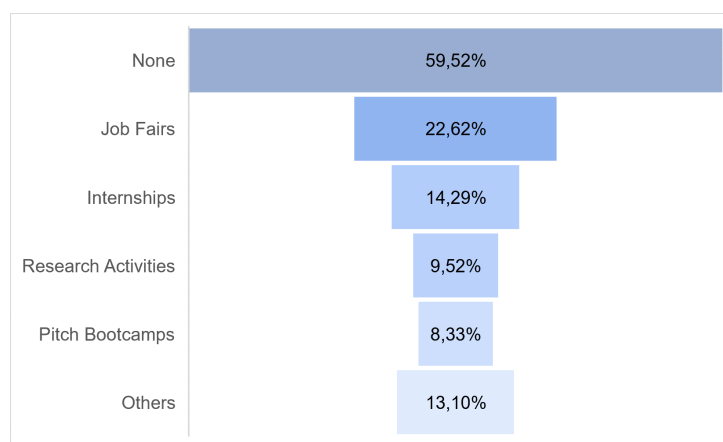


Figure 4.6: Participation in IST's services

on the topic of IST's impact on the entrepreneurs, regarding the services and activities provided, it is problematic for IST to understand that 60% of the founders inquired did not participate in any activity (Fig. 4.6). It was expected to have more people participating in job fairs (23%) since they are transversal to every degree.

It is also pertinent to observe that some founders frequented two important services for aspiring entrepreneurs (Research Activities for innovation and Pitch Bootcamp for pitching in general). Despite that, the people inquired did not partake in any activity provided by the NPI. This result could be caused by the minute sample size of the study. Alternatively, another possible cause for this issue is that entrepreneurs usually venture into the entrepreneurial world after some time in the market, as mentioned

above. This outcome then suggests that the service is adopted by those still present in their academic lives or laboratories as researchers. However, the overall conclusion is that the services do not appeal to the students who aspire to become business owners.

Support

This segment will dive into the support companies obtained during their first steps. Approximately 21% had outside help, either monetary (i.e. funding, credit lines, etc.) or logistically (i.e. networking, workspace, etc.). Due to the low percentage of the companies who had obtained support and diversity in answers, it was impossible to conclude which support was the most available/chosen.

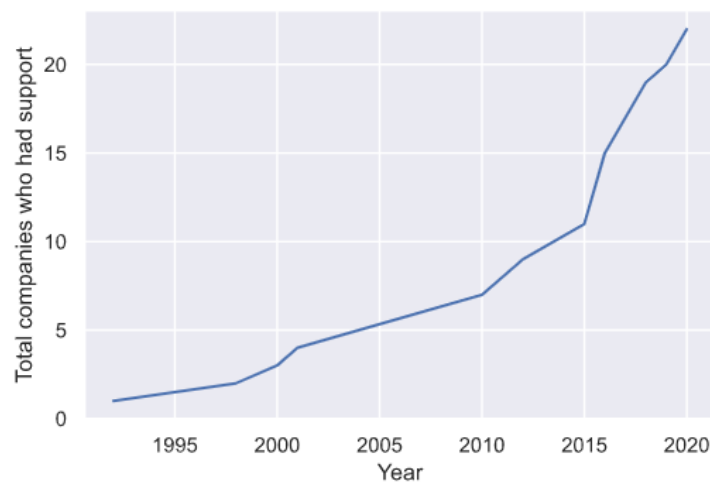


Figure 4.7: Evolution of the number of companies that had support

The graphic on the evolution of the companies who obtained support (Fig.4.7) follows closely the tendency on the graph of the evolution of companies created (Fig.4.3). However, it indicates that the first company that had support was founded only after 1990. A decade without companies with support. The better access to support these days may have contributed to the success of the companies. Numbers regarding this topic will be presented in the next section 4.4.

Main Area of Activity

Regarding the main activity of the companies founded by those who have answered the form, it is interesting to find that Consulting ("Consulting" and "IT Consulting") and "Finance & Management" are appealing activities. This observation goes per the idea that IST students have excellent problem-solving and mathematical skills. Also, IT ("IT Consulting" and "IT") are prominent choices, and that goes in accordance with the degrees of the founders (Fig. 4.8).

However, when taking into account the "Engineering" activity and comparing it with the percentages in Fig. 4.4, it is possible to infer that, usually, the students from traditional engineering degrees (Mechanical Eng., Civil Engineering, Chemistry Eng.,...) did not create a company focused on engineering projects but focused elsewhere. This fact may be the result of Lisbon's ecosystem of IT, administrative and

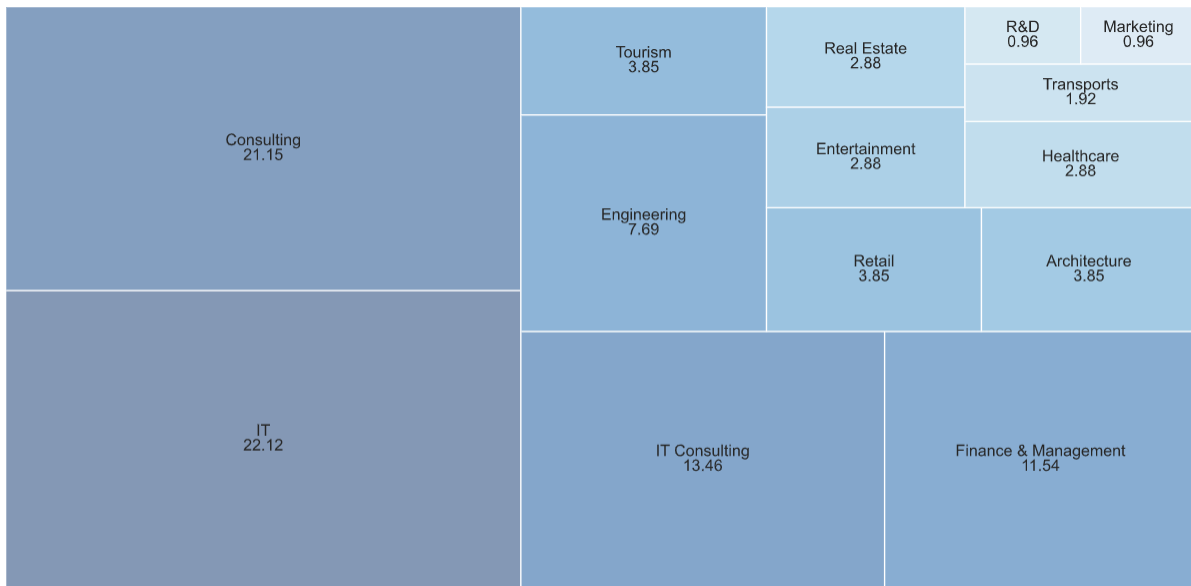


Figure 4.8: Percentage of Main Area of Activity

consulting enterprises. At the same time, the engineering industry is left in the outskirts of the capital, or the country's north.

To understand the evolution and the activity trends in startups, Fig. 4.9 presents the number of companies by "Main Activity" and their "Year of Foundation". This graph reflects how the percentage of companies evolves taking into account the current total of 104. Fig. B.2 illustrates the evolution of the percentages throughout the years but, to facilitate the viewing experience, it was decided to insert it in the B.

As expected, "IT" grew significantly in the 1990s, during the "computer boom" and the 2010s. In 2020, "IT" also saw great interest, possibly due to the prediction of its importance during the pandemic. "Consulting" is a more recent trend, showing tremendous growth starting from 2007. The "Finance & Management" and "Engineering" sectors both present a steady climb lately while the "IT Consulting" focused companies saw a recent boom in the last three years.

One last remark about this subject is the number of flat lines right before the 2008 recession. It is showing the difficulties endured by newly-founded companies during the economic crisis, and the consequent low surviving rate. Furthermore, like it was said as a comment to the total number of companies created, after the end of the financial crisis in 2014, there is a severe uptrend in companies created in every sector.

