Heterogeneity in knowledge-intensive entrepreneurship: an exploratory exercise in young European firms

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Abstract

This paper empirically explores the heterogeneity of young firms in Europe based on the notion of knowledge-intensive entrepreneurship (KIE). In doing so, it attempts to shed new light on questions related to the phenomenon of KIE, which is understood here to involve new ventures that are highly innovative as a consequence of their being engaged in knowledge-intensive activities. Our findings suggest the presence of three groups of firms. The first one, termed "world-class KIE", emphasizes new-to-world innovation based on in-house knowledge which in turn draws on high quality human capital, while the second, labelled "all-around KIE", exhibits a more balanced focus on different aspects of innovation and relies primarily on external knowledge seeking. The group of firms, called "modest KIE", seems to mainly pursuing new-to-firm innovation based on industry knowledge sources while it generally lags behind the other two groups both in terms of knowledge search and innovative activities. Moreover, empirical findings suggest that there are variations in firms within a particular institutional setting or industrial sector, which can be explained as a function of the diverse models of action chosen by entrepreneurs through the acquisition, combination and recombination of resources to exploit profit opportunities.

Keywords: Knowledge-intensity, innovation outcome, entrepreneurship, young firms, heterogeneity

1. Introduction

Firms are found by highly heterogeneous processes, their founding teams are diverse in terms of preferences, founding motivations, entrepreneurial ability and demographic characteristics. Furthermore, firms grow in different political, institutional, industrial, cultural and social environments, have dissimilar access to resources and ultimately achieve various performance outcomes (Delmar and Wennberg, 2010). This diversity among firms, and especially among young ones, cannot be easily reduced to a general model. Their variability calls for a taxonomy or a classification system in order to identify the many variables that can be at play and in turn provide distinct patterns of entrepreneurial behaviour.

This paper takes up the challenge of studying patterns of entrepreneurship in Europe following a recent definition of knowledge-intensive entrepreneurship (KIE) (Malerba and McKelvey, 2016) which is considered as a form of high-potential entrepreneurship with significant impact on economic growth and social well-being. This definition suggests that knowledge-intensive entrepreneurship is associated with *four* basic characteristics. In particular, it refers to *new* firms that have significant *knowledge intensity* in their activity and develop and exploit *innovative* opportunities in *diverse sectors* (both high, medium and low-tech manufacturing and knowledge-intensive business services).

The proposed taxonomy is based on empirical evidence and measured observations emerging from the large-scale which covered ten European countries. Our analysis consists of two steps. First we applied cluster analysis techniques to build a firm taxonomy of entrepreneurial behaviour based on the four predefined characteristics of KIE, next we examined how new ventures exhibiting different degrees of knowledge

intensity and innovative performance are distributed across diverse institutional and industrial contexts.

The results of our research provide a snapshot of the knowledge intensity and the innovative performance of young ventures by classifying them into groups or clusters that share common traits. In particular, the empirical taxonomy identifies three types of entrepreneurial ventures which exhibit distinct KIE characteristics: a) *all-around KIE*[1] b) *world-class KIE* (focusing on product innovation), and c) a third 'mixed bag' category which can be labeled as *'modest KIE'*, where co-exist firms with different degrees of 'knowvation' (a term which combines knowledge-intensity and innovative performance). The 'all-around KIE' group shows a balanced emphasis on knowledge seeking activities (both in-house and from external sources), on new-to-market product innovation, and on process and organizational innovation. On the other hand 'world-class KIE' emphasizes new-to-world product innovation drawing from in-house knowledge which in turn draws from high quality human capital (both in terms of founders and workforce). The 'modest KIE' group focuses on new-to-firm product innovation drawing from external industry knowledge sources. In general, it appears smaller degrees of knowledge-intensiveness and innovation compared to the other two groups.

Moreover, our results suggest that although the strategic preferences of firms are up to a certain extent determined by their environment, within a particular institutional setting (e.g. a particular National Innovation System) or industrial sector, there are variations in firms that can be explained as a function of the diverse models of action chosen by

[1] The term 'all –around' is a metaphor drawn from basketball. The all around basketball players have a combination of speed, agility, jumping ability, strength, power and conditioning. The combination of these skills allows them to be all-around players, able to perform the various actions required during the game- shooting, dribbling, playing defense and grabbing rebounds.

entrepreneurs through the acquisition, combination and recombination of resources to exploit profit opportunities.

This work adds to the literature in several ways: a) it operationalizes and measures KIE by testing its applicability in a large number of firms, thus opening up new ways for a better understanding and further refinement of this concept; b) it provides a way of reducing the heterogeneity identified in the entrepreneurial behaviour of new firms into a few meaningful categories; c) it shows that these categories of firms run across countries and sectors rather than coinciding with them; d) it may assist in targeting and refining policies for promoting entrepreneurship and innovation.

The paper begins with a theoretical discussion on the definition of knowledge-intensive entrepreneurship and attempts to show why a taxonomy of young firms exhibiting variations in their knowledge-intensity and innovative outcome might be useful for better understanding knowledge-intensive entrepreneurship. In the third section we present the survey design and introduce the experimental setting. We then document the empirical results and discuss major findings. The paper ends with our concluding remarks.

2. Theoretical background.

2.1 Defining Knowledge intensive entrepreneurship

It is well established that investments in knowledge generation and dissemination and in human capital generate innovation, economic growth both directly and indirectly via knowledge spillovers (for a review see Malerba and Brusoni, 2007; Fagerberg et al., 2005; Freeman and Soete, 1997; Rosegger, 1996). Nonetheless, large investments in knowledge generation such as research and development (R&D) do not lead automatically to innovation and economic growth. New knowledge does not always

result in new economic activity. Even a higher degree of entrepreneurship and new business creation does not guarantee innovation, enhanced economic performance and faster rates of economic growth (Wong et al., 2005).

Contemporary entrepreneurship research appears to be moving from a view that 'all forms of entrepreneurship are good' towards a more nuanced view where 'high-potential entrepreneurship' is an important driver for economic development (Autio and Acs, 2007; Henrekson and Johansson 2010).

Knowledge intensive entrepreneurship can be considered as a type of high potential entrepreneurship and indicates ventures whose 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.

