ENTREPRENEURIAL LEARNING PROCESSES IN ACADEMIC SPIN-OFFS

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ENTREPRENEURIAL LEARNING PROCESSES IN ACADEMIC SPIN-OFFS

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ABSTRACT

Academic spin-offs are an important means for technology transfer from public research and strongly contribute to regional development. However, these companies have to overcome major challenges at start-up. Academic founders often lack business know-how and a market-oriented way of thinking. At the same time spin-off technology often still is at an early development stage and involves considerable uncertainties. Accordingly, many spin-offs follow suboptimal market chances and fail. Successful entrepreneurs, on the contrary, learn about markets right from the start and incorporate this knowledge in their product development activities. So far, little is known about the nature of these market-based learning processes in new ventures. Drawing on a database of 71 academic spin-offs, this study investigates how new ventures learn about markets at an early stage and how this influences market performance of spin-offs.

INTRODUCTION

The role of universities and public research institutions in transferring innovative technologies is widely acknowledged. Technology transfer increasingly becomes important with the change from industry to knowledge-based economies with respect to technological progress and economic growth. In the context of academic institutions, different channels of technology transfer exist, e.g., scientific publications, cooperation and contract research, consulting or licensing. Above all, spin-offs are regarded to particularly contribute to regional economic development (Dorfman, 1983; Chrisman et al., 1995; Lockett et al., 2003) and hence have been subject of increased interest in the past years. Academic spin-offs are companies that are founded by employees of public research institutions in order to commercialize technology developed within the institution (Steffensen et al., 1999).

However, in order to realise positive economic effects spin-offs must successfully innovate, i.e., transfer their technology into marketable products. This poses a major challenge for a lot of spin-offs (Vohora et al., 2004). Spin-off founders often lack business knowledge and a market-oriented way of thinking (Klofsten et al., 1988). At the same time, spin-off technology often is still at an early development stage, i.e., far from a possible commercialization and requires further development (Jensen & Thursby, 2001). Thus, it is often ambiguous which product solutions are most appropriate. Furthermore, a single technology can serve different markets differently well. This means that academic spin-offs can enter many different markets with their technology, but only few of those market chances possess high growth potential (Shane, 2000; Ardichvili et al., 2003). Hence, the decision on a specific target market is crucial to spin-off success. In this context, traditional market research methods are ill-suited to gain realistic market data and insights due to several reasons. It is not only the identification of relevant users that already poses a problem at this early stage, also user needs are mostly latent and therefore difficult to articulate. Besides, concept and prototype evaluation is hard for users in the light of missing reference products and experience (Von Hippel, 1986; Lettl, 2004). Accordingly, many spin-offs follow suboptimal market chances without having a clear vision of relevant target markets and user requirements and fail accordingly.

Lynn and Akgün (1998) argue that a learning-based strategy is appropriate in such an environment characterized by high uncertainties. However, only little is known how learning processes take place in
new ventures. Particularly, there is few empirical evidence on how founders make sense about the often ambiguous markets and customer needs at an early stage. This study’s objective is to close this gap by investigating market-based learning processes in academic spin-offs as well as if there are differences in learning between successful and unsuccessful spin-offs.

In this article we will first present major theoretical findings from which main hypotheses are derived. Then, methodology and results of an empirical study of 71 academic spin-offs will be presented. We conclude with managerial implications and future research questions.

THEORY & MODEL

Market-Based Organizational Learning & Entrepreneurship

Organizational learning is “a process of improving actions through better knowledge and understanding” (Fiol & Lyles, 1985, p. 803). Learning fosters innovation, reduces the risk of knowledge becoming obsolete and hence contributes to sustaining a company’s dynamic capabilities (Teece et al., 1997). The concept of learning is particularly discussed among strategic management and organization research schools, e.g. in the context of organizations (Fiol & Lyles, 1985; Huber, 1991; March, 1991; Nonaka, 1994) and alliances (Lane & Lubatkin, 1998; Larsson et al., 1998; Inkpen, 2000), learning barriers (Kim, 1993; Szulanski, 1996) or the risk of outlearning and spill-over effects (Hamel et al., 1989; Hamel, 1991). However, there is neither a common notion nor term of learning yet. In this paper, learning is conceptualized as a multi-stage process consisting of knowledge acquisition and knowledge integration activities (Day, 1994; Zahra et al., 2000). Knowledge is the result of learning processes and can be distinguished in explicit and tacit knowledge. Explicit knowledge can be codified in the form of language, numbers, symbols and figures and is therefore easy to transfer. Tacit knowledge dependents on context and person, cannot be articulated and is hence difficult to transfer (Polanyi, 1958; Nonaka, 1994).