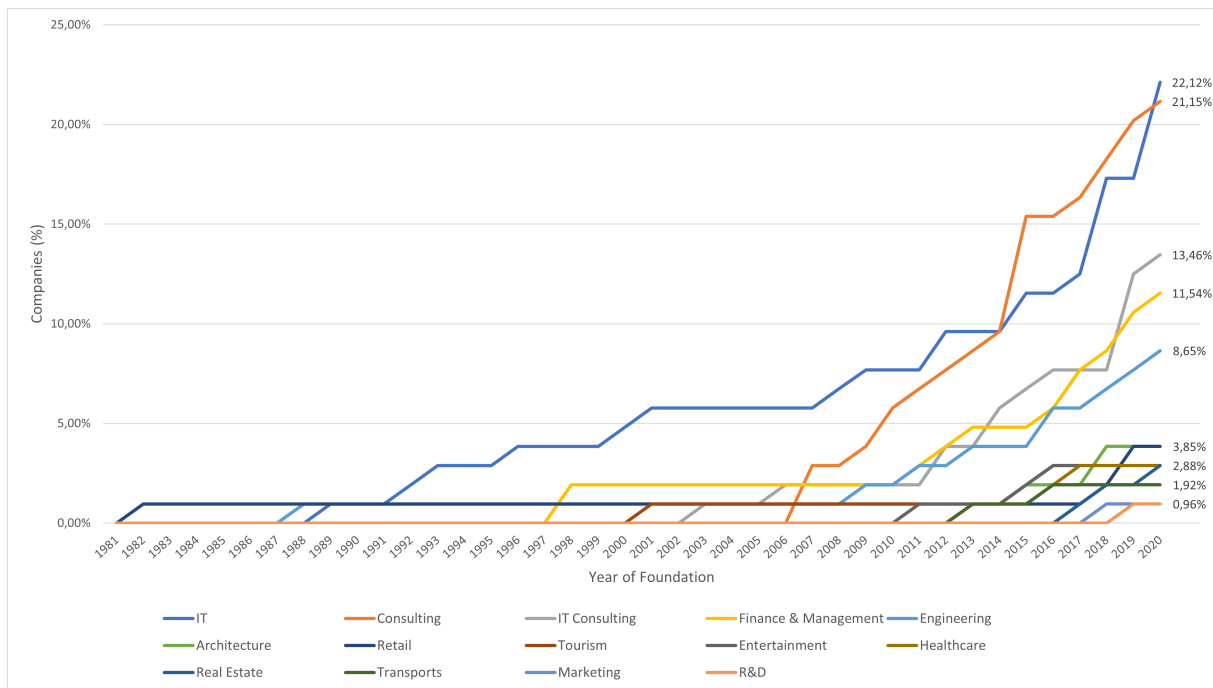


Figure 4.9: Evolution of Main Area of Activity

4.4 2020 Economic Impact of companies founded by IST alumni

This section will be solely focused on the extrapolation of the values obtained through the survey. It will dive in and make a detailed assessment of the numbers obtained by these companies while pairing them with the remaining factors associated and explained before.

Firstly, from the data gathered, when everything is summed, it is possible to observe that the overall value of the volume of revenues is €248 million in 2020. The values for exports and imports were approximately €64 million and €5 million respectively. These results show that the companies founded by IST's alumni give a boost to the economy by bringing to Portugal money from different markets while importing significantly less. Despite that, compared to the overall state of revenues of companies mentioned in section 1.3.3 (Fig. 1.6), the relevancy of the revenue is minimal considering the national panorama. This comparison could be unjust as the population reached in this study is quite underrepresented.

Maturity

Separating the revenues by maturity, and having in mind Fig. 4.5, it is interesting to see that revenues are not proportional to the maturity distribution. Companies where the founders had twelve to fifteen years in the market, are the most successful. This might come from the fact that these entrepreneurs worked in their markets for quite some time, and after analysing a necessity and having a seasoned perspective, they were able to translate their knowledge into a great product.

Maybe due to sheer numbers, the runner-ups were the younger entrepreneurs, who have started their companies in the first three years after graduating. This outcome could be result of the recent infrastructures present in IST and Portugal that facilitate the contact with entities that will help them

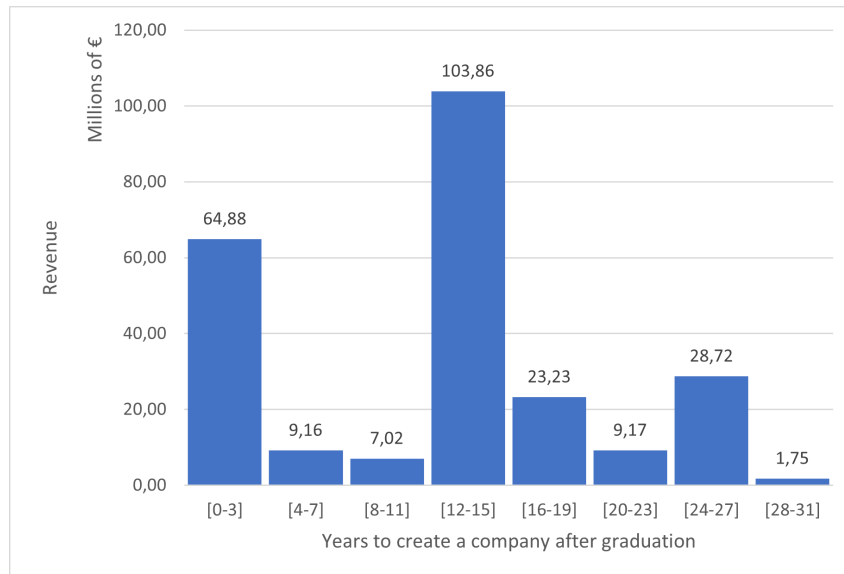


Figure 4.10: Revenue per Maturity of the Entrepreneur

reach more significant numbers. Concluding the analysis on the figure, there does not seem to exist a trend on the other intervals. Notwithstanding, the entrepreneurs on the right side of the graph (16-31) present higher revenues (on average) than those between four and eleven years in the market.

Base of Knowledge

When it comes to how the company was formed, it is relevant to study what is behind the service/product of the said company and analyse it to understand what kind of revenue it brings. Observing Table 4.1, this table differentiates the revenue by the number of employees and the knowledge mentioned above. From this table, it is possible to infer that nearly 5% of the companies inquired made almost ten times the revenue of 66%, and have 61% of the total revenue. From the last row of the table, it is also perceptible that knowledge acquired in IST, when applied in the market, corresponds to the more significant piece of the pie with almost 48%. Non-Technological companies represent the biggest share, but one value that may put into perspective the sample size is that no company was categorised as non-technological and with 10-49 employees.

Comparing the present study with the report from Roberts and Eesley [4], it is perceptible the difference in the overall size of the study. The sample size of companies interviewed is significantly broader than this one, which influences the monetary values, but the number of employees per enterprise is also superior. Their table discriminated the number of employees per "Less than 1000", "1000-10000" and "More than 10000". It was decided to change the intervals to accommodate the Portuguese reality better. It is interesting to compare the outcomes of both studies and identify that "University Technology" (Knowledge) is also the top revenue maker.

To end the analysis of this table, it is crucial to comprehend that companies with a small number of employees constitute the more considerable margin of businesses (>85%) and, consequently, need special attention. It is important to always keep SME in mind when introducing new policies and ini-

Number of Employees	Companies (%)	No Technology (€1000s)	Outside Technological Knowledge (€1000s)	Acquired-in-IST Technology Knowledge (€1000s)	Total (€1000s)
1-9	66.35	7653.1	2862.0	5550.4	16065.4
10-49	20.19	0.0	19130.0	19880.0	39010.0
50-249	8.65	6000.0	3000.0	32800.0	41800.0
250+	4.81	71000.0	20000.0	60000.0	151000.0
Total	100.00	84653.1	44992.0	118230.4	247875.4

Table 4.1: Number of Employees vs Technology Base Companies (in Revenue)

tiatives. Moreover, looking at the total revenues, an increase in employees correlates to an increased value. This outcome may be a result of the recent exponential growth in businesses in the last five years. The evolution of this table over the years will bring exciting insights to the studies that will follow this one.

