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What makes for survival? Key characteristics of Greek incubated early-stage startup(per)s during the Crisis: a multivariate and machine learning approach

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Abstract

This paper maps and analyses the total population of incubated startup(per)s in Athens, the main center of the startup ecosystem in Greece during 2010-2016- the worse years of the economic crisis. Its purpose is to uncover data for the key features of this enterprise group and the factors behind success as measured via survival. We use a descriptive statistics methodology for the total populations of 300 startups and in specific regarding the survival subcohort we applied a combination of a feature selection algorithm and tested a logistic regression modeling family.

The basic findings of the descriptive statistics analysis for the survival subcohort (in comparison to the total population of our data base) show that during the crisis years 2010-2016:

Regarding founder specific indicators, a larger share of founders were: More mature; male; more educated; had degrees in economics and business, science and theoretical studies; were holders of degrees related to the startup sector and had more experience abroad.

Regarding startup/firm specific indicators: The share of Athens was lower and the share of the UK and the USA was higher. The share of Construction-Engineering and Transportation was higher. The share of srvices was lower. Notably, high tech goods and processes were higher and B2C transaction type was lower. The share of startups with customers abroad was higher and the share of startups with family members was roughly the same.

In our logistic regression model using MRMR algorithm, from the five most important input variables, the following had a positive impact for a startup's survival, i.e. a) providing services to both Customers and Businesses, b) having achieved customers abroad, c) having founding members that digressed from original studies and d) applying high-tech processes internally. Also, there was one variable

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identified affecting negatively survival, i.e the variance in Educational Level amongst founding members.

Keywords: demography, entrepreneurship, startuppers, early stage initiatives, socio-economic indicators, drivers of success/survival, incubators,Economic Crisis, Athens, descriptive statistics, machine learning,

JEL Classification: Y10, M13, L26, 052, 033, L29

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1. Introduction

In the years following the outbreak of the economic Crisis in Greece in 2009, a new outward looking and innovative enterprise enclave emerged: that of startups. Intrigued by the birth of this ecosystem and its development, in 2016, we started collecting material on a 'big' unknown: the ecosystem of incubated startups and with the financial assistance of two AUEB funded programs we have now constructed a unique dataset that specifically contains data for a total of sixteen key socio-economic indicators, for a total of 547 early stage startuppers and their 300 initiatives[4] hosted in the thirteen incubators and organizations assisting startup(per)s in Athens throughout the crucial years of 2010-2016--a period during which the Economic Crisis was deepening. In our analysis of this data set we use a descriptive statistics methodology in combination with a feature selection algorithm and the testing of a Logistic Regression modeling family. (See Section 4.1. below). At this point we note that this working paper is a revision of Besis and Pepelasis (2020). The basic differences of this working paper with the previous one are that the data base is larger and that instead of univariate analysis we apply multivariate analysis using a feature selection algorithm MRMR with the Logistic Regression model family.

Our work fills an important gap in the literature. Our substantial data base and variety of socioeconomic indicators examined, in addition to our analysis of the sub-group of survival, together with our combined qualitative and quantitative methodology allow for an in-depth analysis of the early-stage startup ecosystem, our purpose being to understand its drivers.

This study is indeed timely: The 2019 STARTUP HEATMAP EUROPE shows that in spite of an improving economic climate, around forty percent of startuppers eventually leave the country in order to evolve entrepreneurially and this share is substantially higher than what is the case in other countries of Southern Europe. We hope to contribute towards informing the debate on policy actions necessary for a reversal of the brain drain and the further dissemination of an innovative extrovert business ecosystem which is recognized by all today as a sine qua non for a sustainable and tenable path of economic development for Greece.

[4] In this paper we use the terms initiative, startup, firm interchangeably.

We have organized our paper as follows: Section 2 reviews the international and Greek literature. Section 3 briefly presents the incubators/hosts that appear in our study. Sources, data base construction and methodology are discussed in Section 4. In Section 5, on the methodological basis of descriptive statistics we analyse the data for the sixteen selected socio-economic indicators for the total population of startuppers-startups. In Section 6 using the same methodology we analyze the data for the survival sub-cohort- i.e. those initiatives/startups that were alive in 2020 and compare the latter to the findings for the total data set. In Section 7 we analyse in more depth the survival subcohort by applying a combination of a feature selection algorithm and Logistic Regression modeling family. Section 8 is the epilogue of the paper. In Appendix 1, we make a comparison of Greek Studies on the Startup Ecosystem, while in Appendix 2, we provide a Summary Table of Key Socio-economic Indicators of the total sample and in Appendix 3 we compare Startups Survival Results with two additional modeling families.

2. Literature Review

2.1. International Literature

A multidimensional international literature is relevant to the understanding of the phenomenon of startuppers and startups. As mentioned above our data base exclusively consists of a special category of startuppers that of incubees. Although the study of incubators is outside our direct interest in this study, it is worth making a brief reference part of the relevant international literature. For example, the functions of incubators as organizations and how they impacted startups has attracted the attention of the international literature (indicatively see: Mian (1996); Albort-Morant and Ribeiro-Soriano (2016).

As for early stage startuppers and their initiatives, this is a well-researched topic in the rich and disparate international literature. For the organization of our data base and the selection of indicators we have selectively consulted this as well as the literature on Greece (see below).

There are plenty studies linking entrepreneurship/and or startups to economic growth as for example, Tortella & Quiroga (eds) (2013) and Cassis & Pepelasis Minoglou (2006). Some studies in particular have focused on what drives success/ survival: Astebro & Bernhardt (2003) examines the relation between the survival of new small

businesses and bank loans. They have collected a sample of small businesses launched in 1987 in the United States and investigate their survival in 1991. They have found that there is a negative correlation between having a bank loan and business survival, but a positive correlation between having a non-bank loan and survival. Nicolò and Nania (2017) explore Italian firms that were established from 2009 to 2011 and they found that companies with strong capitalization have high survival rates at a five-year period. Cefis and Marsili (2003) use a non-parametric approach to estimate the probability of survival of firms in Netherlands. They suggest that innovation affects positively the firms' survival and young firms are most exposed to the risk of exit. However, in the long term, they benefit most of innovation to survive in the market. Finally, Cook et al. (2012) examine the survival patterns of new firms for the period 2009-2011 and their findings revealed "the odds of a firm surviving from year one to year two appear to be no better than the odds of them surviving from inception to year one".

From the perpective linking in specific internationalization with survival, Coeurderoy et al. (2012) construct a dataset for young firms in UK and Germany and investigate the determinants of internationalization and firm survival. Their findings indicate that young firms are more likely to survive when they pursue an internationalization strategy based on resource consolidation. Cavusgil & Knight (2015) analyze the "born global" phenomenon of early stage companies and its importance. This study links the rise of "born globals" to the contemporary global business environment. It also underlines that technological development may be a catalyst for further enhancement in the internalization process of young firms. Startup survival has also been studied recently from one more perspective: that of funding (Keogh and Johnson, 2021).

In sum, as the international startup ecosystem already has a 'long history' the literature is rich and multidimensional as data are available for various factes of startups.

2.2.Literature on Greece

Turning to the existing literature on the new local startup ecosystem in Greece, it is divided in two interrelated strands. The first strand focuses on incubators and technology parks as organizations and the second strand examines startuppers and/or their initiatives. This strand is only indirectly linked to our topic, the following academic research has been undertaken: Bakouros, Mardas & Varsakelis, (2002) and

Sofouli and Vonortas (2007) provide a history of the genesis and development of science & technology parks and business incubators prior to the Crisis. Another study, that of Ratinho and Mitsopoulos (2021), examines emerging incubators in Greece during the Crisis and their models of support.

Regarding the second strand it focuses on startups. Apart from articles in the local and international press (See references to some of these in Pepelasis and Protogerou, 2018), research has been conducted by a variety of organizations. Notably, the annual Global Entrepreneurship Monitor (GEM) surveys on Greece conducted by the Foundation of Economic and Industrial Research provide demographic data on early stage entrepreneurs, qualitative data on their initiatives and the national entrepreneurial environment. The seed stage fund MARATHON VC (www. Marathon.vc) has referred to investments in Greek Startups for the period of 2010-2016, (Gasteratos, 2017) some characteristics of founders (2018) (education level, age, work experience, previous role) and the investments and exits of successful Greek startups (Gasteratos, 2019). Enterprise Greece (2019), the official agency of the Greek State to promote investment in Greece, has written on the startup ecosystem by providing data about the most funded Greek Startups and Exits, as well as the importance of the new available funding tools that use Equifund (Public-Private Partnership created through European and national funds) to help the Greek Startups grow. In addition, the technology hub Found.ation and the European digital innovation and entrepreneurial education organization EIT Digital (2019) examined the characteristics of pre-seed and seed stage Greek startups (those startups that either maintain the headquarters in Greece or one of its founder is a Greek citizen) while also providing a general view on the incubation ecosystem of startups. Furthermore, the well-known consulting firm BCG (Athens Office) published a paper (2018) examining the obstacles to boost local entrepreneurship. The most detailed up-to-date (2021) all inclusive study of the start up ecosystem is that of diaNEOSis (2022).

As for academic research it has focused on other issues, not strictly or exclusively connected to startups such as for example the rise of creative industries (Protogerou *et al*., 2015) and the new entrepreneurship model (Pepelasis and Protogerou, 2018). There is an obvious gap in the academic literature in studying exclusively the startup ecosystem during the Crisis years. However, we should note the following studies which are of some interest: An unpublished empirical survey at the Laboratory of

Industrial and Energy Economics at NTUA (Lambropoulos, 2015) charts in a power point the features of 77 startups from 2010 to 2015 based on a questionnaire sent to the founders with purpose to analyze the characteristics of startups and incubators and to propose actions to improve the services of the existing incubators. In addition, there are also four articles that focus on startups for the pre-Crisis period: The structured survey article of Kanellos (2013) that has examined knowledge based entrepreneurship in high technology young firms between 2000 and 2010; Vlachos (2016) which examines the determinants of self-employment/creating start-ups from an occupational choice point of view, means entering into self-employment for 2001-2008 analyzed on the basis of a logit model; and lastly, the article of Vliamos & Tzeremes, (2011) that examines through nonparametric techniques, the factors influencing the entrepreneurial process, entrepreneurial characteristics and motives in new business formation in central Greece (the region of Thessaly) on the basis of 164 questionnaires for the pre-crisis period. Vlachopoulou, Ziakis and Petridis examined some of the characteristics of Greek Startups, their success factors and their interaction with the startup ecosystem in Greece. We have constructed a detailed table (see Appendix 1) in which all the studies (apart from our own in the past to which we refer at other points in this paper) that concerned Greek Startups are presented in terms of their database, time period covered, basic questions and overlapping points with our work.

