Fostering Knowledge - intensive entrepreneurship in tertiary education: empirical evidence from engineering schools in Greece

Caloghirou, Yannis; Protogerou, Aimilia; Tsakanikas, Aggelos
National Technical University of Athens, Laboratory of Industrial and Energy Economics

Abstract

This paper focuses on the efforts of promoting entrepreneurial activity among students and young university graduates. Stemming mainly from knowledge entrepreneurship policy discussion, we examine the link between entrepreneurship and relative educational programmes in Greece. In this respect, the paper presents empirical evidence regarding the entrepreneurial activities of the Greek engineers using survey work undertaken among graduates of the National Technical University of Athens (NTUA). The paper provides some empirical evidence on the rate of entrepreneurship, the profile of the graduates, the characteristics and the pattern of entrepreneurial ventures undertaken by young engineering graduates in Greece, exploring also the role of tertiary education in supporting them during thi s

process. Results show that despite the knowledge content of the specific activities undertaken and the high educational profile of founders, the entrepreneurial activity undertaken by young NTUA graduates is rather conventional, depending on existing production trajectory of the Greek economy.

Key words: Knowledge-intensive entrepreneurship, engineering education, developmental university

1. Introduction

Entrepreneurship has been studied as a key driving force of industrial dynamics and industry evolution (Malerba and McKelvey, 2016). Increasing the number of start-ups (Audretsch et al. 2006) has been pursued in the context of typical policy programs in many countries especially the ones that face adverse economic conditions, like i.e Greece. However, the recent financial crisis has underlined the need not only for creating a large quantity of entrepreneurial ventures in an economy but also for encouraging some "special" new ventures that can be sustainable in adverse times and support growth and employment in an economy.

Knowledge-intensive entrepreneurship (KIE) and new ventures in this area can be considered as a sort of high-potential entrepreneurship (Autio and Acs, 2007; Henrekson and Johansson 2010). It indicates ventures whose launching and initiation or expansion is based on the dynamic application of new knowledge. Also, new knowledge-intensive firms can play an important role in sectoral, local and national innovation systems by operating as problems solvers, knowledge brokers, knowledge-intensive service providers, or specialized suppliers (Malerba and Mckelvey, 2016).

One reason for the increased importance of KIE can be attributed to the fact that over the past three decades the share of scientifically educated work force is rising continuously in almost all European countries. This additional supply of highly qualified human capital cannot be fully absorbed only in the existing businesses and thus the need for new entrepreneurial activity becomes more significant (KEINS Final Report, 2008). Such highly educated people can have a background in applied sciences in the various engineering disciplines as well as in new sub-disciplines in physics and chemistry (e.g. material sciences), in biology, medicine, information sciences etc.

Therefore, the need to strengthen the culture of entrepreneurship and risk-taking by fully mobilising human resources - through the improvement of entrepreneurship education- is acknowledged among top policy priorities worldwide (OECD, 2010). In this respect, the role of educational systems can be decisive in increasing the prevalence and quality of entrepreneurial learning and thus in creating entrepreneurial mindsets that help transform ideas into action. The function of higher education goes far beyond the delivery of knowledge and with high-tech and high-growth enterprises becoming a focus of entrepreneurship policies, higher education institutions can be considered as an active component of the innovation policies in Europe (European Commission, 2013). In consequence education institutions should ensure that they

develop and promote a culture of entrepreneurship and innovation through their missions, stakeholder engagement, curricula and learning outcomes (European Commission, 2013).

Universities have been increasingly involved in knowledge transfer activities especially during the last three decades along with a remarkable upsurge in new forms of entrepreneurship associated with new innovations (Franklin et al., 2001) usually taking the form of 'university spin-offs'. The idea that knowledge stemming from research conducted on university campuses can be used in commercial applications, led Etzkowitz (1998) to coin the term entrepreneurial university describing the role that universities have been assuming in modern economic development activities. In this vein, research universities are becoming increasingly engaged in entrepreneurial activities that allow them to capitalize and valorize academic knowledge, while at the same time they also embrace entrepreneurial culture in the main academic areas of education and research (D'Este et al., 2010). Most importantly, the role of entrepreneurial university in development is highly dependent on the preferred conception of development and the socioeconomic context. Knowledge-based inclusive development (in terms of regions, productive sectors etc,) based on the diffusion of the benefits and power of knowledge by cooperating with other institutions and collective actors is important (Arocena and Sutz, 2017). Thus the real challenge for the coming period is the transformation of the European educational systems so that they can stimulate entrepreneurship, especially the knowledge-intensive one.

In this paper we focus on tertiary education as a key enabler in promoting high-potential entrepreneurial activity. In particular we concentrate our study on how education could promote engineering knowledge-intensive entrepreneurship and we provide some empirical evidence on the characteristics and innovative performance of the entrepreneurial ventures undertaken by young engineering graduates in Greece. In this way we try to shed some light on the features of entrepreneurial activity exercised by people that are assumed to have advanced capabilities to set up some knowledge-intensive ventures.

Greece represents an interesting case study for entrepreneurial policies and the linkages with growth. Although it is an economy that is part of an "elite club" with a common currency and a common framework for both fiscal and financing policies, it was severely hit by the economic crisis largely compared to other European countries. At the same time, it was and still is a country with high entrepreneurial rates, although most of it is self-employment. (Tsakanikas et. al, 2016)

Currently, there is a need for a re-positioning of the Greek Economy in the new emerging division of labour at a global level. This can be done through the regeneration of the productive and entrepreneurial system and a restructuring towards a growth trajectory closely associated with job-growth aspirations of entrepreneurs and industrial improvement. This involves at least three directions: a) a technological upgrading of existing firms (especially in low-technology industries and mature industrial fields) through technology transfer from trained and retrained engineers who can combine their technical knowledge background with business and market understanding. b) enrichment of the entrepreneurial ecosystem with newly established knowledge-intensive firms and c) decrease of the excessive brain drain observed among well-educated professionals since the start of recession in 2010 (Labrianides, 2011).

Hence, the Greek case offers unique empirical insights that could be valuable when designing entrepreneurial policies especially for start-ups, but also for a discussion related to an entrepreneurial university (Fayolle and Redford 2014). Our point of departure is that by encouraging the pool of human capital that is most exposed to scientific and technological knowledge towards entrepreneurship may increase the specific weight of knowledge intensive entrepreneurship to the overall new entrepreneurship creation, which is important for a new growth model for the Greek economy.

2. Education and knowledge-intensive entrepreneurship

Cultural variables interact with economic and technological developments or with policies designed to advance entrepreneurship and can play an influential role in the decision of individuals to start a new business (Wennekers and Thurik, 1999). The development of an entrepreneurial culture through educational systems could be a means to stimulate entrepreneurship and thus enhance economic growth. In this section we focus on how educational systems could promote knowledge–intensive entrepreneurship since knowledge, as a result of externalities and spillovers, is particularly important to macroeconomic growth (Romer, 1986; Lucas, 1993).

A definition of knowledge-intensive entrepreneurship proposed by Malerba and McKelvey (2016), stresses new firms that are innovative in terms of economic value creation and present an activity which includes substantial amounts of knowledge. These new firms are not limited to high-technology but permeate diverse sectors (traditional sectors, manufacturing and services, existing and new industries). Consequently knowledge-intensive entrepreneurship is

a complex phenomenon which transforms knowledge to innovation regardless of the type of venture and/or sector. There is no doubt that substantial amounts of knowledge are produced in certain institutions (i.e. universities, firms) that if or when diffused outside these institutions would result in a strong positive effect on the standard of living in our societies. The question is how this knowledge could be diffused. Audretsch and Keilbach (2007) have proposed a relative theory, the so-called knowledge spillover entrepreneurship theory. According to them entrepreneurship could function as the channel of transferring the knowledge produced from its source (specific incumbents (i.e. universities, other institutions / industries)) to the society. In particular, their work suggests that entrepreneurship is an endogenous response to opportunities generated by investments in new knowledge made by incumbent (source) organizations (firms, universities etc.) but which will remain uncommercialized due to the inertia inherent in decision-making under uncertainty known as the knowledge filter (Acs et al, 2004; Audretsch et al, 2006). The start-up of a new venture of this kind provides the channel for the spillover of knowledge from the source organization to the new venture. In fact, all the uncommercialized knowledge produced is an important source of entrepreneurial opportunities waiting to be exploited by ambitious entrepreneurs (i.e. by the students, graduates, staff and outsiders who can benefit from their studies / interactions with the universities or by former employees who can diffuse knowledge produced but not commercialised in the institutions / industries where they worked etc).