Support

Taking into account the support companies had, there seems to exist a correlation between the existence of support and the volume of revenues in 2020. When disregarding every other variable, a company's average revenue, when provided with any support, was close to €5.3 million, while the enterprises that did not have support are approximately €1.6 million.

This result might come from the fact that investors or institutions supporting startups have rigorous criteria. The businesses with a more prominent potential are selected while the others are not. Then, these selected startups end up having a wider network of contacts to develop and access to infrastructures that propel them to an increase in revenues.

With the increase of organisations and institutions in Portugal to accommodate these startups, the perspective in the overall profitability of companies founded in the country is very promising. The access to accelerators and incubators in the long run will provide an increase in revenues (of over three times), if the numbers follow this pattern.

Markets

As it was adverted in section 1.3.3, Portugal, due to its geographical location and dimension, is a country that turns to foreign markets to grow past its narrow borders. To put together all the information regarding the markets IST alumni turned to, Table 4.2 summarises the values obtained.

This table is divided into two segments:

1. The first is focused on what the founders said about the market in which their company is more directed towards, or "Predominant market";
2. The second segment has in consideration the answers to the question about if they worked with "Foreign markets" and which of them are.

Three metrics were created ("Market Dominance", "Exports Dominance" and "Imports Dominance") to understand the contrast between the number of enterprises per market and the value obtained on those markets. These metrics evaluate the ratio between the value of a market and the total value of all markets.

Regarding the table, it is asked for the reader to focus on the following values, as they might create some confusion. The first and most glaring is the one that states that companies whose founders did not insert a foreign market ("No Foreign Market" row) have 2.37% of the "Exports Dominance". This incongruity indicates that they probably misfiled the form. Another mentionable fact is that Oceania has no Exports, which tells that the company is probably headquartered in that continent and works internally. Moreover, the monetary values of exports in the South and Central America are superior to the revenues. This issue is somehow paradoxical.

	Markets	Companies (%)	Revenues (€1000s)	Market Dominance (% Revenues)	Exports (€1000s)	Exports Dominance (%)	Imports (€1000s)	Imports Dominance (%)
Predominant Market	National Market	67.31	134077.50	54.09	9688.00	15.14	3547150	68.7412
	Foreign Markets	32.69	113797.90	45.91	54300.00	84.86	1613000	31.2588
	Total	100.00	247875.40	100.00	63988.00	100.00	5160150	100
Foreign Market	Africa	3.57	4145.00	1.67	2575.00	4.02		
	Asia	2.68	61933.33	24.99	26266.67	41.05		
	Europe	41.96	69933.23	28.21	28027.00	43.80		
	North America	5.36	6133.33	2.47	2562.00	4.00		
	South and Central America	3.57	1880.00	0.76	2843.33	4.44		
	Oceania	0.89	5.00	0.00	0.00	0.00		
	PALOP	1.79	3400.00	1.37	200.00	0.31		
	No Foreign Market	40.18	100445.50	40.52	1514.00	2.37		
	Total	100.00	247875.40	100.00	63988.00	100.00		

Table 4.2: Markets Summary

To better understand the two segments from this table, the following figures (Figs. 4.11 and 4.12) translate those into bar plots and illustrate the competition between markets. Concentrating first on the "Predominant markets", almost two-thirds of the companies inquired are more directed towards the Portuguese market, which is very important for the country. Despite that, when the revenues are considered, the natural consequence is that the businesses focusing on broader markets increase their revenues. The "Exports Dominance" metric of the companies whose focus is the foreign market also dominates the respective column completely. This value may be one of the causes for the almost even distribution of overall revenues.

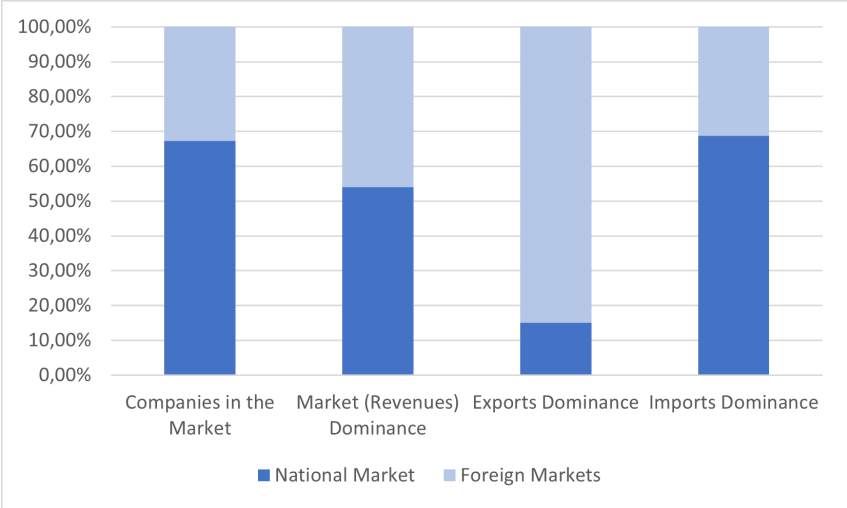


Figure 4.11: Predominant Market Illustration

When considering the "Imports Dominance", it seems that it is quite proportional to the number of enterprises. This figure, in general, translates what was expected from the enterprise ecosystem.

However, it is essential to remember that the data acquired is a small subset of the total target population, and only active companies were considered.

Focusing now on the "Foreign Markets", it was necessary to assume that when the companies indicated that they have worked in more than two options, the values were proportionally divided by each option. Looking at the results, some are very interesting.

Disregarding the "No Foreign Market" anomaly in the exports, their numbers are proportional to the number of companies and revenues/market dominance. The European marketplace, on the contrary, shows a significant disparity in the number of businesses and revenues. Despite that, due to geographical proximity, they have the hegemony of the exports.

The Asian markets are astounding when considering the ratio of the number of companies and values obtained. With just close to 3% of the corporations, this market possesses second place in revenues (one-fourth of the total revenues) and exports (41%, close to Europe's near 44%). These three market segments (fully National, European and Asian) dominated the overall assessment.

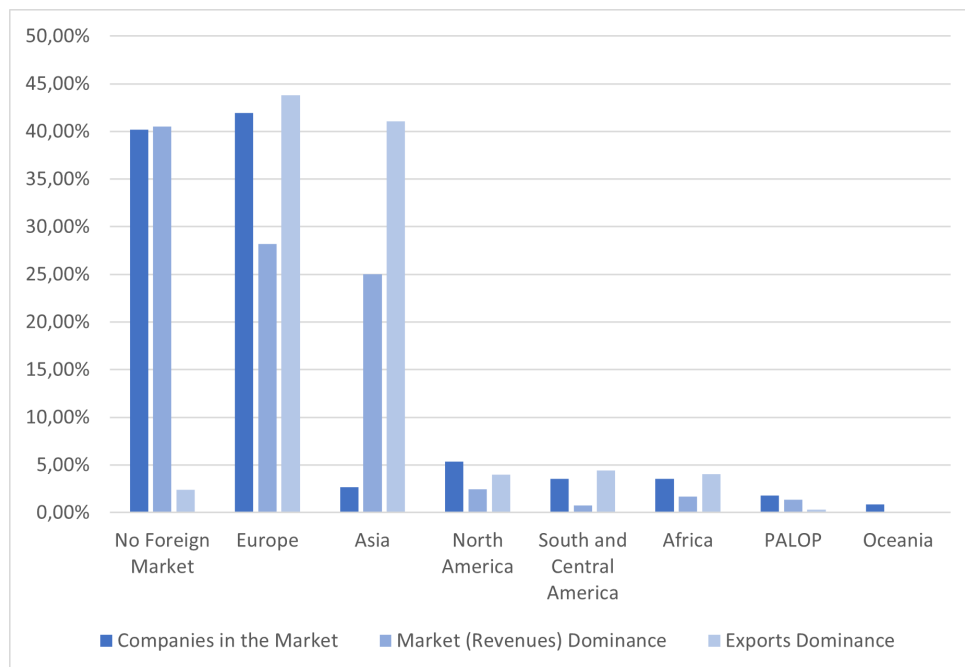


Figure 4.12: Foreign Markets Illustration

Now, zooming into the smaller markets, the American continent is the second more frequent choice for companies to focus and sell their products. This outcome, however, was expected to be higher and it is due to the small sample size. Companies like "Talkdesk" or "Anchorage", based in the USA, were unfortunately unreachable during the dissemination phase. Their numbers would probably be considered outliers in this study and would certainly boost the overall structure of the North American market. The South and Central American markets also show a pattern of having a considerable amount of enterprises, low revenues but great numbers in exports (disregarding the issue indicated above).