The definition of knowledge-intensive entrepreneurship adopted in this study (Malerba and McKelvey, 2016) is associated with new ventures that draw upon and integrate knowledge (both in-house and externally generated) in order to pursue and exploit innovative opportunities; moreover, they are ventures operating in diverse industries (including low-tech industries and services).

The notion of innovative opportunities, as used here, is broader than the pursuit of opportunities stemming from scientific and/or technological knowledge; it also involves the creative process of identifying the potential for delivering value for hitherto unserved market needs, mobilizing and/or creating the requisite resources for realizing the opportunity and, finally, devising ways by which at least part of the generated economic value can be appropriated by the firm.

Perhaps the best way to understand the notion of KIE is to compare it with related but distinct concepts. First, a KIE venture is not simply a new venture or start-up firm; it is a new venture that, as described above, pursues innovative opportunities by purposefully and systematically utilizing knowledge in its operational activities. Second, a distinction should be made with the related concept of new technology based firms (NTBFs). The literature here focuses on new firms that either transform generic (basic science) research into basic technologies (i.e. science-based NTBFs) or new firms that apply basic technologies to develop new products/services for particular market needs (i.e. engineering-based NTBFs). The key difference between these two types of NTBFs and KIE ventures is that for the latter the transformation of science and technological knowledge is not the sole element in the innovation process. This is because for KIE new ventures technological assets are but one class of resources and capabilities needed for the successful commercialization of innovation. The ultimate goal here is *market success*, not 'simply' the development of a radical innovation.

The broader context (i.e. knowledge sources, markets, institutions, and opportunities) within which ventures are embedded assumes a major role in our understanding of KIE. Specifically, it is assumed that the context affects directly and/or indirectly the ways and mechanisms by which KIE ventures are formed in the first place, as well as the management and strategic behaviour of these firms in pursuit of innovation and growth. Whatever effect has KIE venture performance in terms of the dynamics of market structure and wider economic and societal impacts feeds back to the broader institutional context, thus closing the loop. Put differently, KIE and the surrounding context find themselves in a state of constant dynamic interaction.

Beyond the immediate industry specificities (e.g., the existing technological regime in terms of opportunities and appropriability conditions) and factors of demand that make

entry of KIE ventures more or less possible in the first place, the broader institutional and policy context also plays an important role in the supply and performance of KIE (Delmar and Wennberg, 2010). More specifically, depending on context, entrepreneurial ambitions will differ as the demand for specific types of entrepreneurship changes. This practically means that the opportunities identified and exploited, the people involved in self-employment and the firms that are eventually created, grow up and die depend on contextual conditions. National and sectoral systems of innovation are widely held to play a prominent role in this respect.

2.2 Can an empirical taxonomy of knowledge-based entrepreneurship be useful?

New firms have been identified as engines for growth, innovation and wealth creation. While a good share of young small firms are expected to be short lived, exiting the market within a few years from their formation (Headd, 2003; Knaup and Piazza, 2007; OECD, 2014), empirical evidence shows that surviving young firms, and especially a relative small share of them that manages to grow, account for a significant share of new job creation (Hathaway, 2013; Criscuolo et al., 2014; Coad et al., 2014). Firms that innovate successfully increase their chances of survival and growth and are, therefore, a key element for economic development and growth (de Jong and Marsili, 2006; Arvanitis and Stucki, 2012). New firms have been identified as engines for growth, innovation and wealth creation (Audretsch and Turik, 2000). High-potential young firms are described as 'the kind that create value and stimulate growth by bringing new ideas into the market, be they new technologies, new business models, or simply new and better ways of performing routine tasks' (Schramm, 2005, p.163)

New firms are also highly heterogeneous. For example, the process by which firms are found is heterogeneous itself (Delmar and Davidson, 2000), entrepreneurs have

different preferences, and demographic characteristics, firms evolve in different contexts, with different access to resources, and they strive for different performance outcomes (Gartner and Carter, 2000). Thus heterogeneity is a challenge for entrepreneurship and the diversity among young firms cannot be easily reduced into a universal model.

Having in mind the definition of KIE presented in the previous section we are interested in understanding the variability of newly established firms in terms of both their innovative performance and their knowledge assets. Indeed, research indicates that the innovative performance and behaviour of young firms can vary substantially. Some small firms survive by competing in a market niche, while others may pursuit radical innovations and eventually become new market leaders (de Jong and Marsili, 2006). Furthermore, young firms exhibit heterogeneity in terms of their knowledge assets (e.g. educational background and experience of founders, education of employees or employ training) and the knowledge-seeking activities they are involved in (for instance some are more extrovert and invest in collaboration with third parties such as universities and research centres while others obtain new knowledge mainly through their own R&D activities) (Gartner, 1988; Landstrom and Astrom, 2011).

The diversity among new firms cannot be easily reduced into a single model of entrepreneurial venture. Their variability calls for a taxonomy that can be used to identify the many variables that might play a role. Taxonomies of new entrepreneurial ventures that display different degrees of ‘knowvation’ might provide an empirically based framework to test the theoretical concept of knowledge-intensive entrepreneurship as well as to provide useful policy guidelines.

Taxonomies are meant to classify phenomena with the aim of maximizing the differences across groups. A proposed taxonomy is considered useful if it helps in reducing the complexity of empirical phenomena into a few and easy to recall macro-classes (categories) (Archibugi, 2001; de Jong and Marsili, 2006; Pavitt, 1998). Thus a broadly accepted and usable taxonomy is an essential element in the development of a scientific body of knowledge and can serve as an empirically based framework to theory development and hypothesis testing. According to Rich (1992) organizational taxonomies provide a basis for strong research, permit parsimony without simplicity, and the ability to recognize fundamental structure and relationships by comparing organizations and clustering them into categorical types. Moreover, taxonomy is more than a simple classification of items into separate groups. It is rather a specific classification scheme that labels many different items into groups or clusters with common characteristics.

3. Data and variables

3.1 Data

A large-scale survey (AEGIS)[2] was carried out in the first half of 2011 by means of computer assisted telephone interviewing using a structured questionnaire. This survey differs from other relevant surveys, both in its context and scope. It could be positioned between Community Innovation Survey (CIS) and Global Entrepreneurship Monitor (GEM). However, it is distinct from both, but also from other relevant surveys such as the KfW-ZEW Start-up Panel, the Kauffman Firm Survey and OECD.