Finally, indirectly connected to the theme of startups is the study of Apergis and Fafaliou (2014) who collected data from 1,500 students from 2005 to 2010 in order to examine the factors that influence Greek University students to shift into establishing a new business venture.

In a nutshell, there is an interesting and diverse international literature on entrepreneurship and startups, but for the case of Greece there are important gaps in knowledge on the subject. We aim to fill part of this gap with our analysis as noted in the introduction.

3. Athenian Incubators and organizations assisting startuppers

As we exclusively examine incubated startuppers/initiatives it is important that we provide some background information on this form of organization. The incubator ecosystem that has emerged in Greece during the crisis was preceded by failed

attempts of the state from the 1990s onwards to support startups and knowledge based business through the creation of science and technology parks (Sofouli and Vonortas 2007 and Bakouros, Mardas, & Varsakelis, 2002).

During the period under review the Athenian business incubation ecosystem consisted of a total of thirteen incubators and organizations assisting startuppers. There was diversity among them in terms of their, institutional setting/embeddedness and their primary emphasis. The thirteen selected incubators and organizations for our sample satisfied the following three criteria: they were all situated in Athens, not sector based and were exclusively focused on early stage startups.

A brief description of each of these thirteen incubators follows on the basis of information drawn from their websites. They were all established between 2010 and 2016 and we list them in alphabetical order.

- Acein (est. 2014) is based at AUEB the largest Greek business school and a major strategic goal is the transfer of technology from academia to business.
- Aephoria.net (2013) is a business education and networking program for start-ups that enables them to create innovative economic models with a positive impact on the environment and society.
- The Athens Startup Business Incubator (TH.E.A.) (2014) is one of the initiatives of the Athens Chamber of Commerce and Industry to support entrepreneurship,
- EGG (est.2013) is the incubator of Eurobank (one of the four largest bank in Greece) that also acts as an accelerator that provides equity funding to startups.
- Ekinisi Lab (est. 2014) is the incubator of the Hellenic Federation of Enterprises and it differs from the other incubators in that it has a presence not only in Athens but also in two other prominent port cities: Heraklion in Crete and Volos in Thessaly.
- ID-GC (2013) is a non-profit/non-governmental organisation that was founded to promote entrepreneurship in Greece, South East Europe and East Med regions.
- Innovathens (2014) is a modern, open space for fostering new entrepreneurship and developing digital skills.

- Invent ICT (2016) is an initiative of the Innovation and Entrepreneurship Unit of NTUA, which focuses on technological startups.
- Iqbility (est. 2013) belongs to the IT based business group Quest Holdings and it provides pre seed financing via equity funding.
- Microsoft Innovation Center (2009) is a non-for profit civil-law company established by Microsoft Hellas and the New Economy Development Fund (TANEO.gr).
- MIT Enterprise Forum Greece (est. 2013), is a chapter of the global MIT Enterprise Forum founded "by a group of entrepreneurs and business professionals with strong engineering backgrounds. It focuses on rapidly transforming ideas of the local scientific/engineering community into world-changing companies".
- NBG Business Seeds (est.2010) is based at the National Bank of Greece, (the country's oldest and largest bank) and it fosters new business initiatives that are "innovative and export-oriented" while also providing financial support.
- Orange Grove (est.2013) is an initiative of the Embassy of the Kingdom of the Netherlands in Athens and it describes itself as "an international incubator offering support to innovative entrepreneurs around Greece".

All of them have made significant impact on the startup ecosystem and still exist in 2023.

4. Sources, Data base Construction and Methodology

4.1.Sources

It is not possible to gauge through national statistics the demographics and key indicators of startuppers and their initial stage ventures. Thus, in order to construct our sample we resorted to the websites of the thirteen seminal at the time incubators situated in Athens that focused on providing services to early stage startuppers.

In addition, in order to enrich our information on incubees we also consulted the following sources: the web sites of start-ups; social media sites (LinkedIn, Facebook); and articles/interviews in the press on start-uppers and their enterprises. We also gathered some information from questionnaires sent to startuppers-'incubees'. One caveat is necessary here: The examination here of only early stage incubated

entrepreneurship entails a hidden bias in our results as those who seek out incubation are aspiring entrepreneurs who are perhaps best informed and educated.

4.2.Database Construction and Methodology

As already mentioned above, our ultimate purpose being to understand the main features and drivers of success of early-stage startup(er)s in the Greek incubation ecosystem during the Crisis years 2010-2016 we have constructed a unique data base.

There were certain difficulties regarding the construction of the sample. Notably, a feature of the incubated early-stage startup ecosystem is that often one initiative would receive incubation from more than one incubator (i.e. two or more rarely three incubators). For this reason, in such cases in order to avoid double counting we took into consideration only the first incubator 'visited' (This was around 20% of our sample of incubated enterprises).

Our data base consists of 547 individual entrepreneurs and their first stage 300 incubated young enterprises (nascent ventures) and we examine in total sixteen socio-economic indicators. These indicators are divided in two groups:

The first group consists of seven startupper/founder specific indicators:

1. Age
2. Gender
3. Level of education
4. Field(s) of education
5. Variety of skills: Whether the there was a diversity between the founders graduate and post graduate degrees
6. Whether the education of a founder is related to the firm/startup sector
7. Whether the founder has experience abroad. (By experience abroad we mean that the founder has worked abroad for at least one year).

The second group consists of nine startup/firm specific indicators:

1. Geographical Location
2. Business Sector
3. High Tech vs Low Tech in terms of sector (High Tech companies we measure those which are in the categories of software, hardware, robotics, Internet of Things (IoT), analytics, Augmented Reality, biotechnology, gamification, fintech and energy and as low tech: agriculture, agro food, architecture,

education, fashion, art, event services, music, culture, leisure travel and tourism, maritime, fishing, sports and HR)

4. High Tech vs Low Tech in terms of process of production (As high tech in terms of process we measure those companies which are either high tech or low tech but with an advanced production method)
5. Whether the good offered is a (Physical) Product or Service
6. Transaction Type of the goods offered
7. Whether the startup has customers abroad
8. Number of founders per startup
9. Whether among the founders of a startup there exist relatives. Founders who belong in this category have been detected either because this is obvious (as they have the same last name) or because although they have different last names, it has been stated so in interviews or articles.

For each of the aforementioned sixteen socioeconomic indicators we present the statistical findings for the period as a whole, 2010-2016.

In order to enrich our analysis, we also embrace the focus of the international literature on one key area: the drivers of business success. The conventional way of measuring business success is through a variety of metrics in economic performance: sales/turnover, total assets, number of employees etc. But, because we examine first stage startups such a procedure is not possible and so we use startup survival as a proxy for success. This allows for a 'first understanding' of the drivers of business success in the early stage startup ecosystem during the Crisis given our data constraints. For this reason in Section 6 we construct a subcohort that consists of the population of startups that were alive in 2020. We then proceed to compare the findings for the sixteen socio-economic indicators in this survival subcohort with the findings for the total population of our sample.

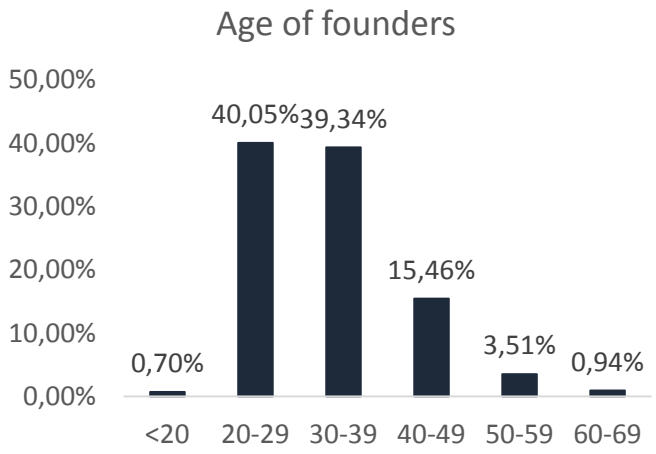
In order to acquire a more varied and deeper understanding of the drivers of survival in Section 7 specifically for the subcohort of survivors we apply a combination of the feature selection algorithm Maximum Relatedness Minimum Redundancy (Peng et al, 2005) and a Logistic Regression (Berkson, 1944). In Appendix 3 we have included a machine learning analysis of two more modeling families: Random Forests (Breiman, 2001) and Decision Trees (Breimman et al, 1984), both combined with the MRMR feature selection algorithm as well.

5.Data for key socio economic indicators of the total population of incubated startuppers and startups

5.1.founder specific indicators

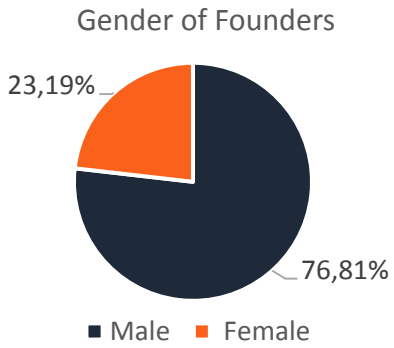
1) Age

The two largest age groups among startuppers are the 20 to 29 and 30-39 year olds. There is only a slight difference in size between these two groups.



2) Gender

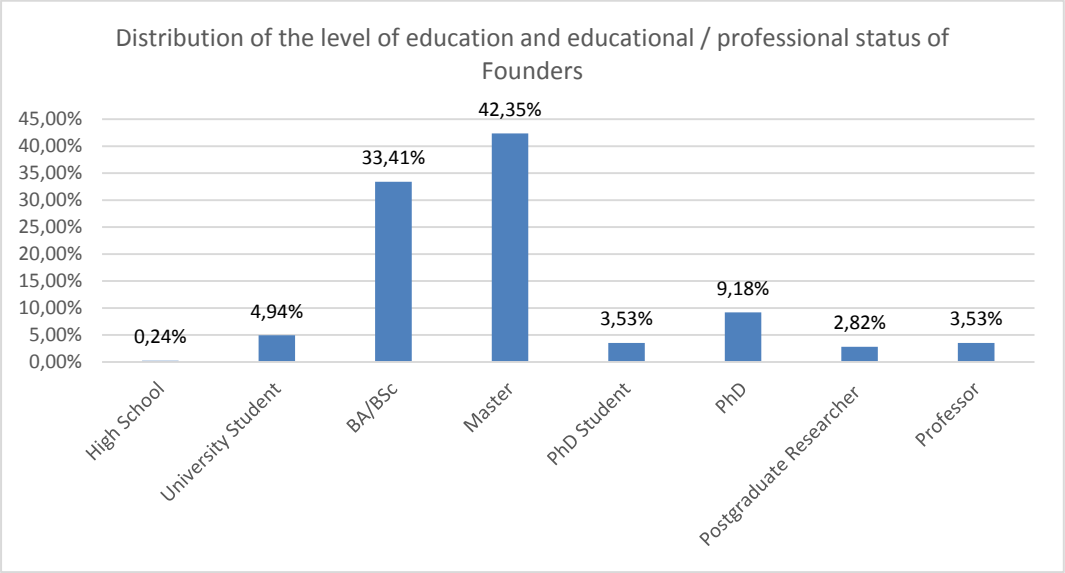
Startuppers are dominantly male as females accounted for under one fourth of the total during the years under review.