Finally, having already mentioned the Oceanic market, the African presents the same trend as the South and Central American market. Adding to African markets the values from PALOP, Africa obtains a noticeable share of the overall dominance.

Time in the Market

If revenues were to be distributed by the time enterprises actively participated in the market, Fig. 4.13 refers to this subject. The percentage of companies could be considered a mirror of new enterprises' evolution over the years (Fig. 4.3). Looking at the average revenue of those companies, one could identify a trend for the companies to increase their revenue over the years, which is a healthy tendency. Nevertheless, this insight could be biased since only successful or otherwise active companies were considered in this study. Furthermore, the values for companies over 30 years old may have cut the trend due to the sample size, or simply stagnated on that value.

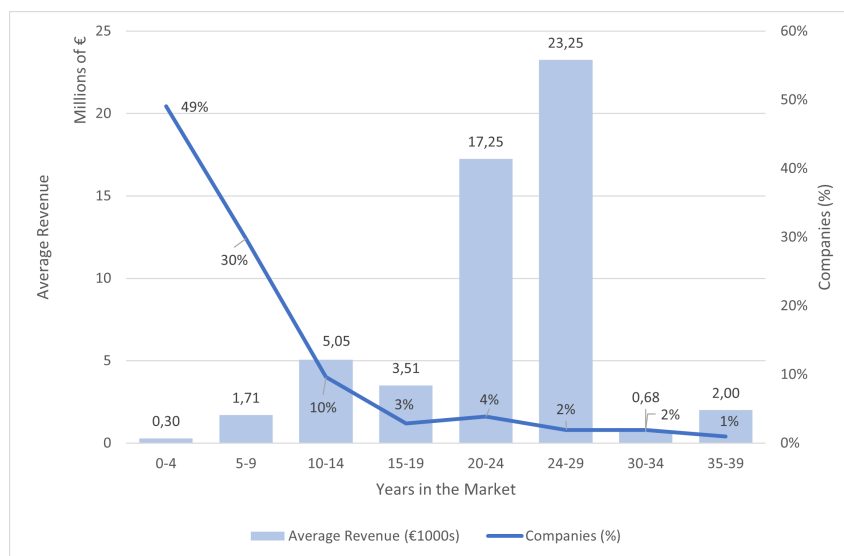


Figure 4.13: Time in the Market and Average Revenue

Main Area of Activity

The information for the main area of activity of the enterprises present in this study (Table 4.3) is structured similarly to the one used in the "Markets" segment (Table 4.2). Every sector is discriminated by their revenue, exports and imports.

When analysing this table, what comes first to mind is that, outside of the top four sectors, the rest lack in dominance compared with their percentage of companies. This issue could come from their lack of time in the market (Fig. 4.9). As it was seen in the previous topic, time in the market usually reflects in more revenue. Companies in the top four in revenues show an increase in number of companies before the other sector, with "IT Consulting" being the exception to the rule. So, time in the market is also important for this subject.

Analogous to what was done in the "Markets" section above, Fig. 4.14 illustrates the different dominance levels for each sector. Besides, it helps to visualise what are the activities that contribute the most to each metric.

Focusing now on the graph, "IT" is an activity that significantly contributes to the revenues and exports of the total dominance, above their percentage of companies, while committing less value to their

Activities	Companies (%)	Revenue (€1000s)	Market (Revenue) Dominance (%)	Exports (€1000s)	Exports Dominance (%)	Imports (€1000s)	Imports Dominance (%)
IT	22.12	90704.5	36.59	20604.0	32.20	881.00	17.07
Consulting	21.15	40921.0	16.51	3852.0	6.02	104.00	2.02
IT Consulting	13.46	35365.4	14.27	7930.0	12.39	1053.00	20.41
Finance & Management	11.54	68800.0	27.76	27490.0	42.96	1563.00	30.29
Engineering	7.69	2040.0	0.82	920.0	1.44	130.00	2.52
Architecture	3.85	1115.0	0.45	75.0	0.12	25.00	0.48
Retail	3.85	2180.0	0.88	507.0	0.79	1000.00	19.38
Tourism	3.85	980.0	0.40	110.0	0.17	50.00	0.97
Entertainment	2.88	189.5	0.08	0.0	0.00	4.15	0.08
Healthcare	2.88	300.0	0.12	0.0	0.00	0.00	0.00
Real Estate	2.88	680.0	0.27	0.0	0.00	0.00	0.00
Transports	1.92	3500.0	1.41	2500.0	3.91	350.00	6.78
Marketing	0.96	500.0	0.20	0.0	0.00	0.00	0.00
R&D	0.96	600.0	0.24	0.0	0.00	0.00	0.00
Total	100.00	247875.4	100.00	63988.0	100.00	5160.15	100.00

Table 4.3: Main Area of Activity Summary

imports. On the other hand, "Consulting" brings many revenues and focuses less on the foreign markets, having values below their companies percentage. "IT Consulting" could be defined as the more proportional, as the revenues and exports are somewhat similar dominance, but despite that, their share of the imports is relatively quite high.