The above theory could be of great importance for policy makers. By encouraging the exploitation of the knowledge produced but not completely or exhaustively commercialized, they could use knowledge-intensive entrepreneurship as the means to diffuse this knowledge to the society. The challenge for universities and policy makers is to find first, how to combine the entrepreneurship education efforts with the commercialization of the knowledge produced in the universities and second, how to create the entrepreneurial mindsets within the universities so that their graduates can exploit and diffuse uncommercialized knowledge wherever it is produced (i.e. in other institutions / firms or even by themselves).

In order to formulate a link between education and entrepreneurship resulting in the creation of entrepreneurial mindsets, researchers have initially suggested the introduction of stand-alone entrepreneurship programmes in the university curricula (business and non-business), focusing mainly on the appropriate content of these programmes and the process of teaching (a review of relative theoretical articles is proposed by Gorman et al (1997)).

However, most recent research has supported that entrepreneurship education cannot unfold its full potential unless it becomes a top priority rather than an add-on activity. In particular the development of an entrepreneurial culture and strategy is needed in the "new" university (Scharmer and Käufer, 2000; Gibb, 2006) and entrepreneurship education could serve towards this direction. In other words, the challenge is to move students from their normal distanced position into the field, instilling skills and letting them experience personally the role of the entrepreneur through simulations, role-play, field work and so on (Löbler, 2006).

Toward this direction, Bager (2011) proposed a "comprehensive" perspective in entrepreneurship training as an integrated approach to the way universities can facilitate the formation of student and graduate start-ups and enhance knowledge spillovers to society. According to this perspective, the entrepreneurship field cannot be separated from the traditional business and management fields of finance, accounting, marketing, strategy and organization; however it approaches them differently, based on the venture creation perspective rather than the large firm perspective. For example discovering (or creating) a new idea, which by definition entails a gap to a possible future state, and evaluating a priori its chance of succeeding should be dealt systematically combining principles from different disciplines (Shane and Venkataraman, 2000). In particular, focus should be on developing the core competences of recognizing - evaluating - exploiting opportunities and building organizations in order to create entrepreneurial mindsets, behaviours and intentions and finally enhance knowledge spillovers from universities to the society through entrepreneurship (Bager, 2011). The "package" of initiatives and reforms that Bager (2011) proposes in order to build the entrepreneurial university includes several aspects: the formulation of an overall university strategy and top-management support; the offering of a variety of entrepreneurship courses (at both introductory and advanced levels); the enhancement of relative research to support teaching activities; the dissemination of innovation by furthering pedagogy and didactics in other fields; the introduction of extra-curricular activities such as events with "outsiders" and business plan competitions; the establishment of hatcheries and incubators; finally, the development of an entrepreneurial culture.

This leads to the concept of entrepreneurial university, that has been developed recently (Guerrero and Urbano, 2012, Fayolle & Redford 2014) and touches upon the so called Third Mission of universities, that is the perceived need to engage with societal demands and link the university with its socio-economic context. Although too many definitions have emerged we

could select Etzkowitz (2003) which states that the Entrepreneurial University is a natural incubator providing support structures for teachers and students to initiate new ventures: intellectual, commercial and conjoint. The literature on how the university can develop an entrepreneurial culture and influence young students and graduates in order to undertake entrepreneurial activity during their studies or after their graduation is starting to flourish (Fayolle and Redford, 2014). On the other hand the effectiveness of the university system itself plays a crucial role not just because it affects the competence profile of the graduates but also because of the networks with the private sector that it develops and the level of the academic entrepreneurship it achieves.

For instance academic entrepreneurship (through academic start-ups, academic patenting etc) appears to be growing phenomenon Europe (Lissoni et al, 2007) and university spin-offs are becoming a significant global phenomenon exploiting a wide variety of different technologies (Shane, 2004). These university spin-offs are quite valuable for our societies since they push local economic development, contribute to the commercialization of university-made technology, promote university research and teaching by providing valuable feedback and generate more income for the universities than simple licensing (Shane, 2004). High-tech spin-offs are mostly found in the industries of biotechnology and computer software and possible reasons for that is the reduced time required from academic research to commercializable outcomes, the concentration of the appropriate expert personnel in the universities, the value for money relationship, the patenting legislation etc (Shane, 2004).

However in new high-tech university spin-offs, the lack of experience on behalf of the entrepreneur combined with the novelty of the venture, constitute an important barrier in the struggle of the new venture to pass through the early stages of growth and become an established firm. Universities typically lack resources and academic entrepreneurs very often do not possess the commercial skills required to create ventures. Moreover conflicting objectives among stakeholders (universities, academic entrepreneurs, venture management teams, venture capitalists etc) create a complicated environment for the spin-offs (Wright et al, 2007).

From an empirical point of view, several university-specific studies based on alumni data have shown that university graduates create a lot of new firms that outnumber faculty spin-offs (Astebro et al., 2012; Wright et al., 2007). Other empirical studies have indicated that these ventures may outperform university spin-offs and thus can generate higher societal benefits

(Wennberg et al., 2011; Siegel and Wessner, 2012). These start-ups are normally less demanding in terms of finance but they may require support in order to grow and create economic and social value. For example, there is a rising demand for specialized master's degrees for non-management disciplines' graduates so as to acquire the necessary entrepreneurial skill to shape and realize the business opportunities that they have identified (Siegel and Wright, 2015). There is probably a lack of research on start-ups established by university graduates due to misalignment with the specific interests of policy makers who primarily focus on intellectual property creation by faculty members. Furthermore most of past empirical research examining spin-offs from universities uses Technology Transfer Offices data, or data pertaining to faculty surveys (Astebro et al., 2012), while generally in the past most universities did not keep track of the companies founded by graduates from their undergraduate, master or Ph.D. programmes (Wright et al., 2007).

3. Engineering education and knowledge-intensive entrepreneurship

As Fayolle et al (2005, p.1) put it "entrepreneurial engineers seem to be innovators and creators of economic wealth". However the entrepreneurial and innovating behaviours of engineers are heavily affected by cultural factors (national, professional etc). Since these factors are either favourable or unfavourable to entrepreneurship it is important to understand the relative mechanisms and their impact on the educational systems in order to find ways to stimulate knowledge-intensive engineering entrepreneurship.

As far as national cultures are concerned, Fayolle et al (2005) support that, in France, for example, the evolution of the role of the engineer in the industry and its correspondent social status formulated a cultural approach (illustrated also in the educational system) that discourages engineers from obtaining an entrepreneurial position. In fact the most famous engineering "Grandes Ecoles" prepare their graduates for a prestigious career within large companies and administrations and ensure that there are strong networks of graduates and relative "elites" that will assist the fulfilment of such endeavours. Moreover the title of qualified engineer is protected by the "Commission des Titres d' Ingénieur" so it constitutes a discriminatory element which is of significant importance within companies.

The above stated cultural approach in combination with the emergence of "professionalism" as the main accepted source of authority (authority justified by the manifested competence instead of the position in the hierarchy) resulted in two types of professional identity for the

French engineers: ability to manage people and technical expertise (Lasserre, 1989). None of them includes the entrepreneurial behaviour.

Professionalism and technology-orientation were also stressed by the German engineers who tend to follow a career within big organizations; however a shift towards market orientation was found by Fayolle et al (2005). On the other hand there are engineers, like the Dutch ones, who may be less specialized in the technical area than their German colleagues but they are traditionally more market-oriented. It seems that, as far as the professional culture is concerned, a significant transition in the engineering culture towards market orientation is taking place.

Regarding the engineering curricula, emphasis is usually given to the development of strong technical culture. This, in turn, results in the creation of specific behaviour patterns and ways of thinking which make it difficult for engineers to take into account what is not measurable. The absence of management training in engineering schools was identified so, eventually, more and more engineering schools include relative training in their curricula, mainly in economics and management (Fayolle et al, 2005).

In this environment which discourages entrepreneurship, there are however, engineers who finally decide to become entrepreneurs. According to the research of Fayolle et al (2005) the main drivers that result in engaging in engineering entrepreneurship include: the school of origin (engineering schools that promote active interaction with training as seen by engineers as institutions that develop entrepreneurial behaviours), the type of training and specialisation (a generalist training provides wider opportunities and thus can lead to entrepreneurial activities away from the original engineering specialisation whereas a specialist training provides technical expertise that can lead to entrepreneurship based on the technical aspect of the product or the service offered by the new venture) and the previous experience (engineers prefer to act entrepreneurially, at least at the beginning of their entrepreneurial endeavours, in areas where they have worked in the past exploiting previous technical knowledge, skills, networks). On the other hand, as far as the day-to-day running of the new venture, building the relationship employer-employee on the basis of promoting innovation and creativity and working in teams are characteristics commonly found in the new ventures created by entrepreneur engineers.