3) Level of education

A miniscule amount of startuppers hold only a secondary level/high school degree. The lion's share of founders are college graduates and M.Sc/Masters degree holders.

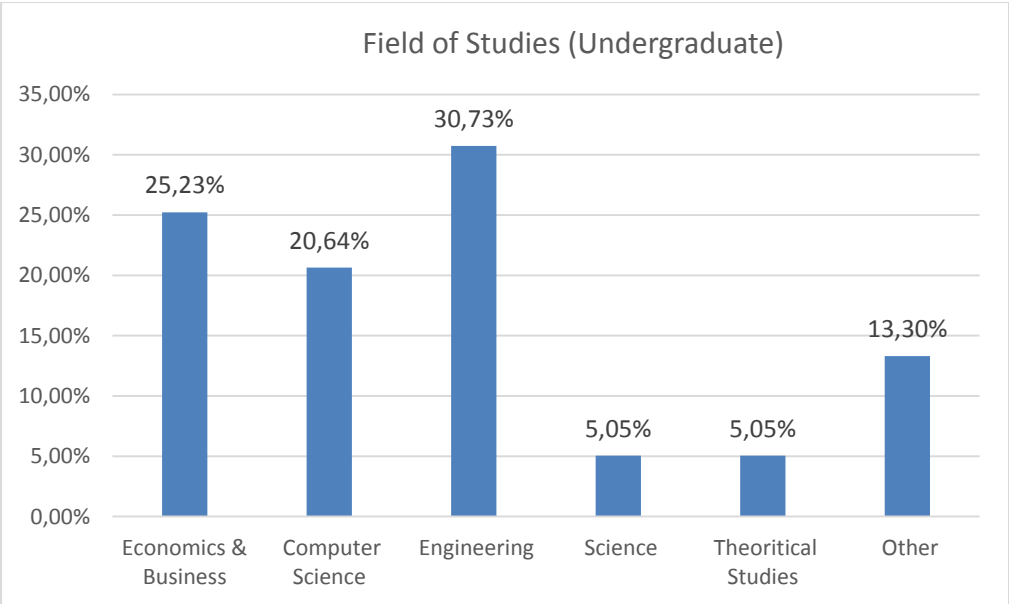
However, the fact that post-graduate researchers, Ph.D students, PhD holders and Professors accounted for almost 20% of the total shows that the links between startups and academia are not negligible.



4) Field(s) of education

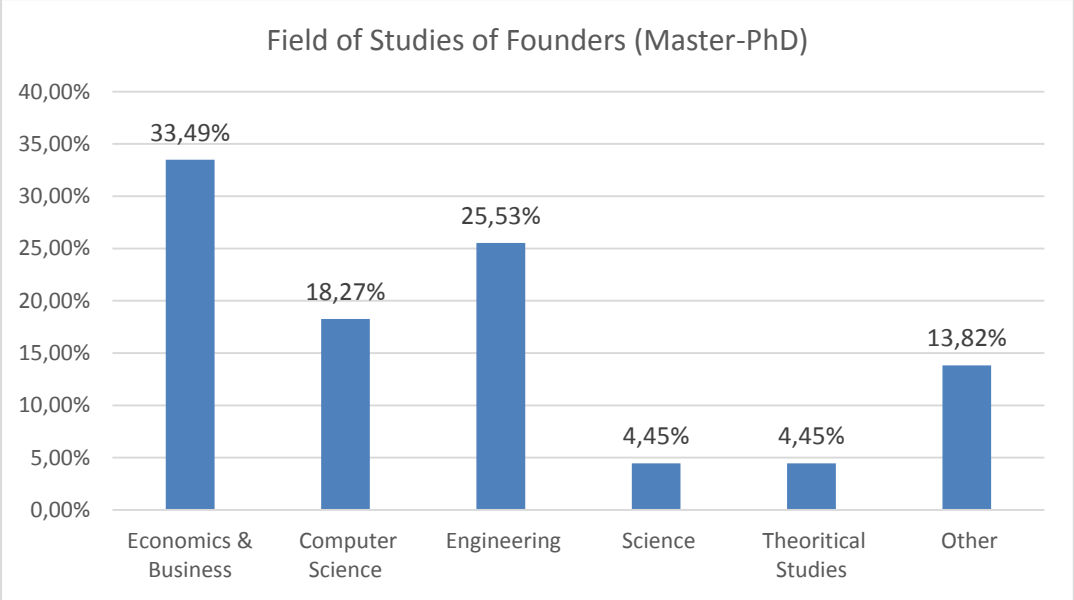
At the undergraduate level of studies, in declining order, the most important three fields are engineering, economics and business, and computer science. Together they account for roughly 77% of founders.

<u>BA/BSc</u>



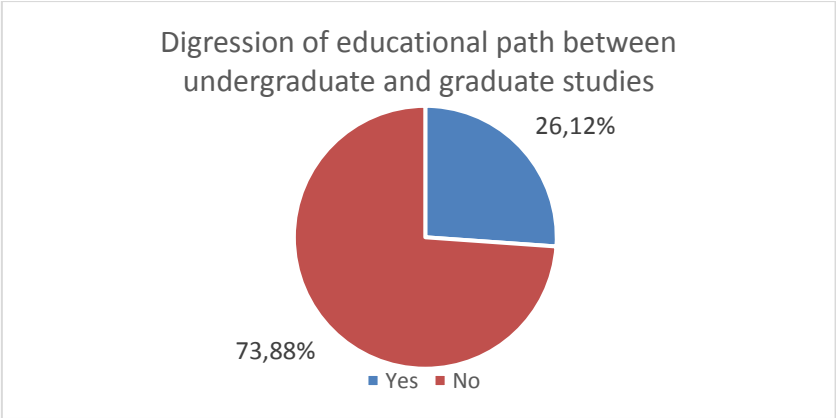
Masters – PhD

At the graduate level of studies (Msc and Ph.D) in declining order the the three most important fields are economics and business, engineering and computer sciences. In total these three filds accounted for nearly 78% of all founders.



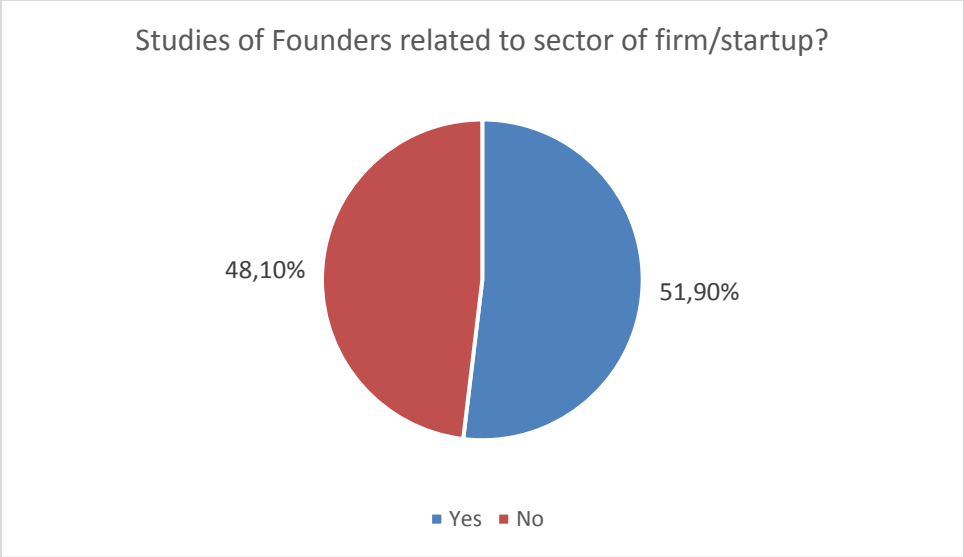
5) Variety of skills (whether there is digression between the undergraduate and graduate studies of founders)

Nearly 60% of the founding members hold a Master's Degree and above. A little over one fourth of this group pursued graduate studies in fields different from their undergraduate specializations. Within the new startup ecosystem this is 'modern' feature that hopefully might become stronger as today a variety of skills is considered a point of advantage in terms of mindset and secures higher rates of success in career and business according to the literature.



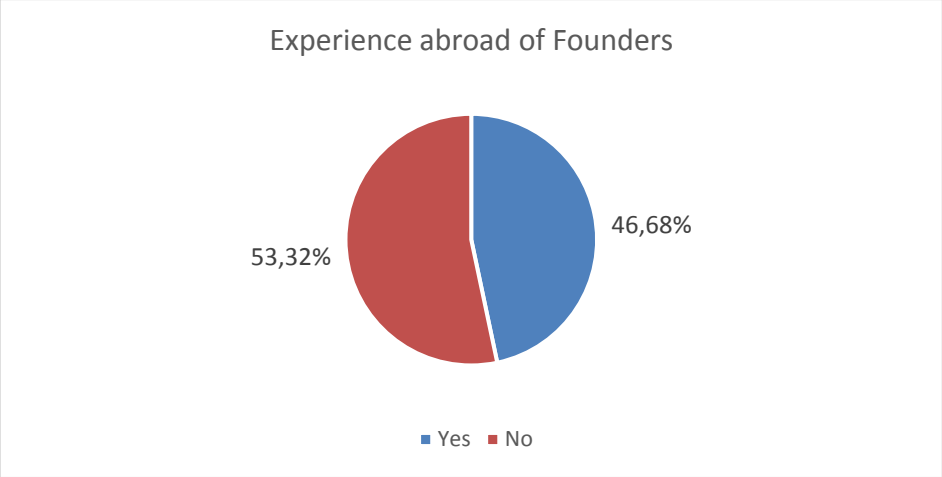
6) Whether education of founders is related to the startup sector.

This is not the case for slightly under half of the founders. Interestingly, there is a growing flexibility/open mindness or perhaps a growing absence of opportunities in their fields of specialization.



7) Whether the founder has Experience Abroad

About 47% of the founders have had working experience abroad for at least one year.