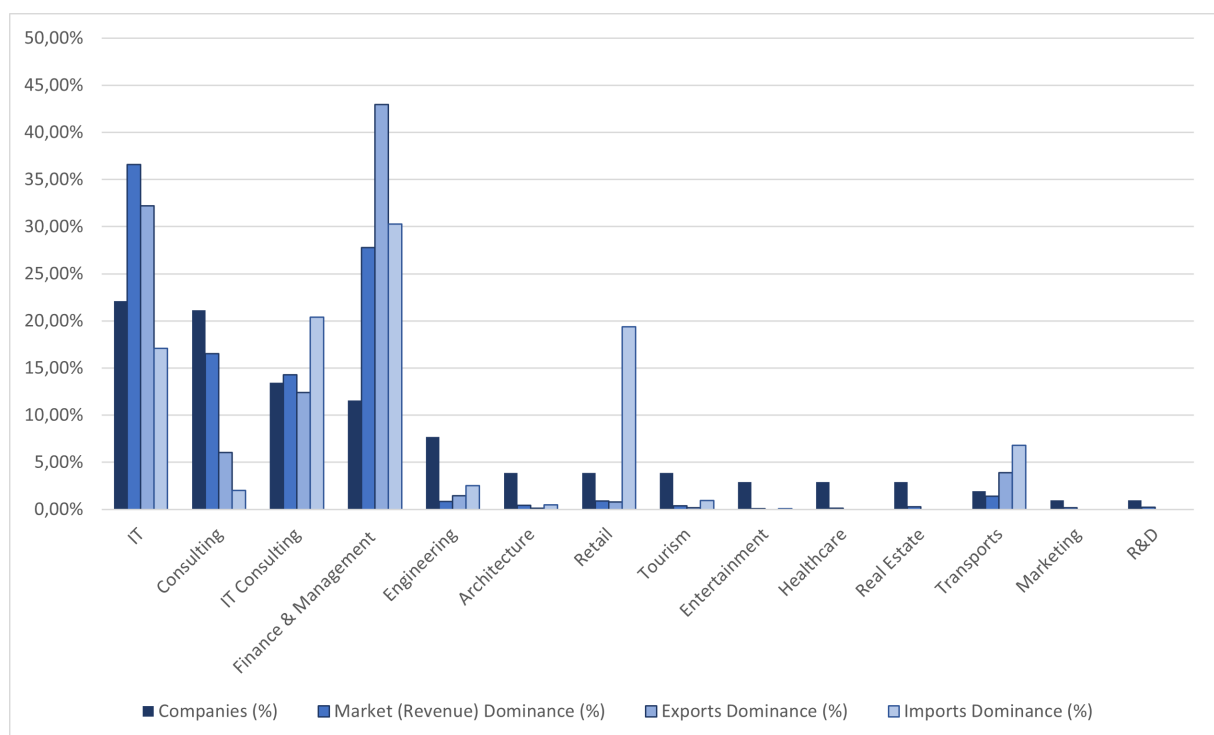


Figure 4.14: Main Area of Activity Illustration

Closing the top four of the companies' main activities is "Finance & Management", with the most substantial gap between their companies percentage and every dominance metric evaluated. This insight might indicate that IST graduates are profoundly proficient in Management and Monetary works and are very requested in this field.

When analysing the rest of the sectors, some conjectures could be created. Apart from the "Retail"

field, being an outlier in the "Import Dominance" metric and the "Transports" sector, bearing some money in all of its dominance variables, the rest fall short of their company percentage and bring little to no value. These inferences could result from their more recent establishments, and it will be interesting to continue following the evolution of their impact.

To finalise, the companies created by IST alumni with the most important economic impact in 2020 come from the IT ("IT" and "IT Consulting") and the "Finance & Management" sectors. Both were probably crucial in the transition to a workforce working from home during the pandemic.

Concluding the topic of the survey results, it could be considered that, even though the number of answers wasn't the best one, there was still a chance to depict an image of the entrepreneur and how impactful this type of alumni are in the economy. It was possible to observe several trends from the results obtained, namely:

- The surge of companies created in the recent years given that 50% of the companies were created after 2015 (Fig. 4.3);
- The more significant predisposition of computer and programming related courses to graduate entrepreneurs (Fig. 4.4);
- An average maturity of 12 years, showing an importance of having a seasoned knowledge of the market (Fig. 4.5);
- An average IST impact on the company foundation: from 1 to 5, the average was 2.86;
- The tendency towards creating companies focused in IT and Consulting (Fig. 4.8);
- The importance of scaling a company due to 5% of them having 66% of the revenues: the companies with bigger number of employees end up having a way more significant impact (Tab. 4.1);
- The higher focus on National Markets (67%) but the Market Dominance is almost evenly distributed with the Foreign Markets (Fig. 4.11);
- The value brought by companies focusing on the European and Asian markets shows a great revenue opportunity for Portuguese companies (Fig. 4.12);
- The value brought by companies focusing on IT and Finance & Management shows areas of great opportunity for startups created by IST alumni (Fig. 4.14).
- The companies founded by IST alumni had € 248M in revenue in 2020.

Chapter 5

Conclusions

This chapter aims to cover the overall outcomes of the project, understand the inherent difficulties of this kind of research, and provide some ideas and recommendations that will work as "food for thought" and more discussion.

As expected, the topic of entrepreneurship is vast and still in active development. This thesis aimed to be focused on certain important concepts to minimise the input of irrelevant information. Nevertheless, the difficulty in summarising each topic to their fundamentals might have left some information behind.

When addressing the concept of entrepreneurial university (section 1.3.2), the story and efforts mentioned in chapter 2, it is factual that IST can be considered an HEI concentrated in entrepreneurship. It follows all the steps on the pyramid (Fig. 1.1) and has provided an apparent intention in bringing more entrepreneurship to its students with the introduction of the MEGIE and a new and more diverse curricular plan with the MEPP2122.

From the first days of IST, an entrepreneurial future is one of the solutions in the students' minds after they graduate. Despite that, it was observed that the average maturity of the entrepreneur is around 12 years in the market. This insight makes it possible to understand that the students cannot (or are not confident to) create a company instantly after finishing their degree.

To complement the previous statement, the country's overall state is also crucial for the entrepreneurs' confidence when creating a business or making it successful. Looking at the number of companies created, the impact of the recessions and economic crisis brings a climate of uncertainty and less opportunity for risks.

IST students are very in demand due to their problem-solving skills, which translates to their entrepreneurial choices after being in the market for quite some time, by chasing opportunities in the consulting and managing world. Furthermore, the most relevant sector is the IT one, where alumni feel it is easier to start an enterprise due to the immense spectrum of technologies flourishing every day and the need of companies or individuals to accompany those trends. However, it is essential to note the lack of structured and consistent entrepreneurial education in these students that embark on the more technological and digital degrees (Tab. 2.2). As stated in section 1.3.2, consistency in the curriculum and the consequent pedagogical methods are crucial for the development of the students. This is a

key difference from the example presented of Technion, where the administration, from sheer necessity, brought to the institution the clear mission of creating highly-skilled entrepreneurs.

Regarding IST's impact on the alumni that filled the survey, the results were somewhat inconclusive and average at best. Its impact on the base knowledge of a company is important but, for the entrepreneurs, they feel like their post-graduate education was the most significant. Mostly in business administration, their post-graduate degrees fill the gap left by IST on the fundamental knowledge to constitute a company in comparison with the one obtained during their engineering, science or technology training. A well-known and old critic to the education guiding principles of IST is that they are too focused on theory and research, and less on real-world applications. This judgement might end up falling with the implementation of the already mentioned restructure in 2021.

5.1 Ideas and Recommendations

This section of the conclusions is reserved to provide some ideas that could improve the entrepreneurial mindset of IST's community. It also brings up some recommendations for external factors that may positively affect the ecosystem.

5.1.1 Internal Factors

This branch of the recommendations will focus on how IST, an HEI interested in promoting entrepreneurship, could improve their services to foment this mindset to their students. It goes over some general university proposals related to their marketing plan, possible entrepreneurial initiatives and leaves a comment on curricular units.

University Incubator

The idea of a University-based incubator could come as a possible initiative to promote entrepreneurship to its students by luring them to an easier way to diminish the risk associated with their startup. However, as mentioned in section 1.3.3, the investment in the said incubator would take valuable resources from the TTO.

Even though IST already has partnerships with two acceleration programmes, and is a shareholder of an incubator in Taguspark (section 2.4.4), it could also benefit from the plethora of incubators available in Lisbon. So, what is proposed is for IST to study the possibility of creating an Incubator Network and, if plausible, reach the several incubators available near the institution. A new network of incubators, therefore could be founded, similar to what already is happening with companies (TPN), and IST could be in the centre of it all.

This way, the institution would profit from the prestige and marketing potential of having a diversified incubator network and cut potential costs of having a fully functional one under its name. Furthermore, it would benefit from the inherent advantages of incubators by increasing the chances of successful businesses founded by its alumni network.

This recommendation could also impact the results obtained in the survey. The percentage of companies that had support may increase from the institutions present in the possible network created.

Inter-University Classes

From the feedback acquired through the survey, it was stated that one of the main difficulties in the creation of a company and its implicit growth management was the business side of every entrepreneurial venture. This issue created a need for an alumnus/a to enrol in an MBA to acquire specific management training or create a network of like-minded people with already acquired business knowledge.

The suggestion proposed next might seem simplistic; however, it may bring some bureaucracy and logistic issues. IST already has a background in courses lectured in other schools (for instance, the University of Lisbon's School of Medicine (FMUL) and Lisbon School of Economics and Management (ISEG)). It would be interesting to explore new possibilities by having entrepreneurship courses with students from universities like ISEG or NOVA School of Business and Economics (NOVA). Thus, the entrepreneurial projects developed in said classes would already have a more diversified founder base, with knowledge in business management and engineering. It could expose students to a new network of contacts (engineering students with business ones and vice versa) and prevent a lack of knowledge that usually provokes the end of a start-up.