As far as the professional culture is concerned, Fayolle et al (2005) distinguish two types of entrepreneur engineers in their research: the manager entrepreneur engineer and the

technician entrepreneur engineer. The former is the engineer who eventually gives less emphasis on the technical dimension of his/her job before setting up (or acquiring) a business whereas the latter is the one who remains concentrated on the technical aspect of his/her job before setting up (or acquiring) a business. These two divergent paths lead to different behaviours when creating a new venture: Having developed new, non-technical skills the manager entrepreneur engineer is described as an innovator or resource coordinator who does not hesitate to develop his/her entrepreneurial activity in areas that are not close to previous experiences or initial specialisations (for example in the service sector and especially in the consulting domain). On the contrary, the technician entrepreneur engineer is described as an inventor who very often creates a new venture in order to continue a technical project which started within the company where he/she worked but could not develop inside the company anymore. This kind of entrepreneur engineer seems to prefer innovating in technologies and products remaining close to scientific and technical fields where he/she feels comfortable. That is why he/she tends to delegate managerial functions to others.

Another aspect of the entrepreneurship that concerns the relative research has to do with the time period (within the professional life of the potential entrepreneur) when the relative activity takes place. Verzat and Bachelet (2006) support that in many cases the entrepreneurial intention occurs very late. More specifically, as far as engineers are concerned, Fayolle (1994) also found that many engineers become entrepreneurs late in their careers.

According to Verzat and Bachelet (2006) entrepreneurship should be approached as a trial-and-error process, the result of which is determined by the vision that the person has created in his mind (regarding his beliefs of what he is capable to achieve and his expectations about what he wants to become) and the effect of the environment in which the person acts. At the beginning of this process Tounés (2003) identifies the “entrepreneurial intention” (intention to adopt entrepreneurial behaviour) as one of the major early stages. So, it could be hypothesized that a kind of “entrepreneurial spirit” exists before the decision of setting-up a new business (Verzat and Bachelet, 2006).

Consequently, by developing the entrepreneurial spirit of young professionals we could probably shorten the period needed to see the entrepreneurial intention to be expressed. Verzat and Bachelet (2006) have proposed a model of promoting entrepreneurial spirit within young engineers (even in students who had no personal entrepreneurial spirit background). This model is based on the dynamic elaboration of professional identity and of specific

attitudes, behaviours and competence feelings. According to this, by being offered the appropriate mix of academic and pre-professional activities (internships, activities within associations etc) young students would progressively reach the desired state of realising what they are capable of achieving in their professional lives and what are their values - beliefs towards what they would like to become.

For Ginzberg et al (1951, quoted by Guichard and Huteau, 2001) this process consists of three stages: the exploratory phase (during which first-year students gather information by participating in discussions with experienced and well-trained personnel (lecturers, career advisors etc)), the crystallization phase (when students (at the middle of their studies) formulate their professional priorities according to their tendencies) and the "specification" phase (when students at the last year of their studies in general, make their "final decisions" regarding their professional future and begin to work on their own project. The appropriate entrepreneurial competences develop accordingly (Verzat and Bachelet, 2006).

To achieve the smooth and effective transition through the above stages new teaching methods that put the student in a real problem solving situation are needed. According to Gibb (1993), entrepreneurship teaching methods should invest on multi-disciplinarity and they should develop specific skills and attitudes that favour entrepreneurship. In particular, as far as engineering students are concerned, teaching methods that focus on altering the risk-aversion attitude (created in engineering schools due to the continuous dealing with well-defined problems and the relative search for a unique solution based on scientific methods and analytical thinking) should be used. For example: "action learning", "learning by doing", learning through experience, learning from one's own mistakes, learning from other people (Garavan and O'Cinneide, 1994; Hartshorn and Hannon, 2002; Leitch and Harrison, 1999) are some of these methods.

To sum up, according to Verzat and Bachelet (2006) even if entrepreneurial orientation is weak, the progressive development of professional identity could be influenced towards entrepreneurship through the appropriate entrepreneurship education (encouraging group dynamics during the curriculum, setting innovation objectives, offering appropriate resources (time, consultant teachers etc)).

Similar conclusions have been reached from relative research concerning the Greek engineers. Empirical studies from Caloghirou et al. (2009) revealed the following as prerequisites for a successful professional engineering profile: adequate theoretical background, excellent

knowledge of the relative technological field, very good command of information and communications technology, adequate knowledge of economics and management, developed skills regarding project management, communication, negotiation and team-working. Moreover, as far as the update of the engineering curricula is concerned, the overwhelming majority of the engineers interviewed (1999-2000) proposed the development of non-technical competences, the encouraging of the use of ICT and the exposure to the fields of management and economics.

On the other hand, the fact that many Greek firms are low-tech SMEs (Liargovas, 1997) which they still use traditional management methods (Makridakis et al, 1997), creates a hostile environment for personnel with a higher educational background. As Liagouras et al (2003) put it; the Greek economy and especially the business sector, seem incapable to absorb the supply of high quality researchers and PhD holders (most of them graduated from well-known European and American universities and technical institutes). In this environment several engineers engage in entrepreneurial attempts either driven by necessity or as a means to escape from the unsatisfactory working conditions offered by their employers (latent entrepreneurship) (Papayannakis et al, 2008).

In this light, the introduction of entrepreneurship courses in the curricula of the Greek universities (focusing on knowledge-intensive entrepreneurship) could serve as a lever in the struggle of the country to modernize its economy. Papayannakis et al (2008) propose an interdisciplinary context of education which combines engineering and non-engineering factors in order to develop the necessary skills (managerial etc) to engineering students. This way they believe that both the quantity and the quality of entrepreneurial ventures in Greece could be raised.

More specifically, they propose the development of an “entrepreneurship curriculum” that will be offered to all faculties (chemical engineering, mechanical engineering etc) as a distinctive module. The programme will focus on the relative field of the students, with regard to the new professional demands for understanding economics and developing managerial and entrepreneurial skills. It will provide educational material analysing the whole entrepreneurial process and it will not focus solely on the start-up phase of a new business. Consultation and open dialogue are proposed in order to overcome established opinions regarding the profile of the engineer and the role of the publicly funded University in the new era.

4. Knowledge and skills required by engineers today

In this paper, we argue that enriching the human capital of a social group that is most exposed to scientific and technological knowledge, i.e. engineers, early enough (i.e. during their undergraduate studies), towards entrepreneurship will increase the specific weight of a particular kind of opportunity entrepreneurship i.e. technological entrepreneurship. This in turn can foster and upgrade the growth prospect and the development trajectory of the country. But, how enriching this type of human capital can happen? It is well argued that "mental thought processes that entrepreneurs engage in to discover, evaluate and exploit opportunities are not fixed and may be taught" (Acs et al, 2005). Thus, by providing engineering students in their curriculum the necessary business and market related knowledge as well as complementary skills, the engineering education system could empower them to better recognize and perceive technological opportunities during their career path and convert them to market opportunities and business ventures. In this respect, "technical thinking" and "engineering feeling" can be complemented during engineering education studies with a knowledge background on market and business environment understanding, managerial and strategic thinking and entrepreneurial feeling.

During the last two and a half decades there have been major changes in the profile and employment of engineers at the international level. A significant change is closely related to the fact that the strict division of labour between technical and socio-economic problems is has negative implications for both economic units and society at large. Furthermore, the increasing complexity and uncertainty of contemporary techno-economic systems have made the traditional engineering profile out-of-date. In order to respond to new changing requirements most technical universities in advanced countries have modified their curricula by upgrading not just the courses in economics and management, but also in social sciences in general.

According to De Neufville (2001), traditional and long-established engineering curricula have failed to meet the need for examining the economic, management, regulatory and political aspects of technological systems which albeit have a central role in the design of these systems. More specifically, he argues that the effective design of a complex technical system requires the understanding and control of different managerial and organizational procedures, the careful organization of decision making and the process/product development processes, and the efficient coordination of the technical teams responsible for different sub-systems. He concludes that the solution to this problem could lie in the introduction of engineering curricula that combine/integrate in an effective way a strong technical education with business

management and public policy domains. Therefore De Neufville proposes that engineering students today should follow high-level management/policy courses and in addition should undertake specific cases/practice work that would help them in combining their technical knowledge with knowledge in business management and policy.