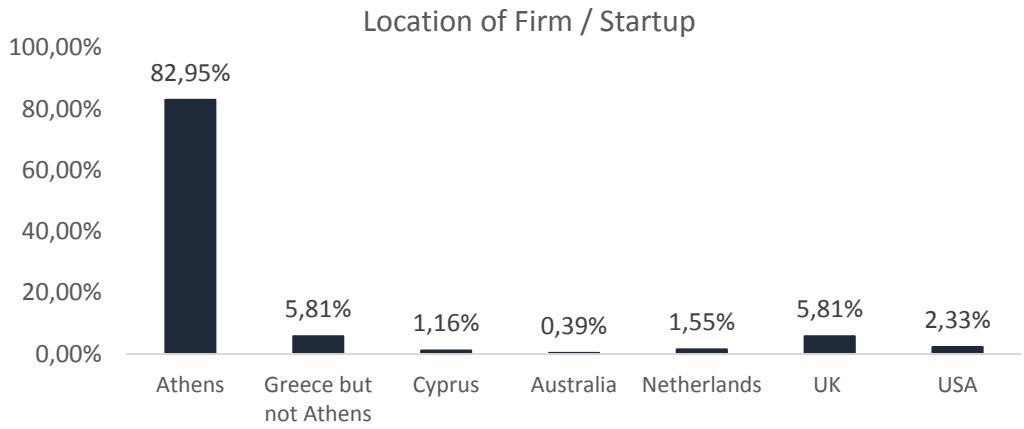


5.2. Data for startup specific indicators

1) Geographical location

Roughly 83% of the startups have their headquarters in Athens and a little under 7% are established in other areas of Greece: Heraklion and other places in Crete, Ioannina, Kalamata and other locations in Messinia, Mytilini, Thessaloniki, the perfectures of Kilkis, Serres and the city of Trikala.

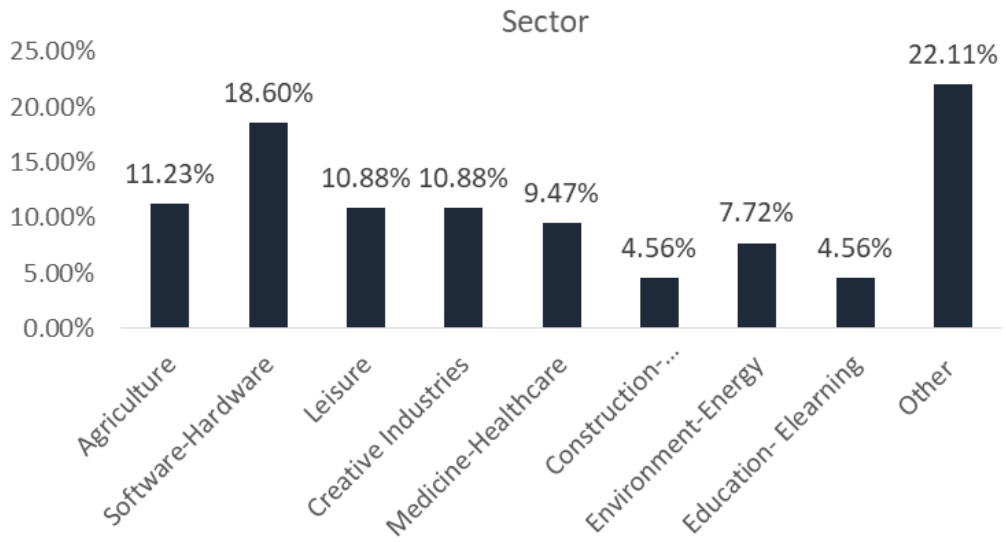
Interestingly, a little over 11% of the startups are established outside Greece. Especially following the imposition of capital controls some companies in order to be more flexible and for tax reasons established their headquarters abroad while simultaneously maintaining production in Athens. The UK holds the first position in this category and in order of importance the following countries followed: USA, Netherlands, Cyprus and Australia. Some of these choices are the outcome of strong ties with long standing Greek expatriate communities and some were related to the geographical dispersion of the brain drain. The choices of the UK and the USA are a product of both factors.



Interestingly nine startups based in Athens had branches abroad. Six have branches in UK, two in Sweden and South Africa and one has a branch in Brazil.

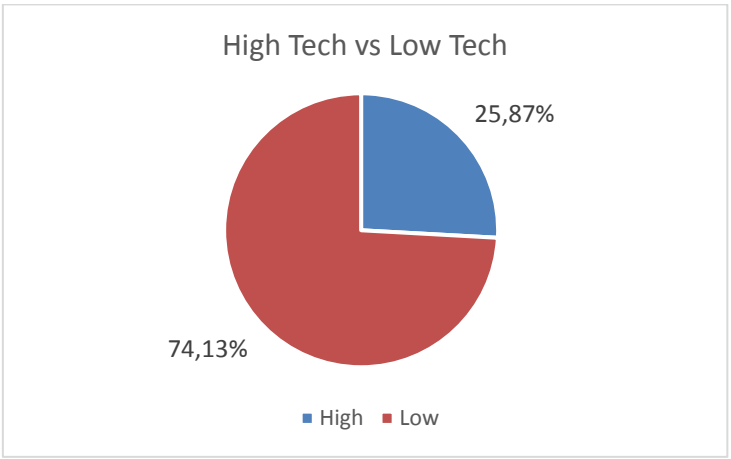
2) Business sector

The top sector of startups is by far that of 'other categories' (E-commerce, Digital Marketing, Consulting etc.), hardware-software came second and in the third category (with small differences among them) were: the creative industries, agriculture, leisure and medicine-healthcare. Interestingly, the share of all the above sectors in the GDP of Greece are far lower than their shares in the incubated startup ecosystem. It must also be noted that these sectors (with the exception of agriculture) are newcomers to the Greek business scene and one could argue off springs of the crisis years. The small share of construction can be partly explained by the fact that from being a major sector of the Greek economy before the Crisis, it received a severe blow post 2008.



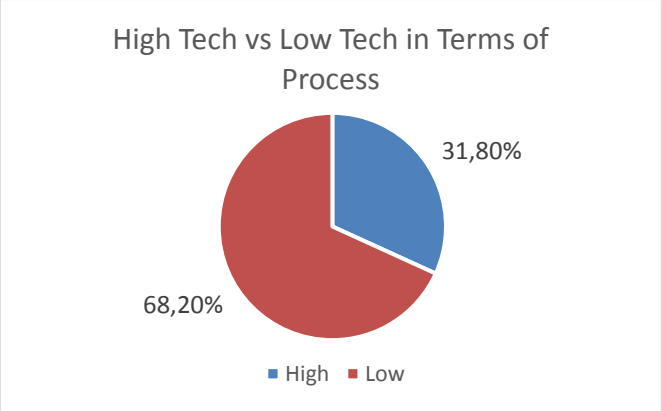
3) High Tech vs Low Tech in terms of sector

Sectors producing low tech goods are predominant and amount to nearly three quarters of the sectors of all startups.



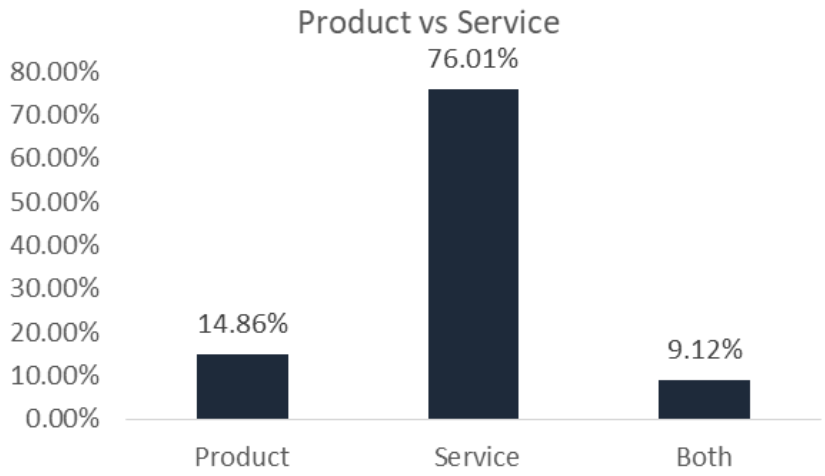
4) High Tech vs Low Tech in terms of process of production

Low tech processes predominates, but the share of high tech processes is larger than the share of high tech goods.



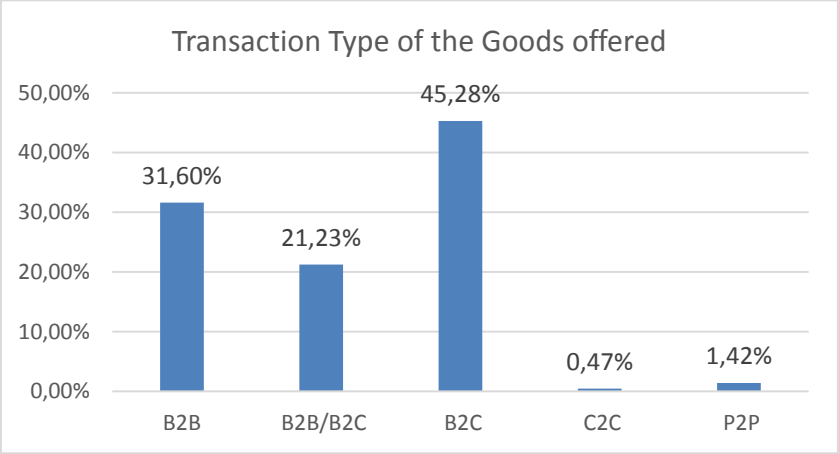
5) Whether the Good offered is a Physical Product or Service

The great majority (76 %) of startups offered services and a little over 9% offered both products and services. This is no surprise given two facts: Firstly, Greece has been deindustrializing since the late 1970s and is largely a services based economy. Secondly, that software applications, IT are important in services, shows that Greek founders -given their high knowledge capabilities discussed above in the previous section- are able to move forward in what is a capital hungry economy with a shrinking GDP.



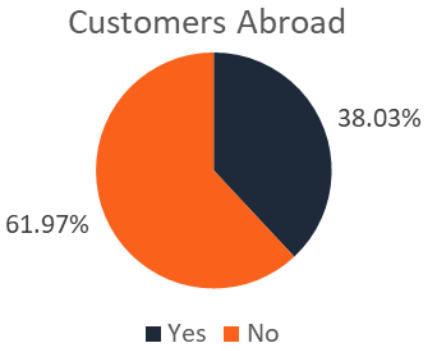
6) Transaction Type of the Goods offered

A little over 45 % of the startups provide goods through a transaction ype of B2C. The category of B2B at nearly 32% is however quite large also. The other two transaction types (C2C and P2P) are miniscule in size.