This measure might be the most influential one in the mindset of the students in the author's perspective. It could improve the results of future surveys by increasing the number of companies created by those who have registered in entrepreneurship related curricular courses and, therefore, IST's impact.

Focus on Entrepreneurial curricular units in Computer Science Degrees

Being Computer Science one of the degrees with more entrepreneurs (Fig. 4.4), it is remarkable that the degree itself has not registered any students in entrepreneurial curricular units since 2015 (Tab. 2.2).

The inherent structure of the course implies the accumulation of several projects being developed over the years of the degree. Despite that, there is not (and will be in the MEPP2122) a course focused on creating a business out of those projects. With this in mind, it would be interesting to see what would be the effect of a course with that focus to enable a more business/entrepreneurial mindset in the students.

This counsel, nonetheless, does not have to stop with Computer Science Degrees. If innovation courses are disseminated among every degree, the probability of an entrepreneur being graduated may rise.

Marketing for Services focused on the Population

This measure would come in complement of the previous one. If services directed towards entrepreneurship or IP are publicised among students registered in entrepreneurial curricular units, it may raise their importance in the survey, and also in the attendance section. Two examples are: a small seminar on IP, in one of the planned classes, could stimulate the students to use the NPI; and the second one is to

promoting Pitch Bootcamp, to practice your pitch in front of companies (even if the content of the pitch is yourself).

This idea comes from the lack of results present in the survey. Most entrepreneurs did not participate in one of these initiatives. A more clear target may redefine the outcome obtained.

Doctorate Programmes in tune with Markets

The research done for this topic was not entirely conducted in relation to IST's practices. However, it is essential to reiterate the importance of market-focused PhDs to increase the applicability of the solutions provided by future academics. This measure will most certainly boost the impact of IST's alumni in the economy and is a topic that could be further researched. Adding to this, possible new partnerships with companies already interested in the innovation sector, possibly startups, could bring state-of-the-art technology to IST.

5.1.2 External Factors

This part will consider the Portuguese landscape and certain aspects that are believed to be crucial for the prosperity of entrepreneurship. It will reveal some ideas about the investment paradigm, the bureaucracy associated with creating a company and comment on the Web Summit's lack of data.

Investment

Even though Portugal has been increasing its investment in R&D recently (following the growth of the ecosystem), primarily due to the increase of company-side investments (Fig. 1.5), it is critical to push this trend to even higher numbers. Therefore it is vital to establish in the more prominent corporations in Portugal the social responsibility of giving back to society. This idea could be achieved by creating corporate funds for startups, increasing the value of the symbolic prizes of startup competitions and more. If the perspective on prizes is that their value is decided from the actual capability of the companies that cannot give more, and not from the actual mindset of just giving a symbolic value, there are other ways that one company could award the winners. By giving the best projects the possibility of integrating an acceleration programme, for example, it would push for the idea to actually go forward and push towards its success.

The government should also take more notable responsibility in enabling the improvement or development of the values invested in HEI or R&D by planning a more considerable percentage of the GDP in the expenditure on innovation to achieve the average European levels. Following the current progress, the country is not getting close to the average, but only accompanying its growth.

Knowing that Portugal is still going through its growing phases in the entrepreneurship world, its important for the implementation of policies like SIFIDE II to not be overlooked and to be actively supervised in order for it to work as it was designed. As mentioned in section 1.3.3, in the State Budget for 2021, this last topic was analysed and new measures will hopefully improve the initiative and, consequently, Portuguese innovation could thrive with more transparent investments.

Bureaucracy

One of the more consequential concerns of the Portuguese entrepreneurs is the bureaucracy associated with creating a company. One of the branches is the taxes and how to comply with all the established rules. According to the European Commission's report already mentioned [46], Croatia has created an initiative to combat the complexity of the tax reports requested of the SME. It could be interesting to discuss a possible adaptation to Portugal. Amending the current tax system (and possibly extrapolating this thought to different use-cases) enables a more straightforward system. If this change is disseminated through education, future entrepreneurs could dominate this topic when starting their companies.

Web Summit

Web Summit has brought an outstanding level of interest from the entrepreneurial world to Portugal and Lisbon. In the tourism and accommodation sector, and the catering sector, it was observable a significant boost in the income, backed by studies and data. However, there is not data available to study the impact on the existing startups participating in the summit. This issue makes it difficult to understand the direct impact of such an event on the startup ecosystem in Portugal. It would come from the government's side to push for this study to evaluate the actual influence besides the touristic appeal.

5.2 Achievements

This section will serve as an author's thoughtful analysis of the work developed. During the various steps of this project, there are some relevant achievements worthy of being mentioned. From the "state of the art" research to the dissemination of the survey and the acquisition of data, the more noteworthy ones are:

1. Being able to conclude this study (under a pandemic situation, while having personal problems) and the writing of this thesis in under five months;
2. Completing the objectives outlined, namely:
 - Understanding IST's history and services;
 - Developing and successfully disseminating a survey;
 - Obtaining interesting insights and formulate conclusions;
 - Concluding with pertinent ideas and recommendations to both IST and the Portuguese ecosystem.
3. Being able to collaborate with various bodies from IST;
4. Having contacted more than 500 alumni founders individually, getting to almost a hundred forms filled, while being a simple Master's thesis student with no apparent public backing from IST;
5. Improving my writing skills, both in English and Python, and being able to discuss entrepreneurship fluently.

5.3 Future Work

This section will refer to open paths created in this dissertation (as foundation) to further develop this study. The results of this research can be enhanced by changing some key pieces or adding pertinent parts.

Due to its intrinsic nature, it is believed that the study conducted can (and should) be continued in the future and periodically. There is also the possibility of adding the ecologic and sociological impact to the present identification of the economic impact (which could certainly be improved). Another opportunity to further this study is to research the main services available in IST in the eyes of the currently enrolled students. Assessing the impact of said services in the entrepreneurs of tomorrow.

A different but no less critical remark is the introduction of the MEGIE in 2020. Its impact on future alumni will be interesting to visualise and further assess. This new field of study can improve IST's economic impact (through entrepreneurship) by providing a solid entrepreneurial mindset in its students. It will be relevant to equate correctly both the effect on its students and value-added to society.

Still, regarding the educational aspect of the future evaluation topics, with the introduction of MEPP2122, more possibilities of studying the impact of IST and its new pedagogical practices reveal themselves among the entrepreneurs of tomorrow. It would also be necessary, for future works, to comprehend how much the students went after curricular units on entrepreneurship, and how consistent these will stay on their teaching practices after all these restructurings.

Another possible consideration for future work is the enrichment of the survey. Two main buckets can be considered:

- The Dissemination;
- The Questions.

After working on this project, these two essential topics can be extensively discussed. Regarding the first item, it is necessary to reiterate that this was not the most efficient way to strew the form. With time and the help of IST, it will be essential to find a way to mass-send the template message in future work. Not only that, the support from IST might give the credibility necessary to bring a more significant percentage of responses.

Regarding a different direction for this study, it would be intriguing to extrapolate the essence of this study to other universities to create a comparison method/benchmark. And not only technological universities but also business and management ones (like NOVA or ISEG). Getting a ranking of entrepreneurial universities could boost the competitive nature of the universities, and produce a warmer entrepreneurial climate in Portugal. Healthy competition usually brings the best out of everyone and the ecosystem tends to improve.