[2] AEGIS (Advancing Knowledge-Intensive Entrepreneurship and innovation for Economic Growth and Social Well-being in Europe) is an EU funded Large-Scale integrated research project in the thematic area of Socioeconomic Sciences and Humanities of the Seventh EU Framework Programme.

Nevertheless, AEGIS takes into consideration most of the above mentioned surveys and incorporates all elements that support its unique aim: to examine the multi-dimensional concept of knowledge intensive entrepreneurship. In this way we will be able not only to identify motives, characteristics and patterns in the creation and growth of new firms, but also pinpoint those key elements that will help us distinguish between discrete types of entrepreneurial new ventures. It will, therefore, be the first time, at least to our knowledge, that empirical data will be used to identify different patterns of entrepreneurial behaviour by classifying young firms based on their knowledge-based intensity and innovative performance (knowvation).

All respondents were usually the founder/entrepreneur or members of the founding team. The survey focus was on young firms in ten European countries, namely France, Italy, UK, Germany, Sweden, Denmark, Sweden, Greece, Portugal, Croatia and Czech Republic. In order to interview actually newly-established firms the survey instrument included a set of screening questions to detect a) firms that were just new legal entities resulting from legal transformation of already existing firms, b) subsidiaries of existing companies, c) mergers, acquisitions, or joint ventures. These firms were characterized as non-eligible for the survey.

The primary data source for the survey population was the Amadeus Database. However additional data sources were used (Kompass, D&B) as during the interview process (screening questions) it was found out that a large number of firms recorded as new were not the case.

An initial sample of 23,405 firms was randomly drawn from the entire population of firms as available at the abovementioned databases. Among them 10,581 were judged as not eligible for the survey during the screening part of the questionnaire mostly because they were not actually new entities but just legal transformations of already

existing companies. The final sample of eligible firms was 12,824 firms and 4,004 of them accepted to respond to the questionnaire, thus the survey obtained an average response rate of 31.2% across countries.

Our choice of sampling was guided by the adopted definition of KIE and the need to limit unobservable heterogeneity, which plagues many contemporary entrepreneurship studies (Shane, 2003). New ventures are largely heterogeneous, ranging from 'mom and pop' retail stores to venture capital backed firms in high-tech industries. Random samples of new firms indicate that only one out of ten young firms can be characterized as 'innovative', while most new businesses are created as replications or marginal variations of already existing products or services (Delmar and Wennberg, 2010). The ventures of our sample are active in a wide variety of industries, including low and high-tech manufacturing and knowledge-intensive business services (KIBS). Thus our understanding of KIE allows us selecting not only traditional knowledge-intensive sectors (i.e. high-tech manufacturing and KIBS) but also low and medium-tech industries suggesting that increased knowledge seeking activities and innovation can also be found in sectors that are not necessarily heavy R&D spenders. In any case the specific sample selection enables us to focus on firms that exhibit some degree of 'knowvation' i.e. they can be characterized up to a certain point as knowledge-intensive entrepreneurial ventures (see Table 1)

<<Table 1 around here>>

3.2 A first step towards establishing a KIE taxonomy

Clustering variables

For the construction of the taxonomy we used cluster analysis techniques. These techniques are sensitive to the selection of the variables used meaning that the addition

of irrelevant variables can affect clustering results (Milligan and Cooper, 1987). Therefore we employed a set of 'core variables' by 'translating' our general understanding of the KIE phenomenon into empirical indicators. In the theoretical background we have already stated that in the context of the AEGIS project, KIE is related to four fundamental characteristics: it concerns new ventures; new ventures that are not to be found solely in high-tech industries (they may well be active in industries with medium or low-tech characteristics or in services); new ventures that are innovative; and finally, new ventures engaging in activities that are knowledge intensive. The first and second conditions are satisfied a priori in our sample. We have collected data from new ventures (from four to maximum eleven years of age), and these ventures are sampled from a wide array of industries, including both high- and low-tech industries. We therefore need variables for the remaining two conditions: knowledge-intensive activities and innovation performance which point to the 'knowvative' content of KIE (i.e. the combination of knowledge intensity and innovative performance)

Table 2 presents the dimensions and variables that formed the basis of the proposed taxonomy. As it can be seen in the table, four classes of variables were employed as distinguishing features of KIE. The three first, as in the AEGIS survey, reflect what might be understood as the venture's *knowledge assets or knowledge intensity* dimension, while the last one represents the *innovation output* dimension.

Knowledge intensity

A firm's knowledge intensity dimension includes measures of 'knowledge seeking activities', 'initial knowledge capital', and 'human capital and innovation input'. *Knowledge-seeking activities* are related to specific linkages that can act as sources of information and knowledge for the young firm. These activities are measured by a

Likert-type scale and confirmatory factor analysis revealed the following five dimensions.

- *External knowledge sources related to industry*: reflects the importance of knowledge sourced from clients, suppliers and competitors.
- *External knowledge sources related to science actors* such as public research institutes and universities.
- *In-house R&D knowledge*: knowledge generated from internal sources (single item).
- *External-Open sources*: knowledge sourced from trade fairs, conferences and exhibitions, scientific journals and other trade or technical publications.
- *Participation in collaborative R&D:* participation in nationally-funded or EU-funded research programmes

The remaining two groups of indicators are 'initial conditions' and 'human capital and innovation input'. Beginning with 'initial conditions', average educational attainment of the founding team can be thought of as representing the initial stock of knowledge founders bring with them when starting the venture. For each individual member of the founding team we measure educational attainment using an ordinal variable taking the values: 1 – elementary education; 2 – secondary education; 3 – Bachelor degree; 4 – Postgraduate degree; 5 – Ph.D. degree. We average across team members to derive an overall measure of founders' education.

The percentage of funding coming from venture capital may be seen to reflect the quality or ingenuity of the original idea that led to the formation of the venture. One would normally expect that, ceteris paribus, the higher the contribution of venture capital the higher the originality and innovation potential of the firm. Taken together, these two variables may be argued to represent the 'initial' knowledge capital available

to the venture at start-up. As regards the next four variables, the positive role of human capital (percentage of employees with advance qualifications i.e. percent over full-time employment of employees with a graduate/Ph.D. degree respectively), employee training (single 5-point Likert-type question) and R&D intensity (the *average* percentage of R&D expenditures over sales for the last three years) as inputs for knowledge creation and innovation is self-evident.