With respect to market-based learning, there is a wide consensus on the positive relationship between market and customer understanding and performance (e.g. Dougherty, 1990; Kohli & Jaworski, 1990; Narver & Slater, 1990; Sinkula, 1994; Li & Calantone, 1998). However, existing studies concentrate on established companies that learn about changes in their business environment and adapt to those changes. The business environment of academic spin-offs, on the contrary, is not yet defined and different in many aspects. First, spin-offs can potentially enter many different markets with one single technology (Shane, 2000), which places the emphasis on the definition and choice of relevant target markets rather than the introduction of incremental innovations in existing markets. Second, new ventures cannot fall back on existing knowledge bases and routines, but rather have to build them up in order to survive and grow. Third, coordination tasks of different organizational functions and departments (e.g. Dougherty, 1990; Narver & Slater, 1990) are less problematic in new ventures’ learning attempts but rather the question how and from where relevant market knowledge can be acquired and how this knowledge can be integrated in new product development. Spin-off’s learning requirements therefore significantly differ from those of established companies both in complexity as well as their direct and long-term consequences on business development.

Although the importance of learning is widely acknowledged in entrepreneurship research, learning in the context of start-ups is still ill-understood (Harrison & Leitch 2005). Most studies focus on the individual level of the founder, i.e. her behavior and cognitive abilities (e.g. Minniti & Bygrave, 2001; Corbett, 2005). Empirical research on entrepreneurial learning at an organizational level is rare and appears relatively heterogeneous (Zahra et al., 2006). Studies show that entrepreneurs usually experiment with different business models and successively learn about their environment (Nicholls-Nixon et al., 2000; Ravasi & Turati, 2005). Zahra et al. (2000) demonstrate the positive performance effect of technological learning gained through internationalization of new ventures. Yli-Renko et al. (2001) analyzed knowledge acquisition from key customers; their results illustrate the relevance of strong personal contacts in entrepreneurial learning processes. However, organizational learning is often
conceptualized very generally, e.g. as a function of knowledge access structures (Almeida et al., 2003) or the degree of organizational change (e.g. Nicholls-Nixon et al., 2001), which hardly contribute to the understanding of the underlying learning processes. The case studies of Xie and White (2004) and Ravasi and Turati (2005) deliver greater in-depth insights by comparing the learning processes in one start-up each. However, the studies’ transferability is questionable due to their very specific context of one particular company. Peters and Brush (1996) give differentiated insights of new ventures’ market information activities but their descriptive study design does not enable to deduce causal effects. Moreover, many studies of entrepreneurial learning focus on technological learning, i.e. the acquisition and integration of new technological skills (Zahra et al., 2000; Saemundsson, 2005). Market-based learning, however, is rarely investigated, which is rather surprising keeping in mind the importance of market information especially for young companies’ survival and growth (Bullinger, 1990; Hemer, 2006). Vohora et al. (2004) conclude from their case studies that spin-offs must possess at least some market understanding to survive. Bond and Houston (2003, p. 132) argue a same and point out that “market-technology barriers that we identified highlight the importance of the firm’s attention to collecting information regarding technological possibilities, customer needs, competitors’ technology strategy and market feasibility as inputs to making strategic technology decisions."

This paper’s objective is to build on and extend existing research by analyzing market-based learning processes in academic spin-offs. We particularly investigate how academic spin-offs learn about markets at an early stage and how this influences their market performance. We differentiate between personal and codified learning as distinct knowledge acquisition strategies and analyze how spin-offs integrate market knowledge in their business activities. We also investigate whether the impact of these market-based learning processes change in dynamic environments.

Our study contributes to entrepreneurial learning research by closely analyzing learning processes in academic spin-offs. As well it compares the impact of different learning strategies with respect to gaining market knowledge and shows how dynamic environments effect a spin-off’s learning efforts. It further contributes to organizational learning research by extending market-based learning to the context of new ventures.

Figure 1 shows the study’s basic research model. According to this, spin-off’s performance is influenced by knowledge acquisition in form of personal (PL) and codified learning (CL) as well as knowledge integration (KI) activities. A moderating effect of technological dynamism (DYN) is assumed. Market performance (MP) is captured by the spin-off’s first product success indicating how successful the company was in transferring technology into a marketable product. Constructs and relationships will be discussed in the following section.

