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PATTERNS OF PERFORMANCE IN NEW FIRMS: THE RELATIVE EFFECTS OF POTENTIAL AND REALIZED ABSORPTIVE CAPACITY

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ABSTRACT

Scholars agree on the importance of new firms in knowledge-intensive fields for creating economic development and growth, yet there is still not a refined framework for assessing and predicting new firm performance. Absorptive Capacity (ACAP) is the capability of a firm to discover, recombine, and exploit technological knowledge internal and external to the firm, and it has been shown to be a relevant predictor of performance in knowledge-intensive fields such as biotechnology. Common operationalizations of ACAP are less useful when assessing the performance of new firms. This paper proposes the proportion of employees with technology or science education as an alternative measure for potential ACAP and patent data as a proxy for realized ACAP. Applying these measures on a full population of knowledge-intensive start-ups we find that ACAP is a relevant construct when predicting survival and multiple aspects of new firm performance, and that proportion of employees with university-level technology/science education seems to be a working and reliable operationalization.

INTRODUCTION

New firms create, define, discover, and exploit opportunities ahead of rivals to create new products and markets yet there is still not a compelling explanation for the ability of some new and established companies to continuously create, define, discover and exploit entrepreneurial opportunities (Zahra, Sapienza, & Davidsson, 2006). Refined theories and frameworks to predict new venture performance would lead to substantial benefits for entrepreneurs, providers of resources and capital, and researchers studying new firms and industry dynamics (Cooper, Gimeno-Gascon, & Woo, 1994; Lehmann, 2003).

Academics have agreed on the importance of creating a deeper understanding about the link between knowledge-based entrepreneurship and economic development. Knowledge-based entrepreneurship is the term broadly used here to describe the discovery and exploitation of entrepreneurial opportunities based on new knowledge and technologies (Acs, 2002; Shane & Venkataraman, 2000). Technological opportunities differ in availability, scale, and scope across industries, and the perceived existence and value of a technological opportunity is a function of knowledge and previous experience (Kirzner, 1997; Klevorick, Levin, Nelson, & Winter, 1995; Shane, 2000). The existence and discovery of technological opportunities has significant impact on the formation and performance of new firms in technological fields (Shane, 2001a, b).

Absorptive Capacity (ACAP) is the capability of a firm to discover, recombine, and exploit technological knowledge internal and external to the firm, and it has been shown to be a relevant predictor of performance in knowledge-intensive fields such as biotechnology (Cohen & Levinthal, 1990; DeCarolis & Deeds, 1999). ACAP can be viewed as a dynamic capability that influences the path and evolution of firm development. However, as an important distinction from the general concept of dynamic capabilities, ACAP is specifically defined as the assimilation of technological knowledge and skills, as opposed to business skills in general (Teece, Pisano, & Shuen, 1997; Zahra & George, 2002).

Common operationalizations of absorptive capacity have been R&D investment/sales, or the proportion of technology/R&D-staff relative to the total number of employees (Cohen et al., 1990; DeCarolis et al., 1999). However, these measures are less useful when assessing the performance of new firms as these firms more often than not do not have the resources or size to operate dedicated R&D departments, budgets or staff.

In this paper we propose the level of technological or science university education in a firm's workforce as an alternative proxy for ACAP. Using this novel operationalization of ACAP, this paper seeks to contribute to the literature on new firm performance by conducting a detailed empirical analysis of the relative impact of potential and realized ACAP on new firm survival and performance over time. The paper is structured as follows; first, a brief summary on previous research on new firm performance with a focus on the different constructs of knowledge used. Then follows a definition of how we measure potential and realized ACAP. Third, we present our hypotheses. After this comes a section on the data and method used. This is followed by a summary of the results and a section with our conclusions.

THEORY AND HYPOTHESES

In explaining entrepreneurial performance, much research has been devoted to the entrepreneurial strategic orientation (EO) of the new firm or individual entrepreneur, leaving the interrelationship with internal characteristics aside. Findings suggest that knowledge-based resources (applicable to discovery and exploitation of opportunities) are positively related to firm performance and that EO enhances this relationship (Delmar, 1996; Wiklund, Delmar, & Davidsson, 2003; Wiklund & Shepherd, 2003). That knowledge is a critical resource for firm performance is echoed in the literature on organizational learning and competences (Kogut & Zander, 1992, 1996; Prahalad & Hamel, 1990). When it comes to knowledge-based entrepreneurship defined as new venture creation in order to exploit a perceived technological opportunity, it may be argued that internal knowledge resources may be even more important than EO as previous research has found that knowledge capabilities are more important than motivation-based factors in explaining successful knowledge transfer (Szulanski, 1996).