Today, the pattern of the technical university which aims to transfer as much knowledge as possible is considered out-of-date. On the one hand, the obsolescence of knowledge is so rapid that it tends to coincide with the time needed for its transfer. On the other, the boundaries between the different areas of engineers' specializations are becoming increasingly vague. The diffusion of computer technology in all technical or non-technical areas and the emergence of new interdisciplinary areas of employment (i.e. environment) seem to be the fundamental causes for the blurring boundaries between the traditional engineering disciplines. In this environment, skills have a significant precedence over technical knowledge.

In general, there is an increased demand for graduates that do not only have technical competence but also a range of higher-order skills, such as communication skills, networking, leadership etc. as well as knowledge in management, entrepreneurship, financial analysis, product development, etc. Education curricula should therefore provide undergraduate students with the right mix of skills and knowledge that would allow them to be able to respond to the challenges posed by the business and market environment today.

In the next two sections we provide some empirical evidence on the characteristics and innovative performance of the entrepreneurial ventures undertaken by young engineering graduates in Greece. In this way we try to shed some light on the features of entrepreneurial activity exercised by people that are assumed to have the capacity to set up knowledge-intensive ventures. Furthermore we provide evidence on the knowledge and skills received by engineers during their undergraduate studies in order to better understand whether engineering education in Greece represented by the National Technical University of Athens (the most prestigious technical university in the country) has the capacity to address the needs of a global economy and foster an understanding of the relationship between engineering and business operations in the formal training of engineers.

5. The empirical data

The National Technical University of Athens (NTUA) is the oldest and most prestigious educational institution of Greece in the field of technology and one of the most research active

technology and engineering academic institutions in Greece. NTUA ranks at the top-10 list of the most central actors in the research networks that have been created in the context of the European Framework Programmes (FWP) since their enactment in 1984 and for the first 7 FWPS (FWP1 to FWP7) (Protogerou et al, 2013). Furthermore, a large number of its graduates have undertaken successful careers in business, public administration and academia, in Europe and USA, and have contributed not only to its highly respected reputation, but also to the country's scientific, technical and economic development since its foundation in 1836.

Currently, NTUA is divided into nine academic faculties: Civil Engineering, Chemical Engineering, Mechanical Engineering, Naval Architecture and Marine Engineering, Electrical and Computer Engineering, Mining and Metallurgical Engineering, Rural and Surveying Engineering, Architecture and an Applied Mathematics and Physical Science School. All degree programmes require five years of study and provide students with a variety of courses and laboratory practice. NTUA follows the continental system of engineering education offering two years of theoretical (science) courses and three years of more applied courses that require advanced knowledge in specific topics.

During the last two decades, NTUA has undertaken various studies, in an effort to better understand the career paths of its graduates and use this as a feedback mechanism for redesigning its educational strategy and tools[1]. In this paper we use empirical evidence based on recent survey work carried out during January - May 2015 to a sample of 1429 NTUA graduates. The aim of the specific survey was to identify individuals that have followed an entrepreneurial career (self-employment included) and explore the patterns of their entrepreneurial ventures. Apart from simply measuring the entrepreneurial rate of NTUA graduates, the survey principally aimed at identifying the main characteristics of their ventures, along with the founders' characteristics. Finally, an effort to map possible contribution of "entrepreneurship" postgraduate studies in undertaking entrepreneurial action was also pursued.

The original population were 14,055 NTUA graduates who registered as professional engineers at the Technical Chamber of Greece between 2000 and 2010[2]. This would allow us to include

[1] Actually the Laboratory of Industrial and Energy Economics (LIEE/NTUA) and authors of this paper have significant experience in such "alumni or career path surveys". LIEE has coordinated three similar NTUA surveys in 1999, 2005 and 2007.

[2] This registration is obligatory for engineers that want to exercise their profession in Greece. People moving abroad may opt not to register, but these was rather limited phenomenon at least until 2010.

in our analysis both some "older" graduates with a timely career path, but also some graduates from the younger generation. The survey was undertaken through personal telephone interviews using a structured questionnaire[3].

6. Patterns of entrepreneurship in engineers graduates

Based on the results obtained from the survey, one out of three NTUA graduates is following an entrepreneurial career (32.4%), self-employment included (465 graduates). This represents a slight increase compared to similar previous studies, as entrepreneurial rate measures before 2007 were always less than 30% (Table 1). Another 7% is an ex-entepreneur, which means that they have been involved in the past with entrepreneurship. More than half of the graduates (56%) have not undertaken any entrepreneurial activity up to now[4].

Engineering schools involved in construction activities (i.e. civil engineers and architects) have the highest entrepreneurial activity rates over time, as more than half of them are involved in some sort of business venture. This affects the sectoral pattern of the identified ventures, as more than ¾ of them are in engineering and construction services (Figure 1).

This represents a usual pattern in the relevant Greek engineering labour market, as it is very common for graduates from these schools to enter the market with their own small "technical office", that is a micro venture (usually of a sole proprietorship status), after or even before having worked at a big construction company or architect company. This is confirmed by the legal status of the identified ventures, as 72% of them are sole proprietorships and only 10% are Ltd or S.A., representing a more "structured" legal entity. The small size of these ventures is reinforced by the fact that actually only 14% of them had an annual turnover above 100.000 € (data of 2014), while 80% of them do not have full-time employees (founders excluded). However only 14% of the cases is single-founded, being thus purely self-employment ventures. This means that the majority of them have at least two partners (actually, 53% of them consist of exactly two founders)[5].

[3] Stratified random sampling on the nine engineering fields was used as a sampling method. A target of 1400 responses was set (10% of the population) for the survey. Based on previous experience on response rates on NTUA alumni, an original sample of 3219 NTUA graduates were contacted. A response rate of 44% was finally achieved.

[4] There is also another 2.7% that has a dual employment: they work for another employer but they also run (at a part time basis) a venture on their own.

[5] Excluding family firms that may have developed very different dynamics, through time

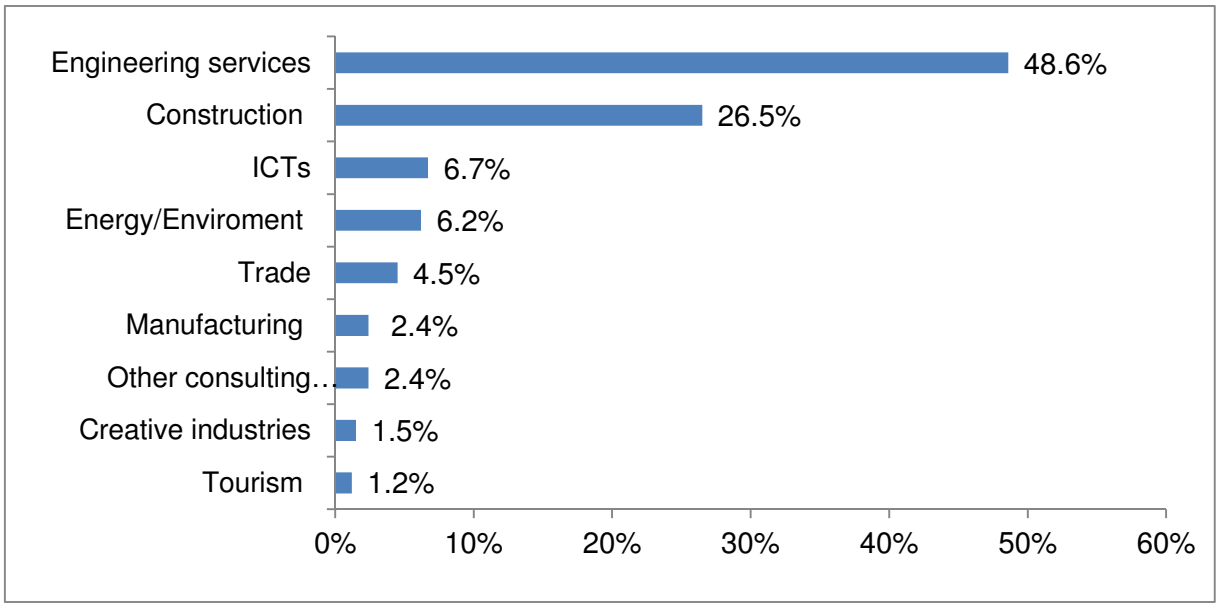
Table 1: Entrepreneurship rate (% per engineering school)

School	1991-1995*	1996-2001*	2000-2010*
Architects	**56.4**	**46.6**	**65.6**
Civil Engineering	**39.3**	**35.3**	**50.0**
Rural & Surveying Engineering	**27.1**	**27.9**	**46.2**
Mechanical Engineering	**32.3**	**16.1**	**32.0**
Mining Engineering and Metallurgy	14.3	17.6	19.5
Electrical and Computer Engineering	12.5	13.7	17.6
Naval Architecture and Marine Engineering	--	22.9	15.0
Applied Mathematical and Physical Science	--	--	14.3
Chemical Engineering	13	9.8	9.4
Total (NTUA)	**28.0**	**24.1**	**32.4**

Furthermore, one out of five of the entrepreneurs of our sample are continuing a family business, usually in the same sector of activity. This can be also explained by the fact that traditionally in Greece members of the offsprings are actively involved in the businesses that have been created in the family. Greece has one of the largest numbers of small and micro businesses within the European Union and most of them (80%) are considered as family businesses (Grant Thornton, 2006). Actually almost half of the "larger firms" (turnover above 100.000 €) are family business, so actually their characteristics cannot be straightforwardly related to graduates' characteristics: the original owners / managers of the firm (older family members) have mainly affected their historical path, at least up to now.