**Personal and Codified Learning**

According to the knowledge based view, knowledge is a company’s most important resource and performance is strongly determined by the ability to apply this knowledge effectively (Penrose, 1959; Grant, 1996a). In the case of academic spin-offs, it is necessary to connect their technological know-how with specific market demands (Bond & Houston, 2003). Thus, spin-offs must be able to translate their technology into marketable products by gaining and integrating market knowledge in their product development activities.

Knowledge can be acquired personally or through codified sources, i.e. independent of other persons (Daft & Weick, 1984). Personal learning (PL) refers to the acquisition of information and skills that are closely connected to other persons and hence necessitates close personal cooperation (Peters & Brush, 1996; Hansen et al., 1999). Both potential users (Von Hippel, 1986), suppliers and competitors (Baum et al., 2000; Vohora et al., 2004) as well as independent industry experts (Vohora et al., 2004) can be appropriate sources for market information. In the context of academic spin-offs PL plays a pivotal role since relevant market knowledge usually is not publicly available and concentrated on only a few people.
Moreover, user needs are mostly latent and therefore often cannot be articulated (Von Hippel, 1986). This highly tacit knowledge can only be transferred via personal interaction with potential users and market experts, in order to make use of it in spin-offs’ product development activities (Nonaka, 1994; Lane & Lubatkin, 1998). Thus, a personal based knowledge acquisition is vital for academic spin-offs in order to access the mainly tacit knowledge about markets and user needs. We therefore assume a positive relationship between PL and market performance.

\[ H_1: \text{The extent of personal learning positively influences a spin-off’s market performance. The higher the extent of knowledge acquisition through personal sources during product development the higher a spin-off’s market performance.} \]

Codified learning (CL) refers to information acquisition independent of other people through codified sources (Peters & Brush, 1996; Hansen et al., 1999). This explicit knowledge is tradable, e.g. in form of traditional market research data and research publications, or is publicly accessible, e.g. in form of market data published in internet and print media. Due to its higher transferability CL involves less time and effort in accessing knowledge than PL. However, the value of codified information acquired is lower since this information is potentially available to any other party, such as competitors, too. As well it only allows gaining superficial general insights (Lane & Lubatkin, 1998). However, we believe that CL complements PL through the acquisition of basic know-how, such as legal requirements and general market trends. Thus, we also expect positive effect of codified learning on market performance.

\[ H_2: \text{The extent of codified learning positively influences a spin-off’s market performance. The higher the extent of knowledge acquisition through codified sources during product development the higher a spin-off’s market performance.} \]

Knowledge Integration

In order to become effective, knowledge gained needs to be integrated within the organization (Cohen & Levinthal, 1990; Grant, 1996b). Knowledge acquisition and knowledge integration are therefore complementary to each other and define an organization’s learning process.

Knowledge integration (KI) is a three-step process that describes how the knowledge gained is captured, interpreted and used in the company (Zahra et al., 2000). Capture refers to the documentation and exchange of information within the spin-off in order to make it available to relevant organizational members. Interpretation is necessary to reflect and evaluate new information. This takes place by jointly discussing analyzing successful and less successful project activities as well as a rather trial-and-error based information processing by which a company successively gains clarity on what has been learnt (Von Hippel & Tyre, 1995; Lynn et al., 1996). Finally new knowledge must be put to use, i.e. applied in new product development. Therefore it is mandatory to draw the consequences of the new market information gained and to integrate this knowledge into the spin-off’s business activities. In turn, we expect that KI positively influences a spin-off’s market performance.

\[ H_3: \text{Knowledge integration describes the capture, interpretation and use of market information acquired. The extent of knowledge integration positively influences a spin-off’s market performance. The higher the extent of knowledge integration during product development the higher a spin-off’s market performance.} \]

Technological Dynamism

According to Glazer and Weiss (1993) a market with environmental turbulence is characterized by (1) a high extent of inter-period change in the levels or values of key environmental factors and (2) substantial uncertainty and unpredictability as to the future values of these variables.
The impact of dynamic environments is mainly discussed in marketing and strategy research. Jaworski and Kohli (1993) empirically analyzed the relationship between market orientation and business performance and the impact of environmental variables that comprise varying degrees of market turbulence, competitive intensity and technological turbulence. Their results did not show any significant effects of environmental factors on the market orientation – performance relationship. Similarly, Calantone et al. (2003) found little support for an interaction effect between turbulent environments and market orientation on performance. The empirical study of Han et al. (1998) indicates some different results. Though they found no influence of market turbulence, they show that technological turbulence moderates the relationship between market orientation and innovation development. Thus, the impact of dynamic environments with respect to market understanding remains ambiguous. However, as these studies focus on established companies, the situation might be quite different for technology-based new ventures, in which the effectiveness of market-based learning is probably more prone to the degree of technological dynamism.