Human Capital

Previous studies that have related the impact of knowledge on the survival and performance of new firms have primarily examined the effects of initial human capital endowments of the founders (Cooper et al., 1994; Gimeno, Folta, Cooper, & Woo, 1997). The concept of human capital which is derived from economic theory is an individual level theory that focuses on the investment in education by the individual and that has been found to have individual-level, firm-level, and macro-level outcomes (Becker, 1993; Delmar, Wennberg, Wiklund, & Sjöberg, 2005; Romer, 1990). Limitations of human capital in entrepreneurship studies are mainly that although the existence and need for multi-level research designs is approved in entrepreneurship, when trying to understand new firm performance there is a demand for an evolutionary perspective as well as utilizing *firm-level theories*, i.e. explaining outcomes that can be assessed by management and manipulated by the firm as an entity (Barnett & Burgelman, 1996; Denrell, 2003; Dyer & Singh, 1998).

Dynamic Capabilities

The Dynamic capabilities literature posit that the knowledge capabilities of the management team in an organization is the main criteria that contributes to commercial success in complex and volatile markets such as emerging industries or high-technology (Teece et al., 1997). As such, dynamic capabilities seems well suited as a framework for analyzing entrepreneurial organizations and new firm performance (Zahra et al., 2006). It is influenced by evolutionary economics, organizational learning, and the knowledge-based view which states that knowledge resides with individuals and the role of the firm is coordination and exploitation (Grant, 1996; Kogut et al., 1996; Winter, 2002). The dynamic capabilities framework primary issue is in applicability for empirical entrepreneurship scholars as the majority of empirical papers on dynamic capabilities are limited in scope, have a descriptive rather than prescriptive research design, and there is a dearth of empirical papers relating the concept specifically to new firm performance (Zahra et al., 2006).

Absorptive Capacity

Absorptive Capacity (ACAP) has been defined as the specific dynamic capability of a firm or organization to discover, assimilate/recombine, and exploit technological knowledge, thereby enabling it to commercially exploit advances in technological fields (Cohen & Levinthal, 1994; Cohen et al., 1990; Zahra et al., 2002). ACAP has been shown to be a relevant predictor of performance in knowledge-intensive fields and differs conceptually from overall dynamic capabilities in that ACAP specifically focuses on the acquisition and recombination of technological knowledge external and internal to the firm, and not on the acquisition and development of general capabilities and business skills (Cohen et al., 1990; DeCarolis et al., 1999; Hansen & Wernerfelt, 1989; Teece et al., 1997; Winter, 2002). The concept has been extended to include two subsets of potential and realized absorptive capacity, where the potential absorptive capacity is the capability to acquire and assimilate knowledge and the realized absorptive capacity is the transformation and exploitation of the assimilated knowledge (Zahra et al., 2002).

There is a general lack of empirical studies applying ACAP to firm performance in general and to new firm performance in particular (Lane, Koka, & Pathak, 2006; Zahra et al., 2006). The established empirical measures for ACAP is the R&D intensity measured as R&D budget/sales or as proportion of R&D-staff relative to the total number of employees (Cohen et al., 1990; DeCarolis et al., 1999). However, these measures are problematic when examining the performance of new firms, as these firms rarely have dedicated R&D departments or staff. A summary overview and comparison of the major constructs:

CONSTRUCT	Dynamic Capabilities	Absorptive Capacity	Human Capital
Level	Firm	Firm	Individual
Locus	Management team	R&D department	Entrepreneur/founding team
Scope	Managerial skill	Technological knowledge	General/firm-specific/industry-specific
Common operationalization	Change outcomes	R&D intensity/staff	Level of education/experience
Application	Dynamic (develops over time)	Dynamic (develops over time)	Static (e.g. initial endowment)

As there is an established connection between technological opportunities and new firm formation, where firms are established to exploit opportunities, ACAP is a prime candidate for analyzing the entry and evolution of firms in knowledge-intensive industries.(Shane, 2000, 2001a). For the purposes of this research, ACAP is more precisely defined as *a dynamic capability that changes over time, and positively impacts the performance of the firm by (a) generating resources for the firm through creating proprietary innovations*, *and also by (b) adding to the stocks of knowledge in the firm, thus enabling it to more accurately predict and exploit technological opportunities and advances* (Cohen et al., 1994; DeCarolis et al., 1999). It should be mentioned that a “good” technological opportunity can still be a less good market opportunity and vice versa, depending on timing, windows of opportunity, corporate politics and random events, but here a linear relationship between the two is assumed.