Going into more detail in the profile of the founder, it seems that the initial idea for setting up the specific venture is primarily related to the engineers' undergraduate studies (62%). Therefore, there is a close relationship between the entrepreneurial activity undertaken and the founders' scientific specialization acquired during its undergraduate studies. More than half of them have professional experience in the same sector, while a small 4.7% had founded another firm before (Figure 2). More than half of them stated that they actually tried to exploit a specific opportunity in the market. This means however, that part of the remaining entrepreneurs are actually necessity entrepreneurs and their ventures are micro or small.

Figure 1: Sector of economic activity



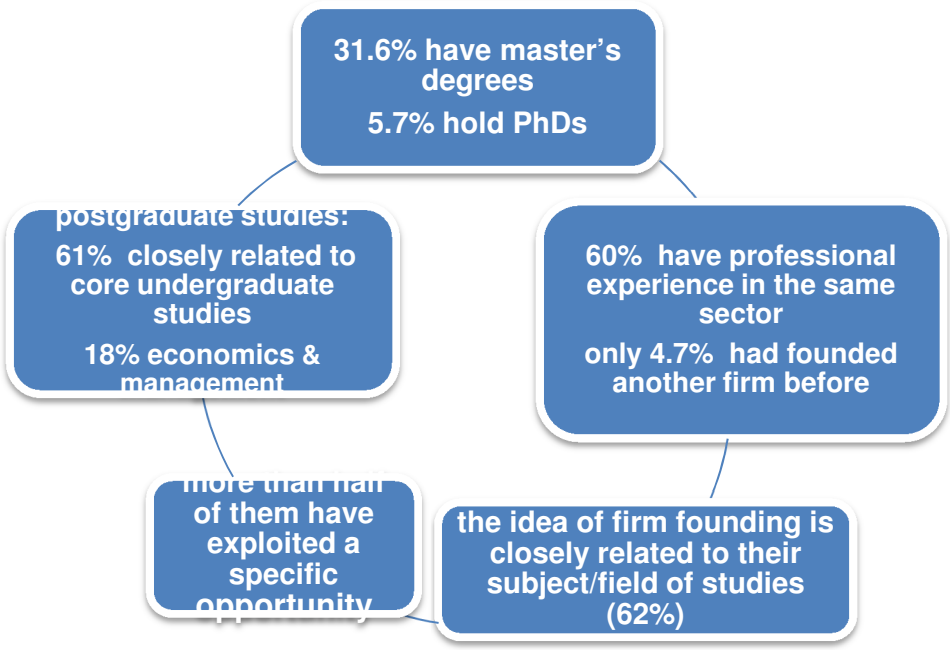
N=465 NTUA entrepreneurs
Source: LIEE/NTUA

In terms of their educational background, a 31.6% have master's degrees and a further 5.7% hold PhDs. Generally, their postgraduate studies is closely related to their core undergraduate studies (61%). Only 18% have followed a postgraduate course in an economics and management, which would reflect a more intensive effort to combine their technological skills with some management skills that might be necessary for running a business.

Looking in more detailed in the type of additional skills that NTUA entrepreneurs have acquired at the undergraduate level, one out of three have not followed any courses related to economics & management (Figure 3). On the other hand, half of the entrepreneurs have had some courses related to "economics" in general, which might be considered as satisfactory, taking into consideration the strict type of the engineering curricula that NTUA offers. A very limited amount of graduates had the opportunity to follow courses of a more practical nature (i.e. risk analysis, finance, market research), that is courses that usually offer some sort of practical tools and hands-on experience to students. Finally, less than 30 graduates out of the 465 entrepreneurs had the opportunity to follow courses on entrepreneurship, which partially can be attributed to the fact that entrepreneurship education was introduced to Greek universities essentially after 2003. Therefore, there was no tradition of offering such courses at NTUA, at least up to 2010[6].

[6] Despite the fact that the provision of courses on entrepreneurship during their undergraduate studies was highly recommended in a previous survey.

Figure 2: Characteristics of the engineer-entrepreneur

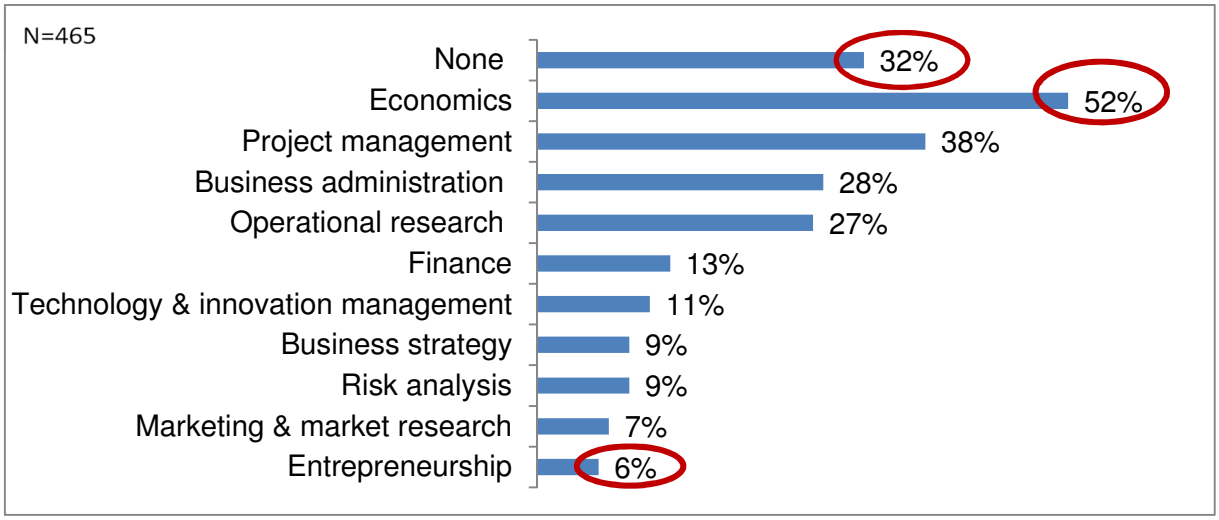


N=465 NTUA entrepreneurs
Source: LIEE/NTUA

These results to some extent represent a choice of their own as they may have not selected such courses from the optional list of courses that are available in each School. But this is mainly affected by the curricula that are actually offered to them in the nine NTUA Schools. The type of courses offered are not the same in all schools with some Schools like Chemical or Mechanical Engineering having a wider list of relevant "economic and business" courses.