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Appendix A

Form

ID	Small Introduction
Questions	Answers
Age	Open question with data validation to be a whole numbers
Sex	Female/Male/Prefer not to say
Degree	Open question
Year of Conclusion of Degree	Open question with data validation to be whole numbers
Entrepreneurial Profile	
Have you created a company?	Yes/No
If yes, how many?	From 1 to 6+
And how many of those are still active	From 0 to 6+

Table A.1: First Sections of the Form

Company Loop	
Questions	Answers
What was the year of the establishment of this company?	Open question with data validation to be whole number
Support	
Have you acquired any support in the establishment of your company?	Yes/No
If "Yes", what institutions granted the support?	University/Bank/Business Angel/Incubator/ Other Public Institution/Other Private Institutions/Other
Activity	
Main Area of Activity	Open question
The product/service:	Was it created with Acquired-in-IST Technological Knowledge Was created Technological Knowledge acquired outside IST It is not Technological
Your products/services are sold primarily in national markets or foreign?	National/Foreign
If you sell to international markets, which are the more representative	PALOP//North America/South and Central America/ Europe/Asia/Africa/Oceania
Economic Impact	
What is the dimension of the company in employees?	1-9/10-49/50-249/250+
Volume of Revenue in 2020? (€)	Open question with data validation to be a number
Volume of Imports in 2020? (€)	Open question with data validation to be a number
Volume of Exports in 2020? (€)	Open question with data validation to be a number

Table A.2: Company loop section

IST Impact	
Questions	Answers
Have you registered in a curricular unit focused on Entrepreneurship during your academic life?	Yes/No
If yes, what was its impact on your professional life?	Scale from 1-5 (1- Irrelevant, 5- Crucial)
Have you participated in any of these events/services as an IST student?	Career Counseling (UNIVA)/ Professional Insertion Office (UNIVA)/ Job Fairs/Research Projects and Activities/Government or Company Protocols/ Internship/Alumni Talks/Pitch Bootcamp/NPI/Técnico Job Bank/ BEST Inside View by BEST Lisbon/None/Other
How do you measure the impact of Técnico in the creation of your company?	Scale from 1-5 (1- Irrelevant, 5- Crucial)

Table A.3: IST Impact section

Appendix B

Attachments

B.1 EU Country Codes

Country Codes							
Belgium	(BE)	Greece	(EL)	Lithuania	(LT)	Portugal	(PT)
Bulgaria	(BG)	Spain	(ES)	Luxembourg	(LU)	Romania	(RO)
Czechia	(CZ)	France	(FR)	Hungary	(HU)	Slovenia	(SI)
Denmark	(DK)	Croatia	(HR)	Malta	(MT)	Slovakia	(SK)
Germany	(DE)	Italy	(IT)	Netherlands	(NL)	Finland	(FI)
Estonia	(EE)	Cyprus	(CY)	Austria	(AT)	Sweden	(SE)
Ireland	(IE)	Latvia	(LV)	Poland	(PL)		

Table B.1: Country Codes

B.2 Business Incubators Certificated in Portugal

Incubators (Location)			
InCubo (Minho, Viana do Castelo)	Project Booster (Alto Tâmega, Viana do Castelo)	ADRAL Évoratech, CAME and CAESC (Alentejo)	ADRAT (Alto Tâmega, Viana do Castelo)
IN Europarque (Oliveira de Azeméis, Aveiro)	AEL STARTUP (Lafões, Viseu)	DNA Cascais (Cascais, Lisboa)	Startup Lisboa (Lisboa)
Caldas Empreende (Caldas da Rainha, Leiria)	AIRV (Viseu)	Amadora Tech (Amadora, Lisboa)	ANJE (Porto)
INCUB'UP ANPME (Porto and Lisboa)	StartSilkHub (Porto)	Acredita Portugal (Vila Nova de Gaia, Porto)	BLC3 (Oliveira do Hospital, Coimbra)
Sines Tecnopolo (Sines, Setúbal)	AIBAP (Mira, Coimbra)	Torres INOV-E (Torres Vedras, Lisboa)	AIP-CIE (Lisbon)
Brigantia EcoPark (Bragança)	Regia Douro Park (Vila Real)	Madan Parque (Caparica, Setúbal)	Build Up Labs (Lisboa)
Startup Lourinhã (Lourinhã, Lisboa)	Loures Inova (Loures, Lisboa)	3INT (Vimioso, Bragança)	Douro-Startup (São João da Pesqueira, Viseu)
CEI (Castelo Branco)	Demium Startups (Lisbon)	CNIRM (Rio Maior, Santarém)	Level Up (Tavira, Faro)
Atlântico Business School (Vila Nova de Gaia, Porto)	Fábrica de Startups (Oeiras, Lisboa)	Tec Labs (Lisboa)	NIDE (Porto e Lisboa)
GrowIN Portugal (Faro)	HUBIP (Alcântara, Lisbon)	Startup Braga (Braga)	IDEIA ATLÂNTICO (Braga)
IEFF (Figueira da Foz, Coimbra)	IDDNET (Leiria)	INOVAGAIA (Vila Nova de Gaia, Porto)	IET (Amarante, Porto)
BioBIP (Portalegre)	IPStartUp (Setúbal)	Startup Porto (Porto)	IPNincubadora (Coimbra)
Mercado da Inovação (Lisboa)	LISPOLIS (Lisbon)	MENTORTEC (Porto)	MOVELTEX (Paços de Ferreira, Porto)
IERA (12 centres) (Aveiro)	Alvaiázere+ (Alvaiázere, Leiria)	ICB (Celorico de Bastos, Braga)	CIM (Lisbon)
INCM Ericeira BF and Mafra BF (Ericeira/Mafra, Lisbon)	Startup Portimão (Portimão, Faro)	IECarmelitana (Tondela, Viseu)	Startup Alentejo (Vendas Novas, Alentejo)
Famalicão Made IN (Famalicão, Leiria)	Incubadora A Praça (Fundão, Castelo Branco)	NERE (Évora)	Startup Santarém (Santarém)
NOVA SBE Venture Lab (Cascais, Lisboa)	CETEC (Coimbra)	Parque Tecnológico de Óbidos (Óbidos, Leiria)	OPEN (Marinha Grande, Leiria)
PACT (Évora)	Parkubis (Covilhã, Castelo Branco)	Partnia (Caldas da Rainha, Leiria)	Terinov (Ilha Terceira, Açores)
Sanjotec (S. João da Madeira, Aveiro)	Vilawork (Barcelos, Braga)	Startup Leiria (Leiria)	Startup Madeira (Funchal, Madeira)
TagusValley (Abrantes, Santarém)	Espaço Bazaar (Lisboa)	AUDAX-ISCTE (Lisboa)	UBINNOVATIVE (Covilhã, Castelo Branco)
Incubadora da UALG (Faro)	UPTEC (Porto)		

Table B.2: Certificated Incubators in Portugal (Source: IAPMEI 2020)