Here we propose the proportion of staff with science and/or technology university education as a proxy for potential ACAP, and patents as a proxy for realized ACAP in new firms. Employees are mobile and it is doubtful whether a new firm has been able to develop processes, routines or competences they way they are described in the literature on resources and capabilities, thus potential ACAP is viewed as a capability residing with the individuals within the firm enabling the flow of knowledge to the firm, whereas innovative output, or realized ACAP is codified and materialized as intellectual property or stock of knowledge of the firm, and thereby can be considered to be a resource (DeCarolis et al., 1999; Prahalad et al., 1990; Zott, 2003). Our definition and operationalization of ACAP thus provides an integrative approach between the resource-based and capabilities literature and at the same time addresses the critique of tautology (is more better by default?) that has haunted the resource-based school.

In that the potential capacity resides with the individuals working in the firm whereas the realized outcomes of this capacity are inherent to the firm as increased stock of knowledge, this makes ACAP a firm-level theory that can be used prescriptively (Dyer et al., 1998). The concept of ACAP has been extended to include two subdomains; *potential* and *realized* ACAP, where potential ACAP comprises knowledge acquisition and assimilation capabilities, and realized ACAP centers on innovative output and exploitation (Zahra et al., 2002). Previous research has shown significant relationships between firm performance, and realized ACAP measured as innovative output e.g. patents (Cockburn & Griliches, 1988; Lerner, 1994). However it has been pointed out that the potential ACAP component has been empirically examined significantly less empirically than realized ACAP (Zahra et al., 2002). Our operationalizations compared:

CONSTRUCT	**Potential ACAP**	**Realized ACAP**
Level	Firm	Firm
Locus	Employees	Organization
Scope	Technological knowledge	Technological knowledge
Proposed operationalization	Proportion of technology educated staff	Patents (innovative output)
Construct classification	Capability	Resource
Application	Dynamic (develops over time)	Dynamic (develops over time)

ACAP is viewed as a dynamic capability that influences the path and evolution of firm development and performance through enabling the firm to better predict and exploit technological opportunities and trajectories (Cohen et al., 1994; Cohen et al., 1990; Zahra et al., 2002). From theory it can thus be expected that potential ACAP, measured as proportion of employees with science or technology university education, will have a positive impact on firm survival and performance.

The fact that a firm is still active is taken as a basic positive performance measure often used in organizational research on new firm performance (Audretsch & Mahmood, 1995; Delmar & Shane, 2004). When measuring firm exits, it is important to recognize that all exits are not of the same character, and we try to make the distinction between negative exits (firm is terminated), positive exits (firm is acquired or merged with another entity), and neutral exits (firm is split into multiple units exit by entering another industry not present in the sample but staying in operation, both of which we consider neutral exits) (Åstebro & Winter, 2002). The effects of ACAP on firm exits are expected to differ, as the characteristics of firm exits from the population can be deemed to be more or less negative performance measures. In light of this; we add additional subordinate hypotheses in order to get a multifaceted picture of firm exits and to model the proposed different effects of absorptive capacity on the different types of firm exits, leading to our first hypothesis:

H1: New firms with high potential absorptive capacity will have a higher probability of survival than new firms with lower levels of potential absorptive capacity, specifically:

- *H1a: Potential ACAP will have a negative impact on negative exits*

- *H1b: Potential ACAP will have a positive impact on positive exits*
- *H1c: Potential ACAP will have no significant effect on neutral exits*

We also have several dependent variables to measure operational and financial performance that will be modeled to visualize the multiple aspects of new firm performance (Cooper et al., 1994). However, the positive impact of absorptive capacity is expected to be consistent across all these dimensions of new firm performance, ergo our second hypothesis:

H2: New firms with high potential absorptive capacity will display stronger performance than new firms with lower levels of potential absorptive capacity.