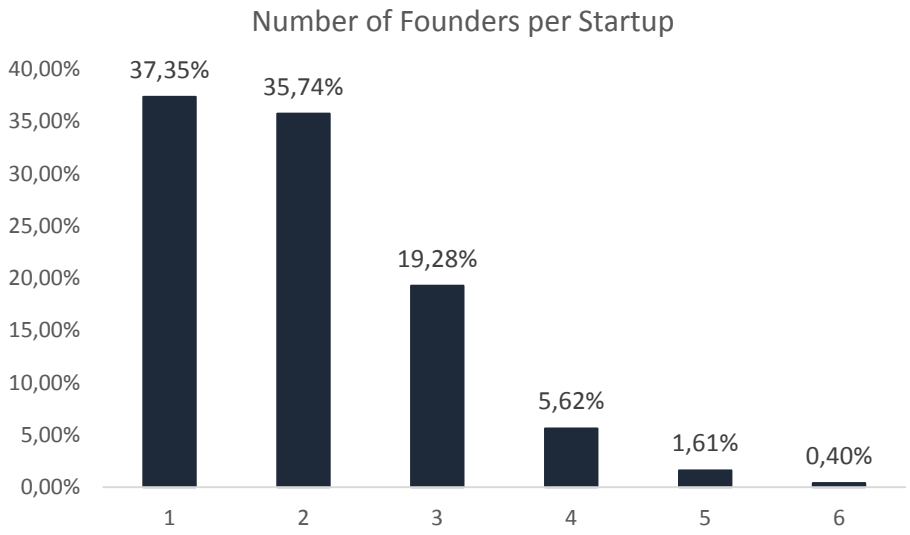
7) Whether the startup has customers abroad

Over one third of startups has customers abroad.



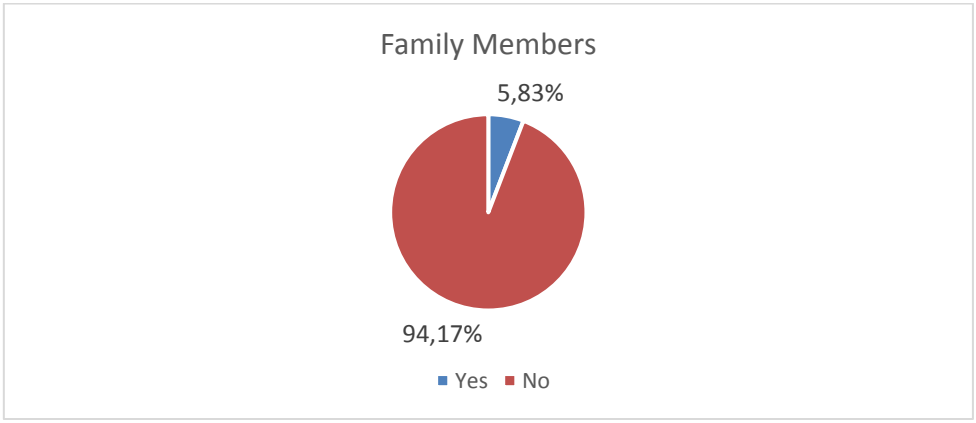
8) Number of founders per startup

A feature of the incubated startup ecosystem is that predominantly initiatives are set up by one or individual.



9) Whether among the founders of a startup there are relatives

Family members are found among founders in less than 6% of of startups, cooperating basically with friends and colleagues that share the samementality and attitude and business approach..



To conclude, on the basis of the statistical analysis of our data base the profiles of the incubated founder and startup during the Crisis years 2010-2016 were as follows:

Our data show that the startupper was an untypical specimen in terms of his/her characteristics and business modeling compared to the bulk of Greek entrepreneurs. He/she was predominantly between twenty and fourty, male; and with undergraduate studies (in order of importance) in the following fields:

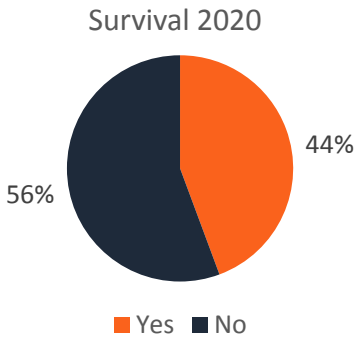
engineering; economics and business; and computer science. There was about a sixty per cent probability that he had completed graduate studies. At the level of graduate studies the first discipline in popularity was economics and business. To some extent there was versatility: Among those who had completed graduate studies for a little over one fourth there was a digression in the field of education between undergraduate and graduate studies. In addition, there wasalmost a fifty percent probability that a startupper had educational expertise unrelated to his business sector (i.e. adaptability). Finally, there was a significant degree of cosmopolitanism/openness as a little under one in two startuppers had experience abroad.

In addition our data show that founder startuppers diverged in their business strategy from typical businesses in Greece. Notably, it was the case that a little over one in ten startups was based abroad. The top sectors of startups in order of importance were: 'other categories', hardware-software, and the creative industries, the creative industries; agriculture and leisure.One in five startups was high tech in terms of products and a little over 30 % was high tech in terms of process of production. The great majority of startups offered services and nearly 40% had customers abroad. The largest category of customer type was B2C but B2B was quite large also. Most startups had one to three founders and few startups had family members among their founders. (For a summary table of findings for all sixteen socio-economic indicators of the total sample see Appendix 2).

6. Key Socio economic indicators of the survival sub-cohort and comparisons with the total sample

In this Section we we present via descriptive statistics the basic demographics of the survivor subcohort and examine if and how the distribution of the socio-economic characteristics of this cohort for the period as a whole differed substantially from that for the total population of startups in our data base. The survivor sub-cohort consists of those startups which in 2020 were: 1) active (106 in number), 2) had changed ownership (7 in number) and 3) were frozen but for which we observed signals of potential survival (11 in number).

Thus, in total the survivor cohort is comprised of 124startups, namely 44 % of the total sample of startups.



Founder specific socio economic indicators for the survival sub-cohort and comparisons with the total sample.

The data for each socio-economc indicator is presented in the Table below. In the text that now follows for each indicator we compare the data in the sub-cohort with the total sample.

Age distribution: in the survival sub-cohort the share of 20-29 year old founders is lower and that of 30-39 year old founders is higher compared to the findings for the total population of founders. This finding is not surprising as it has been noted in the literature that the average age of founders is 45 in the USA and that up to the age of 60 the probability of success increases with age (Mehta, 2022).

Gender distribution: The share of women is lower in the survival sub-cohort group.

Level of education: In the survival sub-cohort there is a higher presence of holders of Masters and Ph,D degrees. There is also slight larger share of Ph.D students.

Fields of education: In both undergraduate and graduate studies (degrees) there is a significantly higher presence of economics and business, science and a lower presence of computer science and engineering in the survival cohort.

Degree of digression in skills between undergraduate and graduate studies: It is higher in the sub-cohort group compared to the total population of founders. This suggests that within the new startup ecosystem this is a 'modern' feature that hopefully might become stronger as today a variety of skills is considered a point of advantage in terms of mindset and secures higher rates of success in career and business according to the literature.

Founders' education related to the startup sector: It is noticeably higher in the survival sub-cohort. This suggests that founders with a more focused mindset were probably more successful.

Experience abroad: It is somewhat higher in the survival sub-cohort. It seems more logical that companies that have survived have founders with experience abroad, since they may be more familiar with trends as well as business models of companies in different country (ies).

Startup/firm specific socio economic indicators

Location: The share of Athenian based startups based in the survival sub-cohort group is slightly lower compared to the total population of incubated startups. The shares of the UK and especially the USA based startups are significantly higher.

Sector: The share of startups is significantly higher in the survivor sub-cohort for: Construction-Engineering and Transportation. All other sectors are also somewhat higher with the exception of the creative industries, and environment-energy which are lower compared to the total sample.

High Tech-Low Tech (in terms of good) and High Tech-Low Tech (in terms of process): The shares of startups in high tech in goods and (especially) in high tech processes is significantly higher in the sub-cohort group.

Product or Service: The share of pure/only service based startups is significantly lower in the sub-cohort group, but the share of startups with both product and services is significantly higher compared to the total sample.

Transaction type: The shares of B2B/B2C and less significantly so B2B are higher in the sub-cohort group. In contrast, B2C is significantly lower.

Customers abroad: The share of customers abroad is higher in the sub-cohort group.

Number of founding members per startup: The number of founding members per startup is higher in the sub-cohort group.

Number of family members: The share of startups which have family members is slightly lower in the sub-cohort group.

To conclude, the basic findings of the descriptive statistics analysis for the survival subcohort (in comparison to the total population of our data base) show that during the crisis years 2010-2016:

Regarding founder specific indicators they are as follows: a larger share of founders were: more mature; male; more educated; had degrees in economics and business, science and theoretical studies; were holders of degrees related to the startup sector and had more experience abroad.

Regarding startup/firm specific indicators they situation: The share of Athens was lower and the share of the UK and the USA was higher. The share of Construction-Engineering and Transportation was higher. The share of srvices was lower. Notably, high tech goods and processes were higher and B2C transaction type was lower. The share of startups with customers abroad was higher and the share of startups with family members was roughly the same.

Finally, the reasons for (and significance of) the divergence of some indicators between the survivor sub-cohort and the total sample are not so obvious. For example, the lower share of female founders, the lower share of pure services, and the differences in the shares of diverse sectors need to be further researched.

To close this section: survival was not a matter of chance, it was a matter of deliberate choice, being flexible and the differing weights of founder and firm specific socio-economic indicators made a difference. This finding has implications for policy making.