Naturally, we do not pretend that the aforementioned variables are the only, or even the best, measures that could be used as indicators of knowledge intensity; we simply contend that, within our particular context and data at hand, they represent reasonably faithfully the latent concept of interest.

Innovation performance

The definition and measurement of *innovation performance* dimension is based on fairly standard variables similar to those employed in the Community Innovation Survey (CIS). Taken together they capture various aspects of innovation performance, including product, process and organizational innovation, and methods of intellectual property protection.

Product innovation is measured with variables capturing both the presence and degree of novelty of product innovation that had occurred in the three years previous to the survey. All innovation performance variables are binary (yes/no) ones.

<<Table 2 around here>>

3.3 Variables used for validation

In order to assess the validity of the proposed taxonomy of KIE derived from the above variables, we rely on a set of variables that have not been used in building the firm clusters but are expected to vary across them. For this reason we use variables indicative of various aspects of a firm's founding motives, capabilities and competitive strategy

(internal factors) and performance. These variables can be assumed to vary across groups of KIE firms. For example, if a cluster is made up of young firms exhibiting high knowledge assets and innovative performance we would expect that its firms will develop to a greater extent R&D, product development and networking capabilities compared to their less KIE counterparts. Furthermore, such a cluster is expected to exhibit better performance in terms of growth, sales and exports.

The specific variables used to validate the clusters are as follows:

Founding motives are measured using a Likert-type scale (1: Not important; 5: Extremely important) that asks respondents to '*indicate the importance of various factors related to the formation of the venture*'. Confirmatory factor analysis revealed the following three dimensions (see Annex for CFA results):

- *Founding motive-technical knowledge*: this dimension is related with technical/engineering and design knowledge in the field
- *Founding motive-market knowledge & networking*: this sub-scale reflects the importance of knowledge of the market and of networks built in the past
- *Founding motive-opportunity*: perception of opportunities deriving from technical change and new market needs

Following is a set of variables measuring various aspects of the firm's competitive behaviour. First, we measure the firm's dynamic capabilities using multi-item Likert type scales as reflected in three constructs:

Product development capability represents the firm's capacity to offer novel products, adapt its offerings to the needs of specific market segments and effective marketing and promotion

R&D and alliance-related related capability captures the importance of R&D activities as well as of partnerships and networking with scientific research organizations

Networking capability was measured by operations regarding market processes such as collecting information about competitors, accessing distribution channels, exploring export opportunities, advertising and promotion. Regarding the technology side of the networking capability we employed variables assessing the network's impact on the development of new products/services, the management of production and operations, as well as the easy access to skilled personnel. Finally in order to catch the economic and more generic value of networking we used variables assessing networks' assistance in obtaining business loans and attracting funds or providing support on legal issues.

The three multi-item scales pertaining to dynamic capabilities were tested following Confirmatory Factors Analysis (CFA) in order to confirm that particular items relate to a specific dynamic capabilities construct.

Next, we used two variables to measure strategic behavior: *strategy* and *sales in international markets*. Strategy is an indicator variable showing whether the firm follows a low-cost, differentiation, or focus strategy. Sales in international markets, is a continuous variable measuring the percentage of sales obtained in international markets in the last three years. It reflects the degree to which a firm pursues opportunities beyond domestic markets.

Third, we measured venture performance with two variables. The first is a subjective, single item measure that asks respondents to indicate their venture's *average profit* over the past three years. The response scale ranges from 1 (losses) to 8 (more than 5 million Euros). The second is a continuous variable measuring *average sales growth* over the past three years. Because the empirical distribution was highly non-linear with extreme skweness and kurtosis, we transformed this variable to range between 1 (negative growth) and 10 (corresponding to the 10% to 90% percentiles of the empirical distribution).

4. Empirical results and discussion

Our analysis consists of two steps. We first applied cluster analysis techniques to build a firm taxonomy based on the characteristics of KIE and then we used analysis of variance and χ^2 tests in order a) to further test the validity of the proposed taxonomy using additional variables to those originally used to form the proposed clusters or groups b) to examine how new ventures of different knowledge intensity and innovative performance are distributed across different institutional and industrial contexts

4.1 Empirical taxonomy

Two remarks are in order here. First, all variables used for clustering (see below) are binary, including those that are originally operationalized as Likert-type scales (e.g. employee training) or as continuous (e.g. percentage of full-time employees with Ph.D. degrees). This is due to technical reasons. Recall that most of our measures on innovation performance are binary. Clustering algorithms require a measure of (dis)similarity among cases (in our case: new ventures), and this typically necessitates that all variables are on the same metric. Since it would not be possible to transform binary variables into interval ones, we opted for the opposite. For interval variables (i.e. those ranging from 1 to 5) the transformed dichotomy took the value of one when the original value was greater or equal 4 (and zero otherwise), whereas for continuous variables the lower threshold for one was a value greater or equal the 75% percentile of the empirical distribution (and zero otherwise).

Second, the reader may notice that some variables that might seem obvious to include in the clustering procedure are missing from Table 3 below. This basically concerns two measures of innovation performance (i.e. percentage of innovative sales and percentage of innovative services). Again the reason of not including these two variables is technical. There are simply too many missing values for these variables,

and therefore their inclusion would greatly reduce the sample size. With the variables described in the above section, we have 3,226 firms with complete data.

We are interested to determine whether there exists a meaningful grouping in our observations on the basis of their similarity in knowledge assets and innovation performance as reflected by the (binary) variables identified above. We performed Kmeans cluster analysis with the STATA 12 software, employing the simple matching binary similarity coefficient (Sokal and Michener, 1958). Kmeans is a partition method that attempts to break the observations into a distinct number of non-overlapping groups (clusters). The main problem with cluster analysis is to decide on the number of clusters, to balance the need to represent the data appropriately and, at the same time to keep the data manageable. Determining the 'correct' number of groups in one's data is an inherently subjective exercise. We set out to examine solutions comprising between two and six clusters. As an aid to the researcher, STATA provides two indexes: the Calinski and Harabasz (1974) pseudo-F index and the Duda-Hart (2001) index. Both these statistics favoured the two-cluster solution, suggesting the three-cluster as the second best (the remaining 4-, 5- and 6-cluster solutions provided much worse indexes). Upon inspection, we decided that the most meaningful grouping in our data is given by the 3-cluster solution. The descriptive statistics on each of the three groups are given in columns (2) to (4) of Table 3. Column (5) gives the sample means.