Realized ACAP has been named as the primary source of firm performance (Zahra et al., 2002). At the same time, previous studies have indicated that high value patents can actually increase firm exits – both due to a higher number of positive firm exits as a result of mergers or acquisitions by larger entities, or as a result of higher hazard rates due to stiffer competition (Gans & Stern, 2003; Lerner, 1994; Nerkar & Shane, 2003). As it is important to conduct an in-depth examination of the interrelation and interaction effects between potential and realized ACAP, we additionally posit the following:

H3. Realized ACAP will have a more significant positive effect on new firm performance than potential ACAP.

H4. Realized ACAP will have a negative effect on firm survival.

METHOD & DATA

We conducted panel data regression on a high quality dataset assembled specifically for the research of the economic role of knowledge-intensive firms. The data set comprises all new incorporated firms in Sweden in this sector between 1995 and 2002. To reduce sources of heterogeneity, we exclude other legal forms. Thus we are dealing with a panel dataset of the full population of newly started firms. Firms that enter the population from other industries (*de alio*) or were created through spin-offs or mergers are included and controlled for. The panel has been assembled and matched to firm financial data from the Swedish Tax Authority by the government agency Statistics Sweden. Patent data from the OECD Triadic patent dataset was added to the firm data. The sample consists of patent that have been applied for in the three major jurisdictions USA (USPTO), EU (EPO) and Japan (JPO) thus serving as a self-selection for those patents viewed as having high commercial or technological value (Dernis & Khan, 2004).

Dependent Variables

Firm survival. We model survival using a Cox regression to measure firm exits. The choice of a hazard model is not without discussion, as we do not measure exit with continuous time, but on a yearly basis. The best from a model perspective would have been a logit model. For ease of comparison with previous studies we opted for a hazard model. However, it should be pointed out that we reanalyzed our data with a logit model and obtained the same results, suggesting that our results are robust to model specification. In total 37,399 exits in our data. A firm is considered terminated the year it leaves the market when we code it as one. Specifically:

- Negative firm exits: firm is terminated (n=23,817)
- Positive firm exits: firm is acquired or merged (n=8,281)
- Neutral exits, firms splits (n=4,306)
- Neutral exits; firm transfers to an industry not in sample (n=1,344)

However, substantially fewer firms are actually analyzed as about half (n = 17,240) of the firms exit the same year as they enter reducing our sample to be investigated. As measuring firm performance is a complex issue when it comes to new firms, we utilize a range of performance variables to get a multifaceted picture (Cooper et al., 1994):

Employee growth. Even though financial statements may differ, the fact that a firm increases or reduces its staff is an indicator of economic performance that is often used in studies of regional development (Baptista & Swann, 1998; Porter, 2003). We measured employee growth as the natural log of the relative growth over a year. We used the log transformation of this variable because the distribution of this variable was heavily skewed, containing several outliers. We corrected for zero growth by adding 1 to all values.

Total salaries paid. Though a high-technology start-up might not have a high initial turnover, it can use venture capital funding, research contracts or bank loans in order to pay salaries. Thus, a knowledge-based company might be doing well and increasing capital expenditures on employees but not increasing turnover. Measuring total salaries paid is an attempt to model this kind of positive performance. The variable for total salary was created by taking the total salary for a specific year and using log transformation of this variable because the distribution of this variable was heavily skewed, containing several outliers. We corrected for zero salary by adding 1 to all values.

Average salaries paid. The evolution of average salaries paid is another reliable measure of economic performance that comes from studying economic and firm development on a macro level (Porter, 2003). Also, average salaries can be a way to assess positive financial performance even though the workforce and total salaries paid decrease, as a company needs financial assets that can have been acquired through investments or loans to pay high salaries, instead of stock options. Average salaries paid was measured as the natural log of the average salary in a specific year. We used the log transformation of this variable because the distribution of this variable was heavily skewed, containing several outliers. We corrected for zero salary by adding 1 to all values.

Return on Assets (ROA) is a financial performance measure of how profitable a company is, and that has become close to an industry standard in recent research on firm performance. It is popular due to its theoretical and practical relevance, and is calculated as net profits before financial costs and taxes (EBIT) divided by the total assets of the firm. ROA was calculated as the net profits divided by total assets. For the same reason as the other dependent variables, we used the log transformation of this variable because. We corrected for zero ROA by adding 1 to all values.

Independent Variable

Our independent variable is the proportion of 3-year technological and/or science university educated firm staff. The existence of higher education is variable often used to measure the construct of human capital, the result of conscious investment in education that has been shown to have an impact on economic growth (Romer, 1990). Here it was used as a measure of the relative ACAP of the individual firm. This variable is time variant, as the size and composition of employees can change over time, thus making it primarily an indicator of the potential flows, as opposed to the stocks, of technological knowledge in firms (DeCarolis et al., 1999).