Socio Economic Indicators per Founder		
	General (300)	**Survival (300)**
Age	<20: 0,70% 20-29: 40,05% 30-39: 39,34% 40-49: 15,46% 50-59: 3,51% 60-69: 0,94%	<20: 1,32% 20-29: 35,68% 30-39: 40,53% 40-49: 17,18% 50-59: 4,41% 60-69: 0,88%
Gender	Male: 76,81% Female: 23,19%	Male: 79,01% Female: 20,99%
Level of Education	High School: 0,24% BA/BSc: 4,94% Graduate: 33,41% Master: 42,35% PhD Student: 3,53% PhD: 9,18% Postgraduate Researcher: 2,82% Professor: 3,53%	High School: 0% BA/BSc: 3,51% Graduate: 32,02% Master: 43,86% PhD Student: 4,39% PhD: 10,53% Postgraduate Researcher: 2,19% Professor: 3,51%
Fields of Education (BA/BSc)	Economics & Business: 25,23% Computer Science: 20,64% Engineering: 30,73% Science: 5,05% Theoritical Studies: 5,05% Other: 13,30%	Economics & Business: 39,13% Computer Science: 16,52% Engineering: 24,78% Science: 4,78% Theoritical Studies: 3,04% Other: 11,74%
Fields of Education (Master-PhD)	Economics & Business: 33,49% Computer Science: 18,27% Engineering: 25,53% Science: 4,45% Theoritical Studies: 4,45% Other: 13,82%	Economics & Business: 38,46% Computer Science: 16,24% Engineering: 24,36% Science: 4,7% Theoritical Studies: 3,84% Other: 12,39%
Variety in skills	Yes: 26,12% No: 73,88%	Yes: 29,18% No: 70,82%
Company Sector related to founder's education	Yes: 51,90% No: 48,10%	Yes: 56,41% No: 43,59%
Experience abroad	Yes: 46,68% No: 53,32%	Yes: 48,46% No: 51,54%

Socio Economic Indicators per Startup		
	General (300)	**Survival (300)**
Location	Athens: 82,95% Greece but not Athens: 5,81% Cyprus: 1,16% Australia: 0,39% Netherlands: 1,55% UK: 5,81% USA: 2,33%	Athens: 80,47% Greece but not Athens: 5,47% Cyprus: 0,78% Australia: 0% Netherlands: 0,78% UK: 7,81% USA: 4,69%
Sector	Agriculture: 11,23% Software-Hardware: 18,60% Leisure: 10,88% Creative Industries: 10,88% Medicine-Healthcare: 9,47% Construction-Engineering-Transportation: 4,56% Environment-Energy: 7,72% Education-Elearning: 4,56% Other: 22,11%	Agriculture: 11,63% Software-Hardware: 20,93% Leisure: 13,18% Creative Industries: 6,98% Medicine-Healthcare: 10,08% Construction-Engineering-Transportation: 7,75% Environment-Energy: 3,88% Education-Elearning: 5,43% Other: 20,16%
High Tech-Low Tech	High Tech: 25,87% Low Tech: 74,13%	High Tech: 30,71% Low Tech: 69,29%
High Tech-Low Tech (in terms of process)	High Tech: 31,80% Low Tech: 68,20%	High Tech: 40,16% Low Tech: 59,84%
Product or Service	Product: 14,86% Service: 76,01% Both: 9,12%	Product: 15,27% Service: 71,76% Both: 12,98%
Customer Type	B2B: 31,60% B2B/B2C: 21,23% B2C: 45,28% C2C: 0,47% P2P: 1,42%	B2B: 34,95% B2B/B2C: 28,16% B2C: 34,95% C2C: 0,97% P2P: 0,97%
Customers Abroad	Yes: 38,03% No: 61,97%	Yes: 42,11% No: 57,89%
Number of Founding Members	1 member: 37,35% 2 members: 35,74% 3 members: 19,28% 4 members: 5,62% 5 members: 1,61% 6 members: 0,40%	1 member: 30,25% 2 members: 36,13% 3 members: 24,37% 4 members: 8,40% 5 members: 0,84% 6 members: 0%
Family Members	Yes: 5,83% No: 94,17%	Yes: 5,35% No: 94,65%

7. Modelling the survival sub-cohort: Through/by/with a feature selection algorithm MRMR and a model family logistic regression

In order to give more depth to our analysis regarding survival we now turn to a modeling approach which we apply specifically to the survival cohort of startups. We use a combination of the feature selection algorithm Maximum Relatedness Minimum Redundancy [Peng et al, 2005] with the testing of Logistic Regression Model.

While both MRMR and econometrics can be used for feature selection, in this paper we chose MRMR, because it is more effective in dealing with high-dimensional data sets, as it considers both the relationship between each feature and the target variable and the relationship between each pair of features. Also, it helps to select a subset of features that are highly correlated with the target variable and are not highly correlated with each other.

As noted above we combine MRMR analysis with a testing of GLM model family [Berkson, 1944]. In Appendix 3, the same feature selection algorithm MRMR is combined with two additional modeling families a) Classification Trees [Breimman et al, 1984] and b) Random Forests [Breiman, 2001] based on classification trees as base learner.

7.1.Minimum Redundancy Maximum Relevance Feature Selection Algorithm

Minimum Redundancy Maximum Relevance (mRMR) [Peng et al, 2005] is a feature selection mechanism that identifies optimal subsets of available data with respect to a regression or a classification task. These subsets often contain variables which are relevant to the outcome but redundant to each other and mRMR addresses this issue by retaining non redundant subsets. MRMR selects those features that are simultaneously highly related to the outcome however as less redundant as possible. MRMR treats correlation not in typical statistical approaches (more suitable in covering linear relationships), but quantifying dependency employing mutual information [Gray 2011]. Therefore, it can be seen as an attempt to maximise the dependency amongst the selected independent variables multi distribution towards the dependent variable.

MRMR in the present paper is used as an external feature selection method accompanying the modeling procedure applied through different classifiers. Selection

of input features is implemented using a carefully selected resampling scheme respecting considerations detailed in [Hastie et al, 2009].

The efficacy of MRMR inclusion in the employed models was proven due to the fact that in all cases the best performing scheme was one with fewer than all the initially engineered independent variables. Therefore, and regardless of the inherent feature selection mechanisms that the employed classifiers models applied, MRMR aided predictive performance and therefore it can be claimed that for example logistic regression aided by MRMR is a different modeling mechanism than a logistic regression, in a respective fashion as LASSO logistic regression [Tibshirani, 1996] differentiates the original linear approach.

7.2 Logistic Regression

By **logistic regression** [Berkson, 1944] in statistics, we refer to the logistic model (aka logit model) that is employed to model the probability of a particular event coming to fruition or not, i.e. pass/fail, survive/not-survive, alive/deceased, ham/spam, legit/fraud. This can be extended to model several classes of events such as determining whether an image contains a cat, dog, lion, etc. Each object being detected in the image would be assigned a probability between 0 and 1, with a sum of one.

LR is a standard statistical model, in widespread use for over 70 years, that manages to identify (if any) a relationship between numerical/categorical input feature space and a binary output, by estimating the parameters (weights) of the input features that optimally estimate the output. Mathematically, a binary logistic model has a dependent variable undertaking as values 0 or 1. In this model the fraction of the probability of event 1 divided by the probability of the event 0 (odds ratio) and in particular the logarithm of this fraction (log-odds) is expressed as a linear combination of one or more independent variables (binary or continuous). The probabilities of both the 0 and 1 classes can vary between 0 and 1. The mathematical expression computing log odds to probability values is called the logistic function, and is responsible for the model's name. There exist other models with different activation functions however are considered out of the scope of the present paper. Also there exist cases where the output has more than two levels, in which case the

logistic regression is referred to as multinomial logistic regression again out of the scope herein.

The logistic regression function outputs a probability for a binary class membership, however can be seen as a classifier in the case the user applies a threshold on the referenced output. Usually, the input variables parameters are not computed using closed form solutions (as is the case in the typical linear regression problems), while instead the method of maximum likelihood is employed.

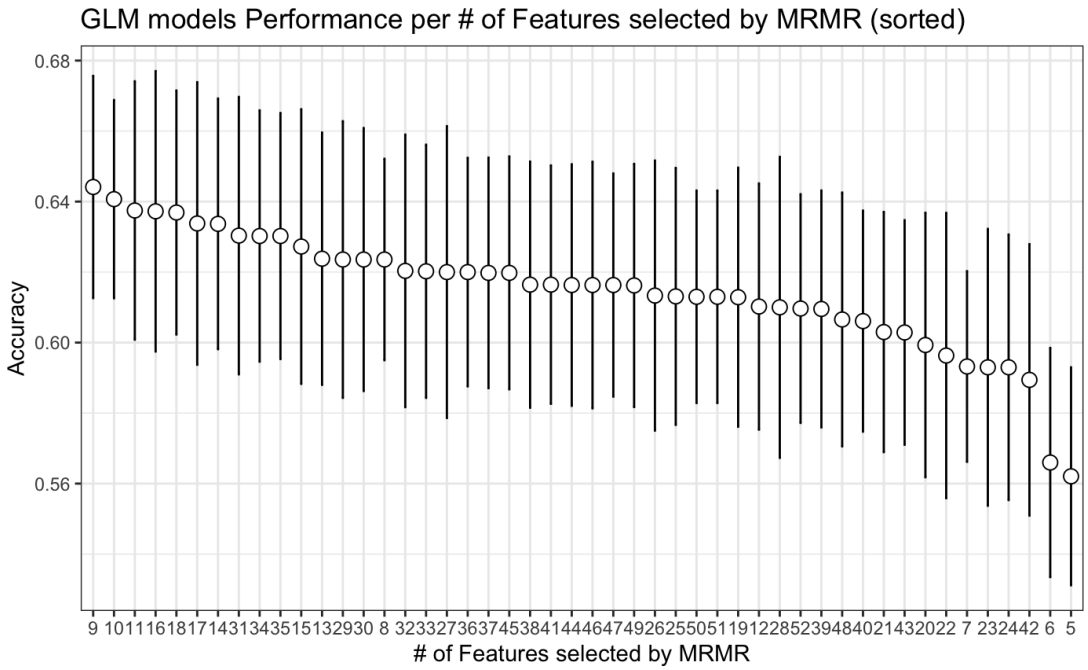
This model does not perform feature selection inherently, even though standard computation packages output a probability estimate of significance for each candidate, which could be used as a filtering mechanism. This inability cannot protect the modeling process from data inherent vices such as multicollinearity and sparsity. To tackle this, additional feature selection methods or regularization modifications are employed. Such is the referenced MRMR algorithm that upgrades the logistic regression model to a more robust classifying mechanism, removing simultaneously features not related to the outcome as well as features orthogonal to other input variables. Feature selection under MRMR is implemented using a carefully selected resampling scheme respecting considerations explicitly detailed in [Hastie et al, 2009].

7.3 Performance and Insights of the model

A model's efficacy is displayed through the ability to predict adequately on out of training sample data as well as provide insights to the non modeling expert [Hastie et al, 2009]. Under this lens, predictive results based on cross validation resampling scheme are displayed and moreover visualizations coming from the decision tree based models are provided along with some commentary.

7.4 Logistic Regression Model with MRMR Algorithm

A set of 52 different models based on logistic regression were tested. Differentiation derived from the multiple sets of features selected by the MRMR feature selection algorithm. Predictive performance on multip le out of sample tests can be observed in the following figure:



The best predictive performance was achieved for the case of a logistic regression model employing 9 features selected by the MRMR algorithm.

The actual model is provided in a linear form relating Startup Survival log odds to the 5 input features (that resulted as important from the initial 9 ones) according to the following formula:

Startup Survival (log odds) =
0.097 + 0.53 * High_Low_Tech_Process(=Yes) - 0.69 * Education_Level_Variance (among founding members) + 0.63 * Education_Digression (=Yes) + 1.10 * Customer_Type_B2B_B2C + 0.91 * Customers_Abroad (=Yes)

Based on this formula there exist four input variables with positive impact to a Startup's Survival, i.e. a) providing services to both Customers and Businesses, b) having achieved customers abroad, c) having founding members that digressed from original studies and d) applying high-tech processes internally. Also there was one variable identified affecting negatively survival, i.e the variance in Educational Level amongst founding members.