<<Table 3 around here>>

As can be seen from Table 3, we distinguish between 'modest KIE', 'all-around KIE' and 'world-class KIE' firms. The 'modest KIE' group is the most highly populated in our sample (i.e. 2012 firms). Its main characteristic is that none of the means of the

variables used in cluster analysis is greater than the respective sample average.[3] Apparently, this group of firms do engage in knowledge-intensive activities and innovation. For instance, they are the second best group in terms of process and organizational innovations outperforming the 'world class' KIE ventures. However, they generally lag behind in most variables compared to the other two groups. For example, only 44% of firms belonging into this group have introduced product innovation in the last three years compared to 100% for both remaining groups.

'All-around KIE' (AaKIE) firms are distinguished by their balanced emphasis on knowledge seeking activities (both in-house and from external sources), on new-to-market product innovation, and on process *and* organizational innovation. Interestingly, initial knowledge stock, as reflected in founders' average educational attainment, does not seem exceptional; only 20% of these firms report founders with graduate degrees or higher compared to 57% in the last group. All-around KIE group of firms also do not patent as much as world-class KIE, and more generally they do not emphasize much intellectual property protection, again as compared to the last group, except for lead-time advantages.

In contrast, new-to-world product innovation, IPR protection, and knowledge creation stemming from highly educated founders and human capital seem to be the distinguishing marks of the last group, hence the label 'world-class KIE' (WcKIE). WcKIE ventures appear to lag behind the other two groups in terms of process innovation implying a distinctive prevalence of product over process and organizational innovation. It is interesting to note that in this group, firms depend mainly on in-house knowledge creation and less so on knowledge from external sources (the latter

[3] Note that in Table 3, means are in bold when they are greater than the overall mean. Also note that because variables are binary their means represent the percent of firms *within each group* that score one in any given variable.

characterizing AaKIE). It is perhaps no coincidence that this group is the least populated in terms of number of firms: 487 compared to 727 for 'all-around KIE' and 2012 for the 'modest KIE'.

What is the general picture emerging from these results? Are there KIE ventures in our sample? The answer, we believe, is yes; in fact we find three clear varieties of ventures that they are exhibiting different degrees of 'knowvation'. The AaKIE group appears a more balanced emphasis on different dimensions of innovation and relies basically on external knowledge seeking, while the WcKIE emphasizes new-to-world innovation drawing from in-house knowledge which in turn draws from high quality human capital (both in terms of founders and workforce). In addition, we find a third group of new ventures that although involved in diverse knowledge seeking and innovative activities, it generally demonstrates a lower degree of both knowledge intensity and innovation performance as compared to the other two. In terms of product innovation, the'modest KIE' group, focuses mainly on new-to-firm products and draws to external knowledge sources such as customers and suppliers. At the same time it is close to the average sample and well above WcKIE ventures as regards to process and organizational innovations.

A further assessment of the validity of clusters and the proposed KIE taxonomy can be achieved by exploiting variables not used to form the clusters, but known or expected to vary across them (Milligan and Cooper, 1987; Hair et al., 1998 p.501).

Specifically, we examine differences with respect to three sets of external variables used for this purpose: (a) motives related with forming the venture; (b) a host of internal factors (e.g. dynamic capabilities, strategy, etc); and (c) firm performance.

We performed simple analysis of variance to produce the results shown in Table 4. We report the means of interval or continuous variables (column percentages for nominal

variables) for each venture type, together with the sample means. The last column shows the number of observations available for each comparison, together with the probability level of significant difference. Notice that because the number of available observations is generally large (minimum 1911; maximum 3226) even small differences across venture types are statistically significant. In general, the analysis of variance indicates significant differences across the three groups in all variables. The nature of these differences is consistent with the characterization of clusters in our taxonomy

<<Table 4 around here>>

In terms of founding motives and other internal factors, such as those characterizing competitive behavior more KIE ventures also stand out compared to 'modest KIE' somewhat more clearly. The results in Table 4 show founding motives -originating in technical knowledge, market knowledge and networking, and in the perception of opportunities- to be more strongly associated with KIE firms exhibiting a higher degree of knowledge seeking and innovative activities. It may be argued that 'modest KIE' are more 'traditional' ventures in the sense that they are not found on the basis of discovery of some form of latent opportunity to be exploited. Notice that founding motives, as measured in our survey, reflect both 'technology push' and 'demand pull' conditions. However, it also be noted that the average score on market knowledge as a founding motive is not significantly different between 'modest KIE' and WcKIE firms indicating that both groups are equally motivated by this type of expertise. Moreover, and perhaps surprisingly, we also find that technical knowledge as a motive for founding is stronger for AaKIE than WcKIE (but again the pair-wise difference is not significant). Overall, however, the general impression is that these two groups of KIE ventures are driven

more towards exploiting opportunities than the 'modest KIE' group, which is what we would expect, given our definition of KIE.

Turning to dynamic capabilities and strategic behaviour, the results are again as we would expect. Our findings suggest that more knowledge-intensive firms, i.e. firms that have more knowledge assets and exhibit better innovative performance (characterized as 'world-class KIE' or 'all-around KIE') have developed to a greater extent all types of dynamic capabilities as compared to their less knowledge-intensive counterparts. They have built more strongly their product related capabilities, they engage more strongly in networking activities, and of course, spend significantly more on R&D. In addition, more KIE ventures tend to pursue differentiation and focus strategies more intensively as compared to the 'modest KIE' group, which shows more emphasis on low cost strategies. Similarly, 'world-class' and all-around' KIE ventures are more heavily geared towards international markets, presumably based on their more innovative profile and they seem to enjoy higher performance both in terms of average profits and average sales growth rate.