Control Variables

We used a number of control variables that from previous research can be expected to impact new firm performance and thereby our models. We measured initial size of firm as number of employees, firm age, and number of plants in the firm any given year. From a financial performance, we controlled for sales and assets, thereby for financial performance and assets control.

Patents are here considered the realized ACAP of the firm, and can therefore be viewed as more persistent knowledge stocks, or assets proprietary of the firm (Zahra et al., 2002). We did not here measure the knowledge contents or relative quality of the patents (Trajtenberg, 1990). Finally, at the firm level, we controlled for type of entry, introducing dummies for all types of entries except *de novo* entries as they represent the largest group, but also the group with the highest probability of failure. We also measured the proportion and level of 3-year university education in firm staff, including science and technology university education. Following the same logic as for our absorptive capacity measure, the existence of higher education per se is variable often used to measure the construct of human capital (Becker, 1993). However, in this study we are interested in discriminating between a generally well educated staff and a staff specifically oriented towards science and technology.

Firms and especially growing firms often are part or become part of company groups . Hence, they are not all independent, and they have often differential access to resources. Therefore, we controlled for company group affiliation. We do this by controlling the number of plants and the sales generated by the total company group. At the industry level, we measured patenting in the industry, industry size as total number of employees) and industry sales (measured as median and mean sales in industry) (Acs & Audretsch, 1987, 1988; Audretsch et al., 1995; Delmar et al., 2005; Nerkar et al., 2003). We also used a dummy for manufacturing as a majority of our firms enter service industries. Finally, we controlled for cohort effect by adding year dummies for all year, except 2002 which is our reference year.

Correction for Selection

One problem with studying determinants of the performance of new firms is that only those firms that survive are measured, and many new firms do not survive. The coefficients on variables that have a significant effect on both survival and other performance measures will be biased downward in regressions predicting those other performance measures than survival if only surviving firms are included in the sample and researchers do not correct for the selection bias. This selection bias arises from the fact that the firms that fail are more likely to have lower values in the predictor variables . To correct for this problem, we used Lee's (1983) generalization of the Heckman selection model to create a selection correction variable (Heckman, 1979). By introducing this variable that we call "Lambda" into our models predicting firm sales, we could obtain more precise estimates for our independent variables (Greene, 2000). We used the hazard of exit during the 7 years of observation calculated from a Cox regression model to predict firm exit for our 38,036 firms that have more than one spell to generate the selection correction variable (lambda).

RESULTS

Table 2 shows the results of models to test our hypotheses concerning survival. To test hypotheses 1a to c that relates the positive effect of absorptive capacity on survival, we rAn a Cox regression to model hazard rates; i.e. the probability (risk) that a new firm will not survive. Model 1 models all sort of exits. Model 2 models the termination of the firm. Model 3 predicts split of firm. Model 4 displays the merger or acquisition of the firm, and finally model 5 exits from the industry sector. The control variables acted in the expected direction. All forms of entries, other than de novo lead to increased survival. Furthermore, survival increased with age, having numerous plants and being part of a company group. Industries with many employees increased survival. However, we found patents did not have an effect. One reason might be that so few firms in our data actually have any.

As we can see in model 1, our ACAP measure; proportion of employees with university-level technology/science education, had a negative effect on the probability of termination, implying that ACAP had a positive effect on new firm survival (-.36, $p<.001$). The negative effect differed markedly from the effect of the proportion of employees with general university education in general which actually seemed to have a negative effect on firm survival, thus clearly separating and defining the positive effect of ACAP on firm survival from general human capital effects.

When breaking down the effects on the different types of firm exits, we can conclude that the effects were consistent for negative exits (firm terminations, -.36, $p<.001$), with a significant positive effect of ACAP and negative effect of general human capital as measured by level of education, on survival. We have also conducted a logit analysis of survival and the results are consistent and evidence of model robustness, but, as pointed out previously, we primarily display the Cox regression in this study to facilitate comparisons with other studies using this method. Thus our Hypothesis 1a is supported.

In model 3 and 4 we can see that our hypothesis 1b is rejected as ACAP also had a negative effect on positive firm exits, merger and acquisitions (model 4). Finally, our hypothesis 1c was partially sustained as there was significant negative effect on firm splits (model 3) but no significant impact on neutral exits (-.04, $p>.1$), when the firm exits the firm population to enter an adjacent industry.