Academic spin-offs, as most technology based companies, are usually situated in highly dynamic and volatile environments. This implies that time plays a major role in this context that is characterized by an acceleration of market and technological changes and an explosion of available information (Slater & Narver, 1995). In these environments, spin-offs have to cope with an abundance of new emerging market and technological data within short time while they develop and commercialize their technology. Bourgeois and Eisenhardt (1988) describe highly dynamic markets in which changes are so rapid and discontinuous that information collection at the beginning of new product development cycle can become obsolete by the time products are launched. Thus, market information becomes time sensitive in these environments (Glazer & Weiss, 1993). An immediate and direct access to market knowledge creates a competitive advantage due to the reduction of development time of innovations (Calantone et al., 2003) and the ability to earlier launch and market new products than competitors. This is crucial in turbulent environments, in which technological life cycles become shorter and technological breakthroughs occur at a more rapid pace. Hence, the capability to respond rapidly to evolving technical and market information is a critical factor to success (Iansiti, 1995). As competitive advantage of spin-offs strongly depends on their technology and the ability to effectively commercialize it, this study particularly focuses on the impact of technological dynamism (DYN). This is defined as a turbulent environment, in which the time intervals between major technological innovations continuously decrease.

Personal learning is particularly important in dynamic environments, as the highly tacit market knowledge can only be transferred in short time via personal interaction with external partners. Close cooperation with users, suppliers, and market experts hence is necessary to stay abreast of competitors. Transferring information via personal interaction allows accessing up-to-date market information within short time. Moreover, the direct contact with external partners does not only enable to immediately request and transfer knowledge, the interacting parties can also instantly feedback on the information exchanged and thereby reduce misunderstandings. Accordingly we assume that an environment characterized by high technological dynamism reinforces the relationship between personal learning and spin-off’s market performance.

\[ H_{4g}: \text{The extent of technological dynamism positively moderates the effect of personal learning on market performance of academic spin-offs.} \]

As codified learning builds on knowledge acquisition from existing and accessible data and publications, this learning strategy involves the risk that the knowledge sources are less up-to-date than personal sources. Indeed, codified knowledge is characterized by some time lag reflected in the time between the discovery, processing, storage and publication of information and data. Especially market research data, if available, is time-delayed as it rather comprises past customer needs and competitor activities than future customer attitudes and requirements and competitor strategies respectively. Contrary to personal learning, we assume that a high extent of technological dynamism weakens the effect of codified learning on spin-off’s market performance.
H4b: The extent of technological dynamism negatively moderates the effect of codified learning on market performance of academic spin-offs.

Concerning knowledge integration, spin-offs must respond rapidly to new market information. This is especially the case in highly dynamic environments, in which the ability to react faster than competitors is crucial. If knowledge is not captured, interpreted and used in short time, superior knowledge will become obsolete and competitive advantage will be lost soon. Accordingly we expect that the relationship between knowledge integration and market performance is reinforced by technological dynamism.

H4c: The extent of technological dynamism positively moderates the effect of knowledge integration on market performance of academic spin-offs.

**METHODOLOGY**

To examine the relationship between market learning processes and market performance, a study of 152 spin-offs from higher education institutions in Germany was conducted. To be included in the sample four criteria had to be met: (1) the spin-off has been founded by employees of a public research institution, (2) the spin-off’s core technology originates from this research institution, (3) the company is independent and (4) its maximum age is 10 years.

Data was collected in form of standardized questionnaires in personal interviews with spin-off founders. A multiple key informant approach was used as suggested by Kumar et al. (1993) and Ernst (2002) to reduce a possible informant bias. The spin-off’s founder was ask to state on the spin-off’s characteristics at start-up as well as performance while a second key informant who was involved in new product development and launch (e.g. project manager) was ask in a shorter questionnaire to indicate the knowledge acquisition and integration activities during that time. The final sample consists of 116 usable questionnaires of which 71 were fully completed by both key informants. These spin-offs have an average age of 5 years, size of 11,5 employees and turnover of 887 T€ in 2005 which is comparable to other studies on academic spin-offs (Jones-Evans et al., 1998; Steffensen et al., 1999). 37% of the companies are based on information technology, 21% on biotechnology, 23% on electronics, photonic and nanotechnology and 19% on other technological fields.