4.2 How KIE ventures are distributed across different sectors and national innovation systems?

In this section we will examine whether the three new ventures groups identified using the proposed taxonomy are distributed evenly across different types of institutional context. Our main interest lies on examining prevalence rates across different types of industries and different National Innovation Systems (NIS). Should we find statistically significant differences in the concentration of ventures in specific types of institutional (and industry) settings, that would mean context does indeed influence the presence of KIE.

Table 5 presents the results of simple Chi-square tests, where we show the prevalence rates of the three types of ventures identified with cluster analysis (i.e. 'modest KIE'; AaKIE and WcKIE) across: (i) different national innovation systems, and (ii) different types of industries (classified according to their technological content).

To construct a *NIS indicator* we used the Innovation Union Scoreboard (IUS, 2011)[4] classification of national innovation systems, which is based on a wide variety of innovation-related measures at the national level of analysis. Given the countries present in our sample, the indicator takes the following values: (1) 'Modest' innovators (i.e. Croatia[5]); (2) 'Moderate' innovators (i.e. Czech Republic; Greece; Italy; and Portugal); (3) 'Followers' (i.e. France and UK); and (4) 'Leaders' (i.e. Denmark; Sweden; and Germany).

The Chi-square tests show that, within the institutional and industry settings examined, the distribution of firms across the clusters is not uniform. Hence, context does seem to matter, but how exactly? We begin with the distribution of KIE ventures across different NIS (panel A).

Table 5 around here

The best way to interpret the results presented in Table 5 is by comparing the percentage in any given cell (e.g. 66.5% for low-tech and 'modest KIE') against the corresponding 'total' (i.e. 62.4%). What does this 66.5% tells us? It says that 66.5% of the sample firms belonging to the low-tech group of sectors are found in the 'modest KIE' group, and this is higher than the 62.4% of all firms in the sample that are classified as 'modest KIE'. It appears that there is a higher concentration of 'modest KIE' firms in the low-

[4] Innovation Union Scoreboard, 2011, http://ec.europa.eu/enterprise/policies/innovation/files/ius-2011_en.pdf

[5] Croatia is not included in the Innovation Union Scoreboard report. We assume that Croatia's innovation system falls within the "Modest" category.

tech industry than would be expected should the firms distributed evenly across categories.[6] To ease reading the results in Table 5, figures higher than expected are in bold characters, whereas percentages lower than expected are in italics.

Looking at panel A, which shows the association between KIE and NIS, we find statistically significant differences. The results show that: (a) world-class KIE are mostly found in 'leader' economies (i.e. Denmark, Germany, and Sweden) as would be expected; (b) in contrast, in these countries we find fewer all-around KIE than expected; (c) these firms are found mostly in modest (i.e. Croatia) and moderate (i.e. Czech Republic, Greece, Italy, and Portugal) economies; (d) and -surprisingly, there is a higher than normal concentration of 'modest KIE' firms in 'follower' economies (follower economies are second only to leader economies in terms of their national innovation systems). *The general message therefore is that ventures exhibiting higher degrees of 'knowvation' are mostly to be found in leading economies and (surprisingly) in modest and moderate (in terms of NIS classification) countries. On the other hand, 'modest KIE' firms can also be found in UK and France which are economies closely following the innovation leading countries.*

Finally, panel B shows results in connection to the association between KIE and industry type. Again the findings show significant differences in prevalence rates across industries. Specifically, we find that: (a) 'modest KIE' firms are more concentrated in low-tech manufacturing, medium-low manufacturing, and KI Market services; (b) world-class KIE are basically to be found in high-tech manufacturing, KI high-tech services, and in KI market services (and correspondingly are less concentrated than expected in low-tech and medium-low manufacturing); and (c) all-around innovators

[6] Statistically speaking, 'evenly' means: according to the marginal percentages. Put differently, since 62.4% of the sample belongs to the 'modest KIE' group, we would expect the percentage of modest KIE groups *for each industry* be around 62%.

are more prevalent than expected in almost all types of industries, except for high-tech manufacturing. *In general, therefore, industry context also seems to play a role in KIE, with the qualification that all-around innovators appear to be spread in somewhat higher proportions than expected across all industries except in high-tech manufacturing.*

5. Concluding remarks

In this study we were interested in developing a useful taxonomy of young ventures on the basis of entrepreneurial behaviour. More specifically, we have attempted to shed new light on questions related to the phenomenon of knowledge-intensive entrepreneurship, which is understood here to involve new ventures that are highly innovative as a consequence of their being engaged in knowledge-intensive activities. A useful taxonomy is one that reduces the complexity of empirical phenomena to a few and easy to remember categories. Thus a taxonomy of young firms taking into account their knowledge intensity and innovation performance provides an empirically-based framework that may help to refine and further build a theory of knowledge intensive entrepreneurship as well as to guide related policies.

Using data from more than 4,004 new ventures, we first sought to identify firms in our sample that could be characterized by similar traits in terms of their entrepreneurial behaviour. Specifically, employing cluster analysis we investigated whether there exists a meaningful grouping in our observations on the basis of their similarities in various measures of knowledge assets and innovation performance. The results obtained showed the presence of three unique groups of firms. The first of these, termed ‘world-class KIE’, emphasizes new-to-world innovation drawing from in-house knowledge which in turn is based on high quality human capital (both in terms of founders and workforce), while the second, labelled ‘all-around KIE’, shows a more

balanced emphasis on different dimensions of innovation and relies basically in external knowledge seeking. The third group, called 'modest KIE' appears to be mainly pursuing new-to-firm innovation drawing from industry knowledge sources while it generally lags behind the other two groups both in terms of knowledge seeking and innovative activities.

Our results confirm that the proposed taxonomy of ventures that is based on differences as defined by their knowledge intensity and innovative output can also be extended to map differences in founding motives, capabilities, business strategies and firm performance. These particular variables are important not only because they confirm the validity of the explored taxonomy but also because we find that differences in these variables can systematically be linked to differences in knowledge intensity and innovative performance helping us better understand additional aspects of KIE and refine its measurement.