In our second step, we use a random-effects GLS regression to model the effects of ACAP on the performance of new firms to test hypothesis 2 and 3. The results are displayed in table 3. The results for relative employee growth are displayed in model 1. The result for total salaries paid is found in model 2. Model 3 displays the results for average salary. Model 4 shows the results for return-on-assets (ROA). Similarly with survival, we also find that the control variables acted as expected. Here we also found that patents had no effect. The company group variables when tested had a positive effect on performance and so did many of the industry variables. Most importantly our selection correction Lambda was significant in all regressions. This indicates that correcting for selection was important to obtain unbiased estimates. Cohort effects were significant but suppressed from the displayed tables for sake of space.

Interestingly enough, we see from the regression results that ACAP actually had a negative and contrary effect to our hypothesis on relative employee growth (-0.01, $p<.05$), and thus we can reject hypothesis 2a. Also, the proportion of employees with general university education had an even more marked negative effect on employee growth. On total salaries paid, our hypothesis 2b was supported as ACAP had a small but positive effect (.05, $p<.01$), however it should be noted that this effect is of the same magnitude as the general human capital effect and therefore cannot be attributed solely to ACAP.

Finally, hypotheses 2c and 2d were supported, as our ACAP variable had significant positive effect on the evolution of average salaries paid (.30, $p<.001$) and return-on-assets (ROA) (.03, $p<.001$). Importantly, the effect of ACAP was markedly more pronounced than the effect of proportion of general university education in the same models, thus providing robust empirical support for the positive effects of technological knowledge on these measures of new firm performance. The effect for general university education was .07, $p<.001$ for average salary, and .01, $p<.001$ for ROA. As both ACAP and general university training were measured as shares of total employees, they are directly comparable. The ACAP proxy was 4.2 times more important than general university training for average salaries and 3 times more important for ROA.

Summary of Results	
Hypotheses	**Results**
H1. New firms with high potential absorptive capacity will have a higher probability of survival than new firms with lower levels of potential absorptive capacity	SUPPORTED
H1a: ACAP will have a negative impact on negative exits	*Supported*
H1b: Potential ACAP will have a positive impact on positive exits	*Rejected*
H1c: Potential ACAP will have no significant effect on neutral exits	*Supported*

H2. New firms with high potential absorptive capacity will display stronger performance than new firms with lower levels of absorptive capacity	SUPPORTED
H2a: ACAP will have a positive impact on Employee growth	*No support*
H2b: ACAP will have a positive impact on Total salaries paid	*Supported*
H2c: ACAP will have a positive impact on Average salaries paid	*Supported*
H2d: ACAP will have a positive impact on Return on Assets	*Supported*
H3. Realized ACAP will have a more significant positive effect on new firm performance than potential ACAP.	No support
H4. Realized ACAP will have a negative effect on firm survival.	No support

ANALYSIS AND CONCLUSIONS

Our study contains a number of limitations that could undermine the validity of our results. Even if our data are unique in the sense that we are dealing with a multi-industry population followed over a period of 8 years, our variables and analyses are could be additionally developed. Additionally, our definition and operationalization of ACAP does not enable the analysis of interorganizational factors contributing to knowledge transfer and firm performance such as strategic alliances, network affiliations, or board members and consultants, that have been shown to affect absorptive capacity and/or firm performance (Dyer et al., 1998; George, Zahra, Wheatley, & Khan, 2001).

The results however indicate that as can be expected from theory, ACAP had a positive effect on new firm survival, and the effect of ACAP as the proportion of employees with technology/science university education is more pronounced than the effect of the proportion of employees with university education in general. Further research could conduct more fine-grained analysis looking at additional independent as well as dependent variables. For example, an interesting avenue of research is to examine what effects, in addition to education, the length and type of previous work experience in employees has on new firm survival and performance. Another area of further studies is to separate founders from employees and examine their potential differences in effecting new firm survival and performance.

In conclusion, our definition of ACAP seems to be a fitting framework for predicting entrepreneurial dynamics and new firm performance in knowledge-intensive industries, and the proportion of employees with university-level technology/science education seems to be a working and reliable operationalization. The application of ACAP to new firms can enable academics to quantitatively measure and assess the quality and flows of technological knowledge previously unattainable on a large scale for new and small firms in technological fields.