Also, the GML model combined with the MRMR algorithm achieves the level of 64.41% in terms of mean accuracy, and a lift of 28,82% from the naïve model*. (See also, Appendix 3) Also, it employs 9 features in terms of accuracy (as described above).

*As a naïve model, we define a binary classification model with no prior knowledge that assesses startup survival based on a uniformly random guess, i.e. predicting 0 or 1 with equal probabilities, achieving 50% of accuracy.

Taking into account that the two additional models (Random Forests and Decision Trees) have their own advantages, we have implemented the same approach to observe their accuracy and to extract different results for further research and analysis.

8. Epilogue

Our research project has been the first to study in detail the features of early stage incubated startuppers in Athens at a critical time period of the long Greek Economic Crisis. Our purpose has been to understand the key drivers of this emerging ecosystem as an entity and in particular the forces making for the sub-cohort of the startups group defined by business success (aka survival) we would like to share certain observations resulting from these first findings from our data base analysis.

Firstly, the emergence of a novel nexus of 'visionaries' and (to use the terminology of GEM reports "opportunity" driven entrepreneurship. In Greece traditionally business is oriented towards the domestic market, low technology processes and products/ services But this ecosystem which we have observed, though small in size diverged from this pattern, within the sea of despair in the country and deepening deindustrialization this enclave was a breath of fresh air and an emblem of hope.

Secondly, the existence of an entrepreneurial oriented sophisticated/well educated pool of talent in Greece committed to high value/opportunity driven entrepreneurship that actually in part ameliorates that large brain drain during the crisis as it has formed links with neo-high knowledge emigrants abroad.

Thirdly, the high flexibility of this ecosystem and its ability to detect and unlock new opportunities. Following the imposition of capital controls in 2015 there was a slowdown in startup births and pivoting in terms of headquarters while in the years following our period of study there was an upturn in startup births as the economic climate improved, and as a result, more than 150 startups from the selected incubators were born.

Finally, we would like to note that certain findings are useful for policy makers. Among them we would like to pinpoint .that policy making should be informed by the facts that the presence of women in the survival cohort was lower than in the general population of startups , and that agricultural startups had a low survival rate and this is something the country cannot afford given the huge food trade deficit.. In addition, it is useful for policy makers to note the positive impact for a startup's survival, of a) providing services to both Customers and Businesses, b) having achieved customers abroad, c) having founding members that digressed from original studies and d) applying high-tech processes internally. Also there was one variable identified affecting negatively survival, i.e the variance in Educational Level amongst founding

members. As we are writing the final words of this paper Greece, like the whole world is still experiencing (hopefully the final phase of) the tragic covid-19 pandemic and the Russo-Ukranian War. These tragic developments arrived at moments when the country appeared to be ready to exit the long Crisis. What can contemporary startuppers learn from our study? One lesson is the need for flexibility in a time of rising nationalism . Another lesson is the urgency of understanding better the keys for survival in a deglobalizing troubled world economy (a much desired objective of startuppers and also policy makers).

Of course we cannot cover everything and a number of questions remain unanswered. Hopefully other researchers might turn to interesting topics such as mapping in detail the moves towards digitalization, sources of funding for early stage startuppers, types of innovation and business models and the multifaced connections between the startups and economic growth.

APPENDIX 1

Comparison of Greek Studies on the Startup Ecosystem

(The papers are sorted in chronological order starting with the most recent)

Number	Author and title of article/report	Data base	Time period covered	Basic questions - Main Categories	Other comments	Overlapping Points
1	Pepelasis, I.S, I, Spyropoulos, G.Kokkotas, D.Zisis, I. Besis (2022) "Charting the Greek Startup Ecosystem" diaNEOsis	used data from various sources	2021	A) The Startup journey B) Features of startuppers and startups C) policy overview and proposals	Non academic	Yes, slight overlapping (Characteristics entrepreneurship in Greece) Very Detailed
2	IOBE- Tsakanikas A., Giotopoulos I., Valavanioti E. & Stavraki S. (2019)-" Annual Entrepreneurship Report 2018-2019"	Global Entrepreneurship Monitor	2018-2019	A) Characteristics of early stage entrepreneurship B) The domestic business environment: National Experts' Survey C) The role of the structural characteristics of the financial system from a business development perspective	Academic	Yes, slight overlapping (Characteristics of early stage entrepreneurship) Very Detailed
3	Found.ation, EIT Digital & Velocity Partners (2019) "Startups in Greece: Re-mapping the investments landscape"	Not specified	Not specified	A) General Data for the Greek Economy B) Description of Equifund C) Characteristics of Companies that received funding through Equifund D) Comparison of Pre-Seed and Seed Stage Startups in Greece and Europe (Country, Gender, Size, Focus, Sector) E) Funding F) Mapping of Incubators, Accelerators, Co-Working Spaces and Competitions-Hackathons G) Top 10 funded startups H) Profile of Early Stage Startups	Non-Academic	Yes, slight overlapping (Mapping, profile of early stage startups) Very Detailed
4	Chris Gasteratos-Marathon VC (2019) "The Greek Startup Industry: Investments and Exits, 2010-2018"	301 firms 268 VCs	2010-2018	A) Investment Amounts B) Investment Rounds C) Investments amounts per stage D) Investment rounds per stage E) Investment rounds per geography F) Investment amounts per Geography G) Average price per seed round H) Geographical allocation of Greek startups I) Investment rounds source J) Amounts raised source K) Acquisitions and IPOs	Brief Survey	Yes, slight overlapping (geographical allocation of Greek Startups)

Number	Author and title of article/report	Data base	Time period covered	Basic questions - Main Categories	Other comments	Overlapping Points
5	Chris Gasteratos-Marathon VC (2018) "Greek Founders Attributes"	143 firms (raised Financing) 175 founders 110 firms	2010-2017	A) Tech vs Non-Tech B) Education Level C) Education Level vs Startup Success D) Starting Age E) Work Experience vs Startup Success F) Previous Role G) Previous Role vs Startup Success	Brief Survey	Yes, slight overlapping (High Tech vs Low Tech, Education Level, Starting Age)
6	BCG-Antoniades V., Giakoumelos M., Petkakis T. & Zacharia Z. (2018) "Greece's Startup Ecosystem"	Used data from several sources	mainly 2012-2018	A) A snapshot of the Greek Startup Ecosystem B) Problems that Startups face in Greece C) BCG's Vision for the Greek Startup D) Introducing Policies to strenthen the Startup Ecosystem E) How the policies will achieve their scope	Non-Academic, Policy-Oriented	No overlapping Very Detailed
7	Chris Gasteratos-Marathon VC (2017) "Investments in Greek Startups"	137 firms	2010-2016	A) Number of Investments Rounds B) Aggregate Investments C) Acquisitions	Brief Survey	No overlapping
8	Vlachopoulou, M., Ziakis, C. & Petridis, K. (2017), ICT Innovation Hub, "Startups: Characteristics and their interaction with the Greek startup ecosystem in Greece"	121 firms	Not specified	**General Information** A) Number of Founders B) Number of Employees C) Legal Entity D) Location & Reasons of Choice E) Sectors F) Location of Clients G) Time Frame **Characteristics of Startups** A) Motivation of creating a startups B) Startups and Business Plan C) Origin of the Idea D) Patentization of the idea E) Education of Founders F) Education of Employees G) Funding Sources H) Types of Collaborations I) Difficulties during Initiation **Reasons of Success of Startups in Greece** A) Comparative advantages of startups B) Characteristics of Founders C) Funding D) Support E) Education F) Government Support G) Prospects of Success	Brief Survey	Yes, Overlapping (Number of Founders, Number of Employees, Location, Sectors, Education of Founders)

Number	Author and title of article/report	Data base	Time period covered	Basic questions - Main Categories	Other comments	Overlapping Points
9	Stavros Lampropoulos (2015) "The startup ecosystem in Greece: An empirical investigation."	77 firms	2016	A)Number of Founders B)Age of Founders C)Age and Level of Education D)Professional Experience per Age E)Origination of the Idea F)Average Number of Employees per Year G)Participation in Supporting Structures H)Evaluation of Supporting Structures I)Funding J)Funding Sources K)Evaluation of Greek Startup Ecosystem L)Reasons that Impede the Development of Startups	Academic Workshop Presentation	Yes, slight Overlapping (Number of Founders, Age, Level of Education)
10	Nikos Kanellos (2013) "Exploring the characteristics of knowledge-based enterpreneurs in Greece"	100 firms	2000-2010	A) Year of establishment B) Number of Employees C) Number of Founders D) Highest Educational Attainment of Founders E) Founders' last Occupation Before Firm Establishment F) Main Areas of Expertise of Founders G) Factors Influencing Firm Formation H) Sources of Funding for Setting up the Company	Academic (Article)	No overlapping (Different time period)
11	Vliamos, S. & Tzeremes, N. (2012) "Factors Influencing Entrepreneurial Process and Firm Start-Ups: Evidence from Central Greece"	164 firms - Central Greece	2005-2007	A) Factors determining entrepreneurial process and firms' formation B) Background of the Entrepreneur C) Problems Entrepreneur faced to startup business D) Description of Process	Academic	No overalapping, but interesting as it covers new ventures

APPENDIX 2

Summary Table of Key Socio-economic Indicators of the total sample

Socio Economic Indicators per Founder	
	General (300)
Age	<20: 0,70% 20-29: 40,05% 30-39: 39,34% 40-49: 15,46% 50-59: 3,51% 60-69: 0,94%
Gender	Male: 76,81% Female: 23,19%
Level of Education	High School: 0,24% BA/BSc: 4,94% Graduate: 33,41% Master: 42,35% PhD Student: 3,53% PhD: 9,18% Postgraduate Researcher: 2,82% Professor: 3,53%
Fields of Education (BA/BSc)	Economics & Business: 25,23% Computer Science: 20,64% Engineering: 30,73% Science: 5,05% Theoretical Studies: 5,05% Other: 13,30%
Fields of Education (Master-PhD)	Economics & Business: 33,49% Computer Science: 18,27% Engineering: 25,53% Science: 4,45% Theoretical Studies: 4,45% Other: 13,82%
Variety in skills	Yes: 26,12% No: 73,88%
Whether founder's education is related to startup sector	Yes: 51,90% No: 48,10%
Experience abroad	Yes: 46,68% No: 53,32%