B.3 Expenditure in R&D vs High-Tech Exports

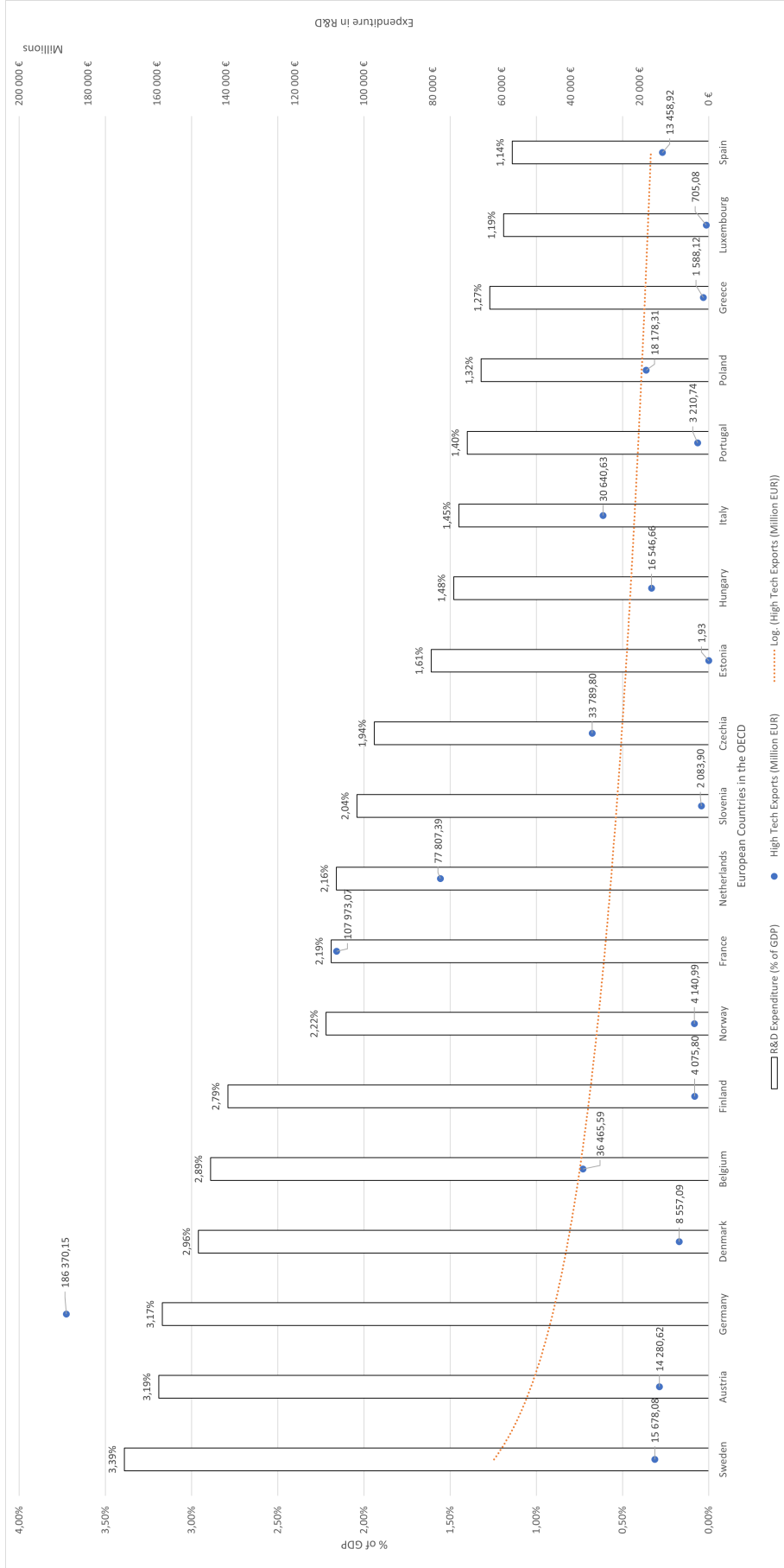


Figure B.1: Expenditure in R&D vs High-Tech Exports (Sources: GlobalEconomy.com and Eurostat)

B.4 Tables of Variables

Variable name	Type of data	Information Stored
id_pessoa	int64	Identification number unique to every entrepreneur. This value will tie together the three tables.
Idade	int64	Age of the entrepreneur.
Sexo	object	Gender of the entrepreneur.
Curso	object	Degree of the entrepreneur.
ano_conclusao	int64	Year of finishing the degree.
criou_empresa	object/boolean	Answer to "has created a company?"
empresas_criadas	int64	Number of companies created.
empresas_ativas	int64	Number of active companies.

Table B.3: Variables in Table id

Variable name	Type of data	Information Stored
id_empresa	int64	Identification number unique to every company. This value will tie together the entrepreneurs with the companies.
id_pessoa	int64	Identification number unique to every entrepreneur. This value will tie together the three tables.
ano_fundacao	int64	Year of the foundation of the company.
apoios	object/boolean	Company had support or not.
apoios_espec	object	Which support.
princ_activity	object	Principal activity.
knowledge	object	Kind of knowledge attributed to the foundation of the company.
market	object	Predominant market.
foreign_market	object	Predominant foreign market.
employees	object	Number of employees (in an interval).
revenue	int64	Volume of revenues in 2020 (€).
imports	int64	Volume of imports in 2020 (€).
exports	int64	Volume of exports in 2020 (€).

Table B.4: Variables in Table companies

Variable name	Type of data	Information Stored
id_pessoa	int64	Identification number unique to every entrepreneur. This value will tie together the three tables.
UC_empree	object/boolean	Registered in a curricular unit focused on entrepreneurship.
UC_impact	float64	Impact of said entrepreneurship course (scale from 1-5).
IST_events	object	Services that the entrepreneur participated in during their academic life.
IST_impact	int64	Impact of IST (scale from 1-5).

Table B.5: Variables in Table ist

B.5 Evolution of the Percentage of Main Activities

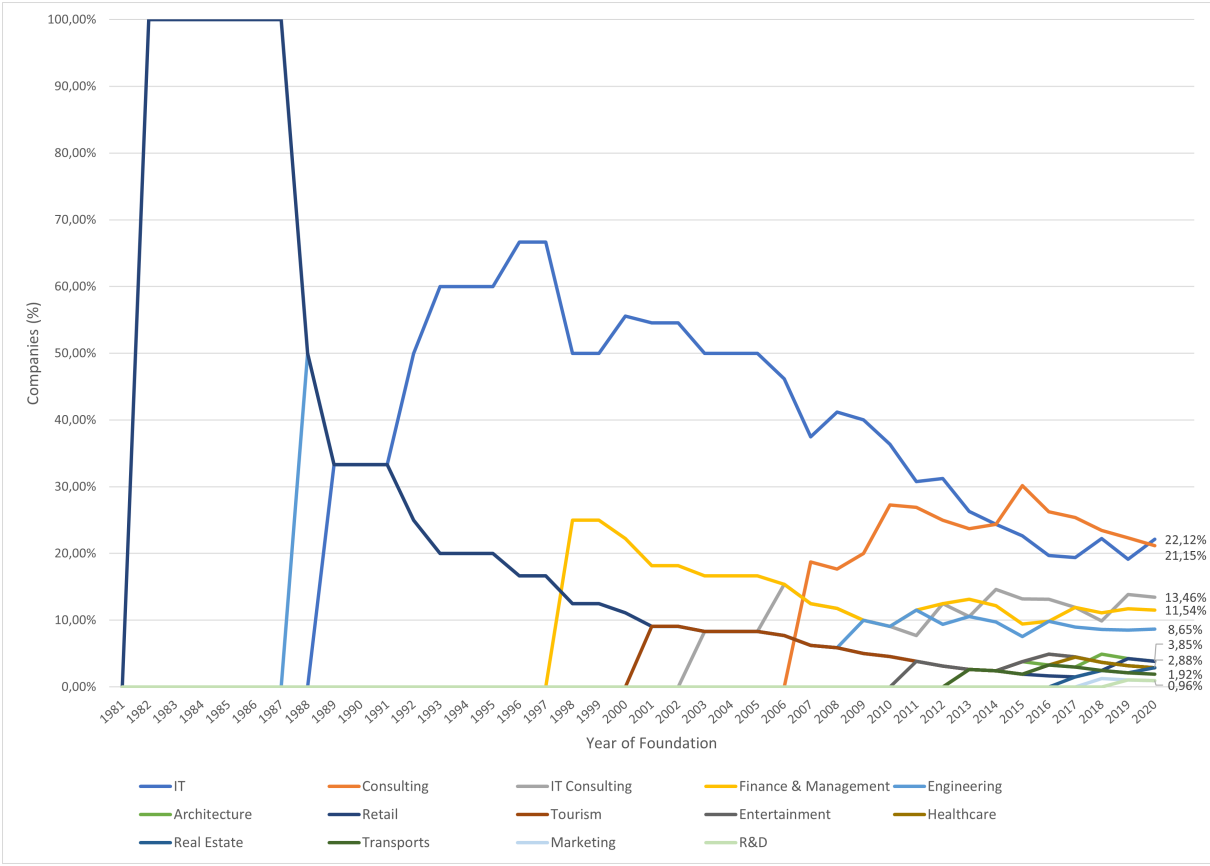


Figure B.2: Percentage of Main Activities through the years