Attention to human resources issues and how to compete with incumbent firms on the market for talent is often overlooked by entrepreneurs. This initial evidence indicates that a deeper understanding of what constitutes quality people represents an entrepreneurial firm’s most important asset, and is crucial knowledge for managers, investors and creditors working with those firms. For scholars, the implications are twofold; first, we have extended the ACAP construct to include the capability to identify and exploit technological knowledge outside of traditional R&D-settings, finding robust empirical support for the impact on a portfolio of firm performance measures and hopefully opening the field for a number of consecutive studies and applications.

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Table 1: Descriptive Statistics

	Variable	Mean	Std, Dev,	Min	Max
1)	Relative employee growth	.59	.40	.00	9.25
2)	Total salary	13.44	1.60	.00	23.57
3)	Average salary	12.30	.86	.00	20.51
4)	Return-on-assets (ROA)	.09	.12	.00	4.71
5)	Proportion Science and tech.	.13	.28	.00	1.00
6)	Proportion University	.13	.29	.00	1.00
7)	Size at entry	18.21	198.13	1.00	20887
8)	Merger	.11	.31	.00	1.00
9)	Split	.13	.34	.00	1.00
10)	*De alio*	.21	.41	.00	1.00
11)	Firm assets (000)	53.80	1340000.00	1.00	186000000.00
12)	Firm sales (000,000)	24.20	618.00	-213.00	100000.00
13)	Firm age	4.23	.13	1.00	14.00
14)	nr plants	1.20	3.65	.00	574.00
15)	Total patent	.01	1.69	.00	363.38
16)	Patent shares	.08	9.56	.00	1716.77
17)	Comp. group plants	7.88	76.28	.00	1710.00
18)	Comp. group sales (000,000)	459.00	5150.00	-213.00	149000.00
19)	Manufacturing	.05	.22	.00	1.00
20)	Industry employees	24958.22	20366.16	1.00	67180.00
21)	Industry patents	80.40	343.56	.00	2475.90
22)	Industry mean sales (000,000)	22.10	130.00	.00	13000.00
23)	Industry median sales (000,000)	1.98	58.00	.00	13000.00

Table 2: New Firm Survival

		Model 1. Any exit			Model 2. Termination			Model 3. Split			Model 4. Merger			Model 5 Industry	
	B	(s.e.)	p	B	(s.e.)	p	B	(s.e.)	p	B	(s.e.)	p	B	(s.e.)	p
Proportion Science and tech.	-.363	(.028)	***	-.362	(.031)	***	-.625	(.088)	***	-.315	(.060)	***	-.042	(.122)	
Proportion University	.209	(.026)	***	.258	(.030)	***	-.056	(.090)		-.023	(.056)		.310	(.122)	*
Size at entry	.000	(.000)		.000	(.000)		.000	(.000)	***	.000	(.000)	t	.000	(.000)	
Merger	.795	(.028)	***	.085	(.041)	*	1.805	(.055)	***	1.380	(.045)	***	1.188	(.102)	***
Split	.440	(.022)	***	-.174	(.031)	***	1.037	(.052)	***	1.387	(.036)	***	.828	(.086)	***
De alio	-.174	(.019)	***	-.139	(.021)	***	-.089	(.057)		-.395	(.046)	***	-.083	(.089)	
Firm asset	.000	(.000)		.000	(.000)		.000	(.000)		.000	(.000)		.000	(.000)	
Firm sales	.000	(.000)		.000	(.000)	***	.000	(.000)	*	.000	(.000)		.000	(.000)	
Firm age	-.164	(.004)	***	-.196	(.006)	***	-.056	(.007)	***	-.109	(.006)	***	-.139	(.014)	***
nr plants	-.006	(.003)	*	-.234	(.036)	***	-.001	(.003)		-.013	(.004)	**	-.007	(.007)	
Total pate nt	.053	(.065)		-.071	(.132)		-.070	(.095)		.070	(.083)		-.003	(.053)	
Patent shares	-.010	(.018)		.027	(.037)		.002	(.001)	*	-.017	(.022)		-.001	(.008)	
Comp. group plants	.000	(.000)	*	.000	(.000)	t	.000	(.000)		.000	(.000)	**	.000	(.000)	
Comp. group sales	.000	(.000)	**	.000	(.000)	*	.000	(.000)		.000	(.000)	***	.000	(.000)	**
Manufacturing	-.166	(.036)	***	-.326	(.047)	***	-.178	(.075)	*	-.228	(.061)	***	.764	(.094)	***
Industry employees	.000	(.000)	***	.000	(.000)	***	.000	(.000)	***	.000	(.000)	**	.000	(.000)	***
Industry patents	.000	(.000)		.000	(.000)	*	.000	(.000)		.000	(.000)	*	.000	(.000)	***
Industry mean sales	.000	(.000)	*	.000	(.000)		.000	(.000)	t	.000	(.000)	**	.000	(.000)	***
Industry median sales	.000	(.000)		.000	(.000)		.000	(.000)		.000	(.000)		.000	(.000)	
No. of subjects		38,036			38,691			39,427			39,004			39,456	
No. of failures (exits)		20,753			15,592			3,324			5,640			1,132	
No. of observations		99,231			114,822			124,790			116,835			127,941	
LR chi2		8536.43			6691.23			2713.33			4186.51			923.76	