Our taxonomy suggests that different sources of knowledge, different innovation strategies and, thus, different pathways of development of KIE ventures can be identified. All too often entrepreneurship and innovation policy that overlooks the diversity of paths toward successful innovation and growth slips into myopic strategies related to oversimplified quantitative targets such as R&D spending and the like (Srholec and Verspagen, 2012). However, such a policy framework for KIE is likely to neglect the essence of innovation process in many ventures. For instance, as external knowledge sources appear to be conducive to the identification of new technology and market opportunities for young firms, policy measures should focus on the development of organizational capabilities and management skills that enable the companies to recognize important external knowledge, combine it with already existing internally generated knowledge and exploit it in a beneficial way (Hirsch-Kreinsen and Schwinge,

2011) In practice, this can be achieved by introducing and promoting advanced management methods and work methods conducive to innovation and at the same time upgrading already existing R&D-related activities or even introducing limited internal R&D capacity.

Next we examined whether our three varieties of firms are distributed evenly across different types of institutional settings. Our main interest here lies in the notion of national innovation systems (NIS), which denotes different socioeconomic configurations that, in theory, provide distinct types of institutional comparative advantages to firms operating within their boundaries. Simple analysis of variance, categorizing our sample countries on the basis of their national innovation systems, showed that world-class KIE ventures are mostly concentrated in leading economies (leading in the sense of having developed an advanced innovation system). Somewhat surprisingly, all-around innovators are basically found in countries with modest and moderate innovation systems. However, it should be taken into account that while the strategic preferences of firms are up to certain extent determined by their institutional environment, within a particular setting (e.g. a particular NIS type or a variety of capital) there are variations in firms that can be explained as a function of the diverse models of action chosen by entrepreneurs through the acquisition, combination and recombination of resources to exploit profit opportunities (Allen, 2006; van der Walt, 2011). This practically means that even in countries characterized as moderate or modest innovators, i.e. countries with unbalanced research and innovation systems, entrepreneurs are certainly able to pursue opportunities for developing knowledge intensive activities. At the same time, the modest and moderate innovators exhibit the highest innovative performance growth rates among the EU 27 indicating a clear catch-up to the higher performance level of both the innovation leaders and innovation

followers (IUS, 2011), justifying, at least partly, the increased presence of all-around innovators in these two NIS groups.

Finally, we examined the distribution of young ventures across different types of industries, categorized according to their technological content. The findings indicate that industry context also plays a significant role, but this concerns mainly word-class KIE. This type of ventures is basically concentrated in high-tech manufacturing, and knowledge-intensive services industries. On the other hand, all-around innovators are more or less equally spread across all different types of industries. According to these results, KIE is only partly industry specific. Our findings point out that knowledge-intensive does not equate with high-tech manufacturing. Therefore, contrary to the stereotypical view that low-tech sectors offer limited opportunities for KIE activities and innovation (von Tunzelmann and Acha, 2005) our analysis indicates that knowledge-intensive firms and can also be found in services and most importantly in low-tech manufacturing sectors. These findings are in line with the case study work undertaken in the context of the AEGIS project which confirms that KIE opportunities do exist in traditional sectors arising from the fact that competitive pressures force actors to modify their role and to adopt an increasingly reflective position towards established practices seeking at the same time to break new ground regarding innovations. Furthermore, the AEGIS case study findings indicate that impact of KIE on existing mature sectoral structures can be quite significant, offer new possibilities for further entrepreneurial activities and in consequence lead to the sustainable improvement of the competitive position of European traditional sectors and firms (Hirsch-Kreinsen and Schwinge 2011). In addition, our findings also suggest that 'modest KIE' firms (at least in terms of the proposed taxonomy) can also be found in high-technology sectors. Thus, our findings suggest that an aggregate sectoral

perspective does not take into consideration important differences at the firm level. It is worth noting, that within an industry there tends to be a wide variation across firms in terms of their R&D intensities, so that it is common to find low-tech firms in high-tech industries and vice versa (Kirner et al., 2009).

Our findings suggest that policy makers should increase their awareness with respect to low-tech industries. They emphasize that measures towards promoting KIE should not only be focused on high-tech industries as low and medium low-tech sectors and firms-contrary to the established scientific and popular beliefs- appear to get heavily involved in knowledge-seeking activities and exhibit innovation potential. Effective entrepreneurship and innovation policy needs to take into account the firm-level variety and at the same time the specific environmental conditions in which companies operate.

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Table 1: Industry coverage in the AEGIS survey

Selected Sectors	NACE Rev. 1.1 codes
Manufacturing	
High-tech manufacturing	35.3, 30, 32, 33, 24.4
Medium high-tech manufacturing	31, 29, 24 (excl. 24.4)
Low-tech manufacturing	21, 22, 17, 18,19, 15,16
Medium low-tech manufacturing	27,28
KIBS sectors	
High-tech services	64.2, 72, 73
Market services	74.1, 74.2, 74.3, 74.4, 74.5, 74.8*

Table 2: KIE variables that formed the basis of the proposed taxonomy

KIE variables
Knowledge intensity
Knowledge seeking activities
External knowledge sources from industry (clients or customers, suppliers, competitors)
External sources of knowledge (public research institutes, universities, external commercial labs/R&D firms, technical institutes)
Internal knowledge sources/In-house R&D
External knowledge from 'open' sources (trade fairs, conferences, exhibitions, scientific journals and other trade or technical publications)
Participation in research collaborative activities funded by national of EU sources

Initial knowledge capital
Founding team educational attainment
% of initial funding from venture capital

Human capital & Innovation 'input'
% of full-time employees with Graduate degree
% of full-time employees with Ph.D. degree
Employee training
R&D intensity

Innovation performance

Product innovation
Introduction of new goods/services during the last 3 years
New goods/services were new to the firm
New goods/services were new to the market
New goods/services were new to the world
Process innovation
Introduction of process innovation during the last 3 years
Organizational innovation the last 3 yeas
Introduction of logistics innovation
Introduction of innovation in support activities
Improvement of management systems
Changes in management structure
IPR protection methods the last 3 years
Patents
Trademarks
Copyrights
Confidentiality agreements
Secrecy
Lead time advantages on competitors
Complexity of design