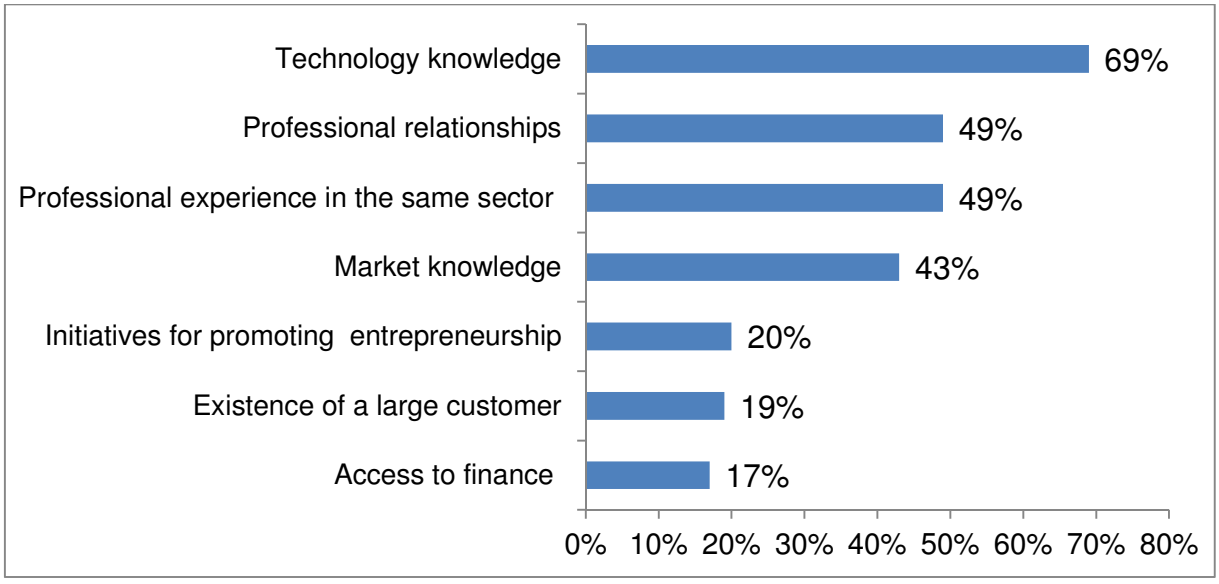
In fact in one of the previous surveys of 2007, the excellence of NTUA regarding its scientific and technical background was highly appreciated. Skills that are considered as important in entrepreneurial activity (e.g. team-working, negation skills, taking initiatives, oral and writing communication skills) were indicated as not adequately cultivated during undergraduate studies. On the other hand, graduates had pinpointed NTUA's major weakness in providing knowledge related to economics and management in general. NTUA graduates had assessed with very low score, dimensions related to the understanding of the wider business environment or the market analysis and opportunity recognition, i.e. two skills that are closely related to the engineers capacity to undertake entrepreneurial action.

Figure 3: Business and management courses at an undergraduate level.



When asked about the most decisive factors that supported their decision to start a business, almost 70% responded that knowledge of technological developments in the specific sector was the most crucial factor (Figure 4). However, half of the entrepreneurs consider the professional experience and the relationships that they have developed during the previous employment as important, indicating the significance of such networking combined with experience in launching a new venture. Market knowledge that usually comes with experience was also assessed as important by a large portion of entrepreneurs whereas other factors such as possible incentives for startups, or acquiring a large customer were not evaluated as being very decisive. Surprisingly enough, access to finance was ranked last in the relevant list. So how did they financed their venture?

Figure 4: Decisive factors to firm creation



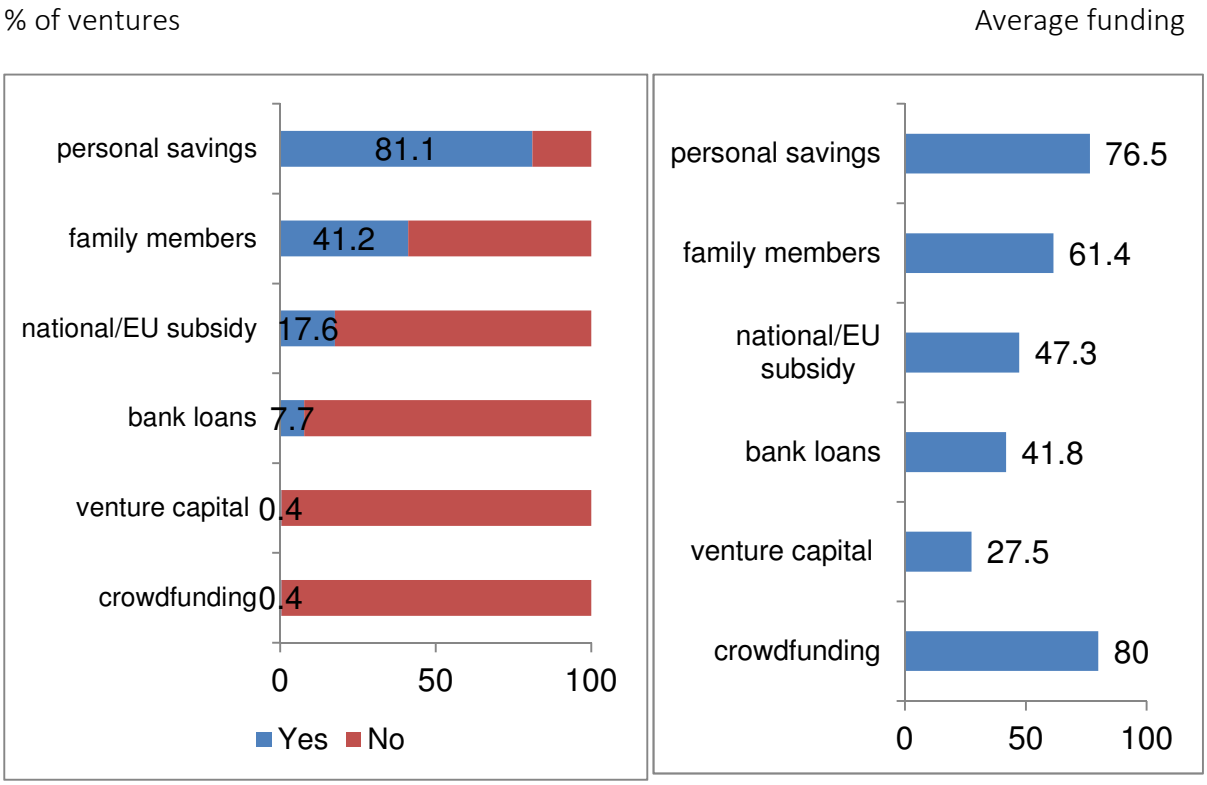
N=465 NTUA entrepreneurs. Source: LIEE/NTUA

Four out of five NTUA graduates used personal savings to finance their venture, which is a rather expected finding (Figure 5). Actually what is most surprising is the fact that there is a 20% that did not use any personal savings. A more detailed analysis reveals that these graduates have actually used financial resources from their family, so these can be considered as "own resources" in general. The most problematic element though is the fact that almost ¾ of the initial investment required to launch the venture was actually stemming from personal savings. This is a very high share, although it corroborates with similar entrepreneurship surveys undertaken at the whole population i.e. Global Entrepreneurship Monitor[7]. The same holds for funding from family resources (61% of the investment).

Hence, most of the capital required to start a business in Greece actually comes from the "unofficial sector", which reveals a malfunctioning of official financing mechanism such as banks or even public supporting subsidies. An extremely low amount of ventures was - at least partially - financed by such schemes, indicating that to start a business in Greece requires mainly personal or family money. Venture capital funding or crowdfunding are also not very popular. To some extent this can be attributed to the credit crunch conditions that emerged in the local banking sector, since 2010. But it represents a rather systemic problem of start ups all over Europe, as Caloghirou et al. have shown at a European level (Caloghirou et al, 2016)

[7] Global Entrepreneurship Monitor Report 2015-2016 (www.gemconsortium.org)

Figure 5: Sources of finance and average funding for new ventures



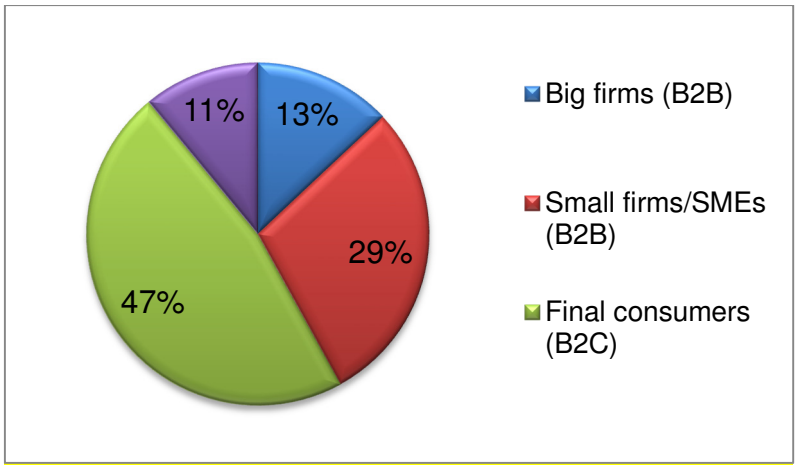
N=465 NTUA entrepreneurs
Source: LIEE/NTUA

Focusing in more detail on the type of ventures that were identified in the survey, we notice that the vast majority of them (81%) is addressing the national market and only a share of 19% appear to have some export activity. This is a rather expected finding strongly related to the nature of the ventures examined in the survey, as most of them represent construction and/or architectural services provided to local customers. In fact, half of them are mainly B2C ventures (Figure 6). Those that do have some exporting revenues are active in the ICT services sector and mainly created by graduates of Computer Sciences. Furthermore, they are also the larger ones while at least half of them represent established family businesses and not new or baby firms.