Socio Economic Indicators per Startup	
	General (300)
Location	Athens: 82,95% Greece but not Athens: 5,81% Cyprus: 1,16% Australia: 0,39% Netherlands: 1,55% UK: 5,81% USA: 2,33%
Sector	Agriculture: 11,23% Software-Hardware: 18,60% Leisure: 10,88% Creative Industries: 10,88% Medicine-Healthcare: 9,47% Construction-Engineering-Transportation: 4,56% Environment-Energy: 7,72% Education-Elearning: 4,56% Other: 22,11%
High Tech-Low Tech	High Tech: 25,87% Low Tech: 74,13%
High Tech-Low Tech (in terms of process)	High Tech: 31,80% Low Tech: 68,20%
Product or Service	Product: 14,86% Service: 76,01% Both: 9,12%
Transaction Type of Good offered	B2B: 31,60% B2B/B2C: 21,23% B2C: 45,28% C2C: 0,47% P2P: 1,42%
Customers Abroad	Yes: 38,03% No: 61,97%
Number` of Founding Members	1 member: 37,35% 2 members: 35,74% 3 members: 19,28% 4 members: 5,62% 5 members: 1,61% 6 members: 0,40%
Family Members	Yes: 5,83% No: 94,17%

APPENDIX 3

Startups Survival Results for all three models

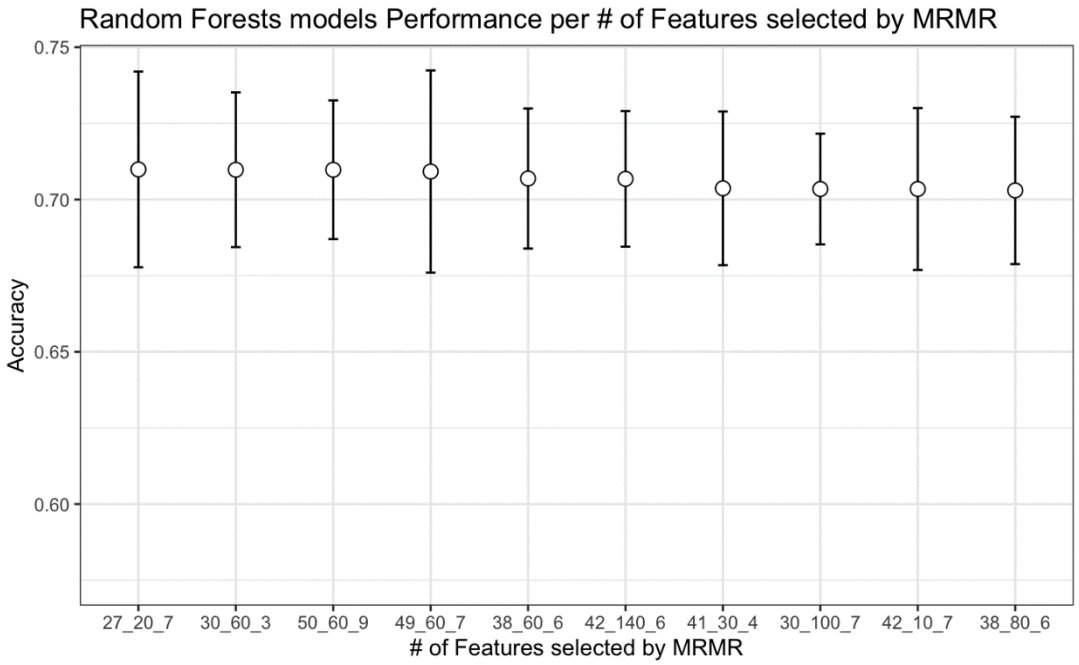
Model	Mean Accuracy (10 fold Cross Validation)	Lift from Naive Model	# of Independent Variables
Naive Model*	50%	0	0
GLM + MRMR	64.41%	28.82%	9
RF + MRMR	**70.09%**	**40.18%**	27
CART + MRMR	63.35%	26.7%	8

* A naive binary classification model with no prior knowledge will assess startup survival based on a uniformly random guess, i.e. predicting 0 or 1 with equal probabilities, achieving 50% of accuracy.

MRMR & Random Forest

Similar to the logistic regression & MRMR case, a set of 52 different model setups were tried out. The final number of models applied culminated to more than 3800, due to the extensive experimentation with RF's two hyperparameters.

Out of sample performance based on a cross validation resampling scheme is presented in the following figure.



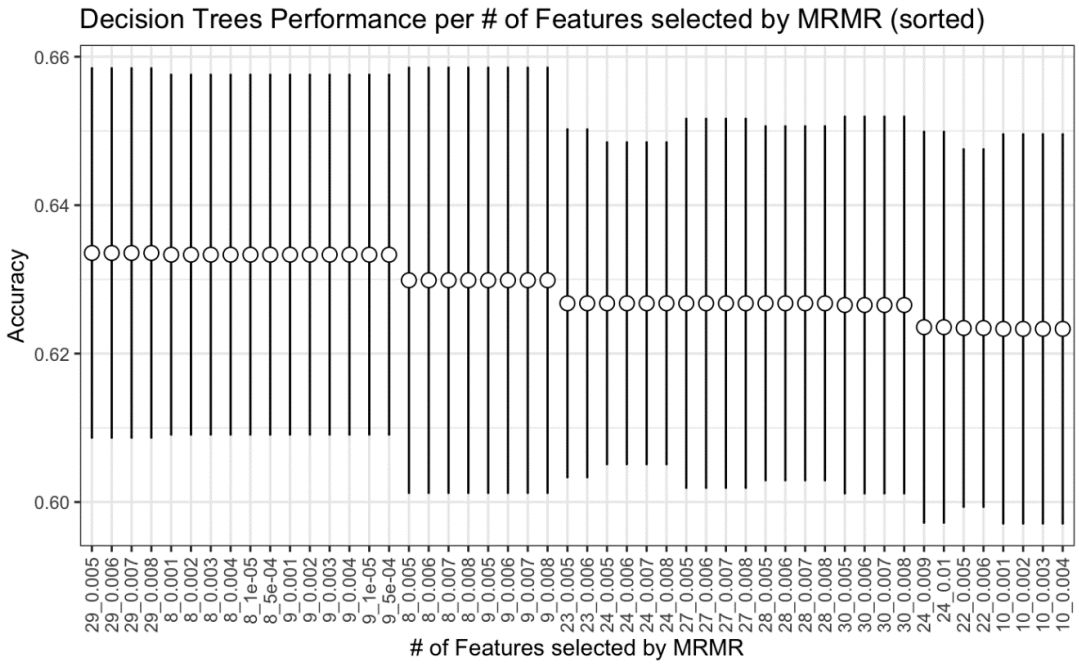
Based on the referenced variable importance metric, the following list of input variables got identified as important for the survival of a startup. It is noted however that the direction of impact (positive or negative) is not feasible through this metric. The list of the most important features is as follows:

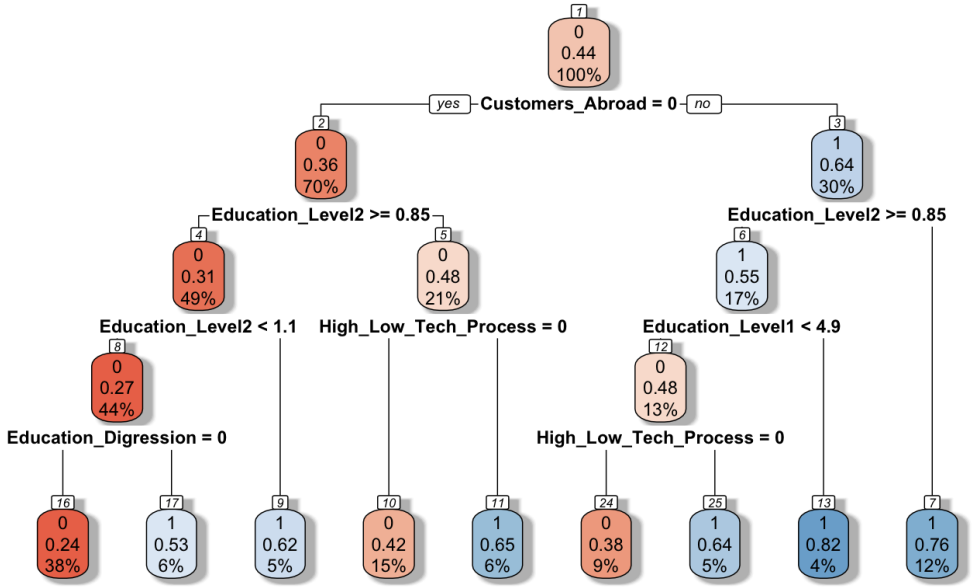
- Founding members average educational level
- Founding members Educational Level Variance
- Founding members mixed gender
- Having achieved customers abroad
- Lack of information on headquarters existence
- Postgraduate studies on economics
- Founding members experience abroad
- Business sector in Health/Medicine, Tourism, Creative Industries, Agriculture
- Hightech processes internally
- Studies in Engineering & Computer Science

Decision Tree & MRMR

As per the two previous modeling approaches, a total number of 480 decision trees were tested on the same resampling scheme. Out of sample results are shown in the subsequent figure, showcasing as top performing models those built from a set of 29

and 8 input features respectively. Based on Occam's razor [Hastie et al, 2014], the best of those two is the simplest one, in this instance simplicity being translated into parsimony, therefore the decision tree resulting from the set of 8 features selected from MRMR.





Based on figure 4, both variable significance as well as deeper insights can be extracted.

Regarding variable importance and impact direction:

- Variables increasing a startup's survival probabilities are:
  - Having achieved customers abroad,
  - Applying high tech processes internally,
  - Founding Members digressing from original studies
  - Founding members average educational level
- The only variable decreasing a startup's survival probability is the educational level variance among founding members

Moreover there exist particular startup profiles with increased survival probabilities. These are:

- Startups with customers abroad and whose founding members have all the highest education levels. These represent 4% of the total population with 82% survival probability.
- Startups that have achieved customers abroad and whose founding members have similar education levels. These represent 12% of the total population with 76% survival probability
- Startups that have achieved customers abroad, whose founding members lower than the highest education level is compensated by applying high tech processes internally. These represent 11% of the total population with 65% survival probability.

Finally, there exist particular startup profiles with considerably reduced survival probabilities. These are:

- Startups with no customers abroad, whose founding members educational level varied and did not digress from original studies. These represent 38% of the total population with 24% survival probability.
- Startups with no customers abroad and low tech processes applied internally. These represent 15% of the total population with 42% survival probability.
- Startups with no customers abroad, lower average educational level and low tech internal processes. These represent 9% of the total population with 38% survival probability.

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3. Other Sources

The following electronic sources have also been mined in order to gain information on the incubated startups and their initiatives in order to proceed in a thorough analysis using Facebook, LinkedIn and selected articles in the Press.

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3.2. LinkedIn, https://www.linkedin.com/

Selection of more 100 articles from:

3.3. Emea, https://emea.gr/
3.4. Epixeiro, https://www.epixeiro.gr/
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