Table 3: Cluster analysis results

KIE variables	Modest KIE	All-around KIE	World-class KIE	Total sample
Knowledge-intensive activities				
Knowledge/External-Industry (0/1)	0.428	**0.642**	0.279	0.454
Knowledge/External-Science (0/1)	0.059	**0.186**	0.066	0.088
Knowledge/In-house R&D (0/1)	0.415	**0.736**	**0.706**	0.531
Knowledge/External-Open sources (0/1)	0.177	**0.421**	0.240	0.242
Knowledge/Participation in collaborative (0/1)	0.069	**0.241**	0.117	0.115
'Initial conditions'				
F-team avrg edu attainment (0/1)	0.249	0.199	**0.567**	0.285
% capital from venture capital (0/1)	0.012	0.016	**0.068**	0.0214
Human capital & Innovation 'input'				
%ft employees:Graduate degree (0/1)	0.124	0.058	**0.246**	0.127
%ft employees:Ph.D. degree (0/1)	0.061	0.116	**0.246**	0.101
Employee training (0/1)	0.360	**0.600**	0.464	0.430
RD intensity (0/1)	0.167	0.470	**0.548**	0.293
Innovation performance				
Introduced new goods/services last 3 years	0.440	**1**	**1**	0.651
New-to-firm (0/1)	0.206	0.283	0.168	0.218
New-to-market (0/1)	0.178	0.476	0.433	0.284
New-to-world (0/1)	0.057	0.241	0.398	0.150
Introduced process innov last 3 years	0.350	**0.817**	0.292	0.446
Introduced logistics innov last 3 years	0.275	**0.795**	0.113	0.368
Introduced innov in support activities last 3 years	0.406	**0.935**	0.331	0.514
Improved knowl mngnt systems last 3 years	0.414	**0.869**	0.417	0.517
Changes in mngnt structure last 3 years	0.258	**0.583**	0.228	0.327
IPR last 3 years:patents	0.026	0.213	**0.304**	0.110
IPR last 3 years:trademarks	0.117	0.519	**0.536**	0.271
IPR last 3 years:copyrights	0.072	0.311	**0.405**	0.176
IPR last 3 years:confidentiality	0.134	0.642	**0.932**	0.369
IPR last 3 years:secrecy	0.056	0.510	**0.799**	0.270
IPR last 3 years:lead_time	0.138	**0.757**	0.692	0.361
IPR last 3 years:complexity	0.088	0.612	**0.704**	0.299
Observations	2012	727	487	3226

Table 4: Comparative analysis of venture types

	Modest KIE	All-around KIE	World-class KIE	**Total**	Observations
Factors important for firm formation					
Technical knowledge	3.305	3.758	3.603	3.452	3224(***)
Market knowledge and social networks	3.855	4.071	3.884	3.908	3223(***)
Identification of opportunities	2.738	3.360	3.058	2.926	3224(***)
Internal factors					
Capability/Product related	3.545	4.105	3.924	3.728	3226(***)
Networking capability	2.832	3.475	2.966	2.997	3226(***)
Capability/RD and Alliance related	2.458	3.203	3.136	2.728	3226(***)
Strategy: Low cost	19.28%	12.24%	7.19%		
Differentiation	58.00%	55.43%	60.57%		
Focus	22.71%	32.32%	32.24%		
Total	100%	100%	100%		3226(***)
%Sales in International market	11.55	18.06	25.06	15.05	3226(***)
Performance					
Avrg. Profit (2007-9)	2.380	2.677	2.538	2.470	2859(***)
Avrg. Growth Sales (quartile)	5.042	5.853	6.088	5.385	2979(***)

Table 5: Distribution of KIE venture types across different types of context

	Modest KIE	AaKIE	Wc KIE	Total	Observations
National Innovation Systems					
CR	*47.4%*	**42.9%**	*9.7%*	100.0%	175
CZ/GR/IT/PT	*58.3%*	**33.4%**	*8.3%*	100.0%	1,230
FR/UK	**72.9%**	*11.6%*	15.4%	100.0%	868
DK/GER/SV	*60.8%*	*14.7%*	**24.6%**	100.0%	953
Total	62.4%	22.5%	15.1%	100.0%	3,226
Pearson chi2(6) = 291.5104 Pr = 0.000					
Technology class					
Low-tech manufacturing	**66.5%**	**25.5%**	*8.0%*	100.0%	1,066
Medium low -tech manufacturing	**67.0%**	**28.8%**	*4.2%*	100.0%	212
Medium high-tech manufacturing	*53.8%*	**30.2%**	16.0%	100.0%	262
High-tech manufacturing	*45.6%*	23.3%	**31.1%**	100.0%	103
KI High-tech services	*48.4%*	**24.3%**	**27.3%**	100.0%	506
KI Market services	**67.6%**	*15.6%*	**16.8%**	100.0%	1,077
Total	62.4%	22.5%	15.1%	100.0%	3,226
Pearson chi2(10) = 191.891 Pr = 0.000					

ANNEX I

Table 1: Description of key constructs (CFA results)

CONSTRUCTS	**Items**
Knowledge intensity	
Knowledge/External-Industry	Clients or customers
	Suppliers
	Competitors
Knowledge/External-Science	Public research institutes
	Universities
	External commercial labs/R&D firms/technical institutes
Knowledge---In-house R&D	In-house (know how, R&D laboratories in your firm)
Knowledge/External-Open sources	Trade fairs, conferences and exhibitions
	Scientific journals and other trade or technical publications
Knowledge/Participation in collaborative...	Participation in nationally funded research programmes
	Participation in EU funded research programmes (Framework Programmes)

Important factors for firm formation		
	Technical knowledge	Technical/engineering knowledge in the field
		Design knowledge
	Market knowledge and social networks	Knowledge of the market
		Networks built during previous career
	Identification of opportunities	Opportunity deriving from technological change
		Opportunity deriving from a new market need
		Opportunity deriving from new regulations or institutional requirements
Firm dynamic capabilities		
	Product development capability	Capability to offer novel products/services
		Capacity to adapt the products/services to the specific needs of different customers/market niches
		Marketing and promotion activities
capalility	***R&D and alliance***	R&D activities Establishment of alliances/partnerships with other firms Networking with scientific research organizations (universities, institutes, etc.)
	Networking	Selecting suppliers

Recruiting skilled labor

Collecting information about competitors

Accessing distribution channels

Assistance in obtaining business loans/attracting funds

Advertising and promotion

Developing new products/services

Managing production and operations

Assistance in arranging taxation or other legal issues

Exploring export opportunities