In terms of innovation, a rather large percentage (40%) reported that their firm has introduced a new or significantly improved product into the market during the last two years. But as several CIS studies have pointed out these innovations are mostly products imported from abroad with embedded technology that indeed might be innovative for the local markets, but represent a business transaction rather than an R&D transaction. Largely this population includes almost all ventures from ICTs and Energy/environment but also some Engineering services as well.

However, when intellectual property protection is examined only 11% of the ventures are protecting parts of their intellectual property[8].

Figure 6: Main customer



As mentioned earlier, there is a small portion of NTUA entrepreneurs (6%, 26 people) that they are of a higher educational background, as they actually hold a PhD. These are mainly IT engineers, while most of them hold a PhD in the main field of their undergraduate studies. Their venture is closely related to technological and research knowledge obtained from their major field of studies, although more than 40% founded their firms before acquiring their PhDs. Perhaps, the most disappointing result is the fact that the majority (18 out of 26) of these firms does not have full-time employees. Actually these represent rather self-employment ventures that were created from young graduates most likely as a legal means for working as researchers, while doing their PhD. Nevertheless, some of the quality characteristics of these ventures do differ from the rest of the ventures identified in the survey. Ventures founded by these PhD graduates exhibit better export and innovation performance, have some patents and are mainly B2B (Business to Business) ventures and not B2C (Business to Consumers). So in fact, ventures created by such advanced human capital have indeed some better quality characteristics, but they are very limited in numbers and their growth in terms of size is questionable.

[8] Most of them being trademarks and industrial designs. There are however 9 patents recorded.

7. Conclusions

Entrepreneurship in general and more specifically knowledge-intensive entrepreneurship are seen as a means to create the knowledge-intensive economy of the future. Our educational systems could contribute towards this direction by developing the appropriate competences, stimulating the entrepreneurial spirit of young students and providing initial assistance in their entrepreneurial activities. During the last twenty years several entrepreneurship-enhancing educational programmes have been implemented and their results have provided us with valuable feedback in order to proceed to further improvements, especially in stimulating knowledge-intensive entrepreneurship.

As far as engineering entrepreneurship is concerned, while it is agreed that graduate engineers are usually equipped with adequate technical knowledge in order to respond to their duties in their professional lives, it has been argued that cultural influences along with the orientation of the engineering curricula on developing technical competences discourage young engineers from engaging in entrepreneurial activities. However, evidence from the implementation of specific educational programmes on engineering students show that entrepreneurial spirit could be stimulated through the appropriate mix of entrepreneurship courses material and hands-on training. The development of non-technical competences, the exposure to the fields of management and economics, the provision of mentoring by senior entrepreneurs, the use of appropriate networks along with incubator facilities and seed financing constitute an integrated educational programme that could enhance knowledge-intensive engineering entrepreneurship.

Results from the survey among young NTUA engineering graduates indicate that one out of three young NTUA graduates undertake some kind of entrepreneurial activity, although mostly in the form of self-employment in construction related activities. The ventures' quality characteristics though are not satisfactory: they are mostly replicates of a traditional pattern of self-employment and micro ventures related to the professional practice of engineering engineering labour market. They are introvert, adopt some shallow innovation, not incorporating or integrating research results and are rather small scale in terms of size and growth. In a nutshell, despite the knowledge content of the specific activities undertaken and the knowledge background of founders, the entrepreneurial activity undertaken by young NTUA graduates is rather conventional, depending on existing production trajectory of the Greek economy.

Some exemptions - or interesting promising cases - include already established family firms, which cannot be strictly related to the graduates' performance (at least not yet) and a more narrow pool of founders holding a PhD. The latter seem to be most promising ventures in terms of growth and innovation potential and are closely related to technological and research knowledge acquired during studies. These are the mainly related to ICTs, energy/environment and much less to traditional construction activities.

Our findings do seem challenging mainly because of the pool of people that they stem from. NTUA graduates can in principal be viewed as a group of people of increased capabilities that could pursue some knowledge-based entrepreneurial activity with growth potential. However, it appears that important prerequisites for enhancing the entrepreneurial capacity of engineers are the combination of "technical thinking" and "engineering feeling", with knowledge background on market and business environment understanding and development of strategic thinking and entrepreneurial feeling. Survey results suggest that although some courses (in principal elective ones) on business and management are offered in the majority of schools, the curricula should be further strengthened and complemented with such courses and hands-on experience so as to nurture and support entrepreneurial culture among young engineers.

Of course entrepreneurial activity of young NTUA graduates cannot be considered as a mere quantitative issue, i.e. encouraging more engineering graduates to set up a firm. Nevertheless, having a critical mass of knowledge-intensive entrepreneurs might be important to raise the probability of ending up with some successful, high-potential firms with significant impact on economic growth and industrial upgrading. So the focus should be in the promotion of the qualitative issues of such entrepreneurial activity i.e. it is largely related to the type of newly-established ventures that emerge from the specific selection pool of these high-capacity graduates. Specifically, it is an issue of a) promoting high-growth knowledge intensive entrepreneurship, either in the form of newly-established ventures or even by contributing to corporate entrepreneurship and the technological upgrading of existing firms; and b) upgrading the average level of engineering practice in the productive system, in order to become more innovative and more responsive to changes at the technological, institutional and market level.

From an entrepreneurship policy level, it is well understood that the aim should not just be an algebraic increase of the number of start-ups that are created in an economy but an effort to affect the quality characteristics of these ventures. Therefore, encouraging a privileged pool of

human capital that is most exposed to scientific and technological knowledge towards such entrepreneurship may increase the specific weight of high-potential entrepreneurship to the overall new entrepreneurship creation, which is an important prerequisite for a new growth model for the Greek economy.

At the universities' strategy level there is a pressure to transform engineering curricula to advance the development of non-technical skills, the provision of sufficient knowledge related to economics and management, the injection of a culture promoting creativity, initiative and entrepreneurship

From 2010 onwards and in the midst of the economic crisis, universities have tried to support entrepreneurship not only at the educational level, but also through complementary activities. In almost all universities, Innovation and Entrepreneurship Units have been established mainly by EU funds. These units aim at promoting the development of innovation and entrepreneurship, especially by facilitating the interconnection of research and technological activities with the economy and the market. They act as a "breeding mechanism" for the development of knowledge-intensive entrepreneurship by students, graduates, postgraduates and researchers. They develop various activities to promote the culture, teaching and study of entrepreneurship and its implications on economic activity, firms, employment and society in large. During the last three years the specific Unit at NTUA supported more than 100 research teams by offering a) individualized mentoring and coaching services so as to take their idea from the lab to the market, b) individualized information on issues related to innovation and entrepreneurship and by facilitating c) the teams' integration into incubating schemes where they were offered more specialized support.

References

Acs, Z. J., Audretsch, D. B., Braunerhjelm, P. and Carlsson, B. (2004) The Missing Link: The Knowledge Filter and Entrepreneurship in Endogenous Growth. Centre for Economic Policy Research (CEPR) Discussion Paper, London: Centre for Economic Policy Research

Arocena, R., and Sutz, J. (2017) Inclusive knowledge policies when ladders for development are gone: some considerations on the role of universities. In Claes Brundenius G., Bo Göransson B. and Carvalho de Mello J.M. (eds) *Universities, Inclusive Development and Social Innovation: An International Perspective*. Cham: Springer

Audretsch, D. and Keilbach, M. (2007), The theory of knowledge spillover entrepreneurship, Journal of Management Studies, 44(7), 1242-1254

Audretsch, D. B., Keilbach, M. and Lehmann, E. (2006) Entrepreneurship and Economic Growth, New York: Oxford University Press

Autio, E., and Acs, Z.J. (2007) Individual and country-level determinants of growth aspirations in new ventures. In *Zacharakis A. (ed.) Frontiers* of Entrepreneurship Research 2007. Babson Park: MA: Babson College

Bager, T. (2011) Entrepreneurship education and new venture creation: a comprehensive approach, *in Hindle, K., Klyver, K. Handbook of research on new venture creation*, *Edward Elgar*, *299-315*

Baumol, W.J. (2004), Entrepreneurial cultures and countercultures, Academy of Management Learning and Education, 3(3), 316-326

Caloghirou, Y., Diakoulaki, D., Mandaraka, M. (2009), The economic and management perspective of engineering studies. The case of the NTUA's Chemical Engineering School. Paper presented at the Conference organized for the *Celebration of the* NTUA's 170 year Anniversary on "Engineers and Technology in Greece", March 4-5, Athens, Greece (in Greek).