Note: t p < .10, * p < .05, ** p < .01, *** p < .001.

Table 3: New Firm Performance

	Model 1. Employee growth			Model 2. Total salary			Model 3. Aver. Salary			Model 24 ROA		
	B	(s.e.)	p	B	(s.e.)	p	B	(s.e.)	p	B	(s.e.)	p
Proportion Science and tech.	-.0112	(.0052)	*	.0490	(.0185)	**	.3005	(.0144)	***	.0308	(.0020)	***
Proportion University	-.0289	(.0046)	***	.0293	(.0101)	**	.0694	(.0085)	***	.0082	(.0015)	***
Size at entry	-.0001	(.0000)	***	.0018	(.0001)	***	.0001	(.0000)	t	.0000	(.0000)	***
Merger	.1302	(.0076)	***	1.8336	(.0310)	***	-.0006	(.0228)		.0089	(.0029)	**
Split	-.0685	(.0054)	***	1.5063	(.0233)	***	.2093	(.0169)	***	-.0194	(.0021)	***
De alio	-.0122	(.0034)	***	.0943	(.0170)	***	-.0343	(.0120)	**	.0031	(.0014)	*
Firm asset	.0000	(.0000)	**	.0000	(.0000)	***	.0000	(.0000)	***	.0000	(.0000)	*
Firm sales	.0000	(.0000)	**	.0000	(.0000)	***	.0000	(.0000)	*	.0000	(.0000)	t
Firm age	.0359	(.0010)	***	.0396	(.0032)	***	.0415	(.0025)	***	-.0044	(.0004)	***
nr plants	.0031	(.0004)	***	.0109	(.0016)	***	-.0004	(.0012)				
Total pate nt	.0062	(.0209)		0.0856	(.0378)	*	.0407	(.0320)		-.0099	(.0061)	
Patent shares	-.0016	(.0025)		-.0058	(.0044)		-.0037	(.0038)		.0006	(.0007)	
Lambda	-.1373	(.0072)	***	-.2289	(.0200)	***	-.0692	(.0160)	***	.0120	(.0025)	***
Comp. group plants	.0001	(.0000)	***	.0006	(.0001)	***	.0002	(.0001)	**	-.0001	(.0000)	***
Comp. group sales				.0000	(.0000)	***	.0000	(.0000)	**	.0000	(.0000)	t
Manufacturing	-.0160	(.0065)	*	.2154	(.0296)	***	-.0788	(.0217)	***	-.0184	(.0026)	***
Industry employees	.0000	(.0000)	***	.0000	(.0000)	**	.0000	(.0000)	***	.0000	(.0000)	***
Industry patents	.0000	(.0000)	***	.0000	(.0000)		.0000	(.0000)	**	.0000	(.0000)	***
Industry mean sales	.0000	(.0000)	***	.0000	(.0000)	***	.0000	(.0000)	*	.0000	(.0000)	***
Industry median sales	.0000	(.0000)		.0000	(.0000)	***				.0000	(.0000)	
	within	between	overall	within	between	overall	within	between	overall	within	between	overall
R-squared:	.1167	.2952	.1951	.0585	.2929	.2897	.0413	.0493	.0372	.0275	.0310	.0344
No. of observations		99,230			99,230			99,230			99,230	
No. of groups		38,035			38,035			38.035			38,035	
Wald chi2		22,737.47			17,709.01			4,406.78			2,730.38	

Note: t p < .10, * p < .05, ** p < .01, *** p < .001.