Caloghirou, Y., Protogerou, A., Tsakanikas, A. (2016), The AEGIS survey: a quantitative analysis is new entrepreneurial ventures in Europe. In F. Malerba, Y. Caloghirou, M. McKelvey and S. Radocevic (eds) *Dynamics of Knowledge Intensive Entrepreneurship: Business Strategy and Public Policy*. Oxon, UK: Routledge

Chamard, J. (1989), Public Education: Its Effect on Entrepreneurial Characteristics, Journal of Small Business and Entrepreneurship, 6(2), 23-30

D'Este P., Mahdi, S., Neely, A., (2010), Academic Entrepreneurship: What are the Factors Shaping the Capacity of Academic Researchers to Identify and Exploit Entrepreneurial Opportunities?, Danish Research Unit for Industrial Dynamics, Working Paper No. 10-05

De Neufville, R. (2001), The emerging curriculum for engineering, International Journal of Technology, Policy and Management, 1(2), 117-127

Etzkowitz, H. 1998, "The norms of entrepreneurial science: cognitive effects of the new university–industry linkage", Research Policy, 27(8), pp. 823-833

Fayolle, A., Ulijn, J. and Degeorge, J. – M. (2005) The entrepreneurial and innovative orientation of French, German and Dutch engineers: the proposal of a European context based upon some empirical evidence from two studies. In Fayolle, A., Kyro, P. and Ulijn, J. (eds) *Entrepreneurship Research in Europe,* Edward Elgar, 227-253

Fayolle, A., and Redford D.T. (2014) Introduction: Towards more entrepreneurial university, myth or reality? In Fayolle, A. and Redford, D.T. (eds) *Handbook on the Entrepreneurial University*, Cheltenham, UK: Edward Elgar

Fairfield - Sonn, J. W. (1987), A Strategic Process Model for Small Business Training and Development, Journal of Small Business Management, 25(1), 11-18

Franklin S. J., Wright, M., Lockett, A., (2001) Academic and Surrogate Entrepreneurs in University Spin-out Companies, The Journal of Technology Transfer, 26(1-2), pp. 127-141.

Garavan, T.N. and O'Cinneide, B. (1994) Entrepreneurship education and training programmes: a review and evaluation – Part 1, Journal of European Industrial Training, 18(8), 3-12

Gibb, A. A. (2006), Towards the Entrepreneurial University: Entrepreneurship Education as a Lever for Change, Policy Paper Series, Birmingham: NCGE

Gibb, A. A. (1993), The Enterprise Culture and Education: Understanding Enterprise Education and its Links with Small business, Entrepreneurship and Wider Educational Goals, International Small Business Journal, 11 (3), 11-34

Gibb, A.A. (1990) Design effective programmes for encouraging the small business start – up process, Journal of European Industrial Training, 14(1), 17-25

Ginzberg, E., Ginsburg, S., Axelrad, S. and Herma, J. (1951), De l'imaginaire au rialisme, *in Guichard, J. and Huteau, M. (2001), Psychologie de l'orientation, Paris: Iditions, Dunod, 122–125*

Global Entrepreneurship Monitor Report 2015-2016 (www.gemconsortium.org)

Gorman, G., Hanlon, D., and King, W. (1997) Some research perspectives on entrepreneurship education, enterprise education and education for small business management: a ten-year literature review, International Small Business Journal, 15(3), 56-78

Grant Thornton Family Business Survey -Center for the Entrepreneurial & Technological Development of North Aegean, June 2006 (accessed 14/4/2008; www.keta-ba.gr).

Hartshorn, C. and Hannon, P. (2002), Paradoxes in entrepreneurship education: chalk and talk or talk and cheese?, paper presented at the 25th ISBA National Small Firms Conference: Competing perspectives of Small Business and Entrepreneurship, Brighton, 1–19 November

Henrekson, M. and Johansson, D. (2010). Gazelles as job creators: a survey and interpretation of the evidence. Small Business Economics, 35(2), 227-244

Hood, J. N., and Young, J. E. (1993), Entrepreneurship's Requisite Areas of Development: A Survey of Top Executives in Successful Entrepreneurial Firms, Journal of Business Venturing, 8(2), 115-135

KEINS (Knowledge-based entrepreneurship: Innovation, networks and systems) (2008), Final Report, Project Funded under the 6th Framework Programme (Project no. CT2-CT-2004-506022)

Lasserre, H. (1989), Le Pouvoir de l'ingénieur, Paris: Editions l'Harmattan

Leitch, C.M. and Harrison, R. T. (1999), A process model for entrepreneurship education and development', International Journal of Entrepreneurial Behaviour and Research, 5(3), 8–10

Lenzi, C., Bishop, K., Breschi, S., Buenstorf, G., Llerena, P., Malerba, F., Mancusi, M. L. and McKelvey, M. (2010) New innovators and knowledge intensive entrepreneurship in some European sectoral systems: a field, *in Malerba, F. (2010) Knowledge-Intensive Entrepreneurship and Innovation Systems, Routledge, London, UK and New York, NY*

Liagouras, G., Protogerou, A., Caloghirou, Y. (2003) Exploring Mismatches Between Higher Education and the Labour Market in Greece, European Journal of Education, 38 (4), 413-426

Liargovas, P. (1997) The White Paper on Growth, Competitiveness and Employment and Greek small and medium sized enterprises, Small Business Economics, 11(2)

Lissoni, F., Llerena, P., McKelvey, M. and Sanditov, B. (2007) "Academic patenting in Europe: new evidence from the KEINS database", Deliverable 27 in KEINS, Knowledge base entrepreneurship: institutions, networks and systems, EU project no CT2–CT–2004–506022

Löbler, H. (2006), Learning entrepreneurship from a constructivist perspective, Technology Analysis & Strategic Management, 18(1), 19–38

Lucas, R. (1993), Making a Miracle, Econometrica, 61, 251–72

Makridakis, S., Caloghirou, Y., Papagiannakis, L. and Trivellas, P. (1997) The dualism of Greek firms and management: present state end future implications, European Management Journal, 15(4)

Malerba F. and McKelvey M. (2016). Conceptualizing knowledge intensive entrepreneurship: definition and model. In F. Malerba, Y. Caloghirou, M. McKelvey and S. Radocevic (eds) *Dynamics of Knowledge Intensive Entrepreneurship: Business Strategy and Public Policy*. Oxon, UK: Routledge

OECD, (2010) "Bologna+10" high – level meeting on lessons from the global crisis and the way forward to job creation and growth: Chair's summary, Paris, 17-18 November: OECD

Papayannakis, L., Kastelli, I., Damigos, D., Mavrotas, G. (2008) Fostering entrepreneurship education in engineering curricula in Greece. Experience and challenges for a Technical University, European Journal of Engineering Education, 33 (2), 199-210

Protogerou, A., Caloghirou, Y., and Siokas, E. (2013) Twenty-five years of science-industry collaboration: the emergence and evolution of policy-driven research networks across Europe, Journal of Technology Transfer, 38, 873–895

Romer, P. (1986) Increasing Returns and Long-run Growth, Journal of Political Economy, 94(5), 1002-1037

Scharmer, C.O. (2007) Theory U: Leading from the Future as It Emerges, Cambridge, MA: SoL Press

Scharmer, C.O. and Käufer, K. (2000), Universität als Schauplantz für das Unternehmerischen Menschen', in Laske, S., Scheytt, T., Meister- Scheytt, C. and Scharmer, C.O., Universität im 21 Jahrhundert, Mering: Rainer Hamp Verlag (English version available at www.ottoscharmer.com)

Shane, S. (2004) Academic Entrepreneurship: University Spinoffs and Wealth Creation, Edward Elgar

Shane, S. and Venkataraman, S. (2000), The promise of entrepreneurship as a field of research, Academy of Management Review, 25(1), 217-226

Siegel, D. and Wright, M. (2015), Academic Entrepreneurship: Time for a Rethink?." British Journal of Management, 26(4), 582-595

Tsakanikas, A., Giotopoulos, I., Korra, E. Stavraki, S., "Entrepreneurship 2015-16: A turning point for the growth dynamics of the business sector", IOBE November 2016 (in greek), http://iobe.gr/docs/research/en/RES_02_01122016_SUM_ENG.pdf

Verzat, C. and Bachelet, R. (2006) Developing an entrepreneurial spirit among engineering college students: what are the educational factors?, *in Fayolle, A and Klandt, H., International Entrepreneurship Education: Issues and Newness, Edward Elgar, 191-217*

Wennekers S. and Thurik, R. (1999) Linking entrepreneurship and economic growth, Small Business Economics, 13, 27-55.

Wright, M., Robbie, K. and Ennew, C. (1997) Venture Capitalists and Serial Entrepreneurs, Journal of Business Venturing, 12(3), 227-249