Scales were either adapted from literature or developed specifically for this study. Guidelines set by Diamantopolous and Winklhofer (2001) were followed in developing the formative scales. Initial item pool generation is based on in-depth interviews with spin-off founders. Scales were successively pretested and revised after each round. At the end of the third final round, respondents indicated that the remaining items were clear, meaningful and relevant. All items were measured on a seven-point Likert scale.

Personal learning was captured by five items on market knowledge acquisition activities by interacting with different personal knowledge sources (e.g. customers, competitors, market experts) during new product development. Similarly, five items referred to codified learning in terms of knowledge acquisition from codified sources (e.g. databases, magazines, internet). Knowledge integration was measured with eleven items on the capture, interpretation and use of market information gained during new product development. Technological dynamism was captured by one item that described the extent of decreasing time intervals between major technological innovations in the industry.

To evaluate performance, many empirical studies use financial (objective) measures, as e.g. sales, profit, cash-flow etc. (Geringer & Herbert 1991). Since this data is very often difficult to collect due to confidentiality reasons or non-availability of data – which is particularly the case for new ventures – researchers increasingly use performance indicators that are based on subjective evaluations of key informants. A lot of studies show that these subjective measures highly correlate with objective criteria and are therefore an appropriate option for performance measurement (e.g. Covin & Slevin 1989;
In our study, a subjective performance measure was used as dependent variable. Market performance was measured with seven items that indicate how the spin-off’s first product performed one year after launch in terms of the achievement of founders’ objectives. In order to reduce informant bias, items on learning processes and market performance were evaluated by two different key informants in separate questionnaires as described above.

We controlled for prior knowledge in terms of the founders’ industry experience in years as well as existing relationships with customers at start-up. Moreover, spin-off’s main technological field, founders' team size and technological uncertainty at start up were used as controls. Finally we controlled for the time lag between the spin-off’s start-up and their first product launch.

**EMPIRICAL RESULTS**

To test the hypotheses a moderated regression analysis was performed as suggested by Aiken and West (1991). According to this, all independent variables are simultaneously considered in a step-wise process in which first the controls, then the main effect variables and finally the interaction effects are included into the regression equation. All independent variables were centred prior the computation of interaction terms.

All measures were analyzed for reliability and validity. The correlations (Pearson) of the main variables ranged from 0.02 to 0.46. Descriptive statistics and correlations of main variables are shown in table 1.

Moderated regression analysis as shown in table 2 confirmed the proposed direct positive effects of personal learning and knowledge integration on performance (H1 and H3 supported), while there the direct effect of codified learning is not significant (H2 not supported). However, our results indicate a positive interaction effect of personal learning and technological dynamism and a negative interaction of codified learning and technological dynamism on performance (H4a and H4b supported). The effect of knowledge integration does not change in technologically dynamic environments (H4c not supported).

Further tests indicate that multicollinearity is unlikely to pose a problem with variance inflations factors (VIF) below 1.8 and a maximum condition index (CI) of 3.9. Multicollinearity possibly exists if correlations are above 0.70, VIFs above 10, and CI is higher than 30. Moreover, a multi-trait multi-method (MTMM) analysis as proposed by Campbell and Fiske (1959) was conducted to control for validity of key informants’ statements. MTMM analysis showed that both convergent validity and discriminant validity of key informants’ statements can be confirmed.

To further analyse results the significant interaction effects were graphically plotted as proposed by Aiken and West (1991). Figure 2 shows the interaction of personal learning and technological dynamism on performance. Personal learning obviously is of minor importance when a spin-off’s environment is less dynamic but it becomes a crucial factor with increasing technological dynamism. On the contrary, codified learning becomes increasingly counterproductive the more a spin-off’s environment is characterised by high technological dynamism as shown in figure 3.

**DISCUSSION AND IMPLICATIONS**

Summing up, our study shows a positive impact of personal learning and knowledge integration on spin-off’s market performance. Results further indicate a positive interaction effect of personal learning and technological dynamics on performance, while codified learning has a negative effect in technologically dynamic environments. We conclude that personal learning and knowledge integration are important means for developing marketable products in academic spin-offs, while codified learning seems to be a less effective or even a counterproductive way to acquire market information at an early stage.
Our results show the importance of investigating the learning concept in a more differentiated way. A personal based learning strategy seems to be particularly appropriate in the context of spin-offs; also knowledge integration is not to be neglected when researching learning processes. Results also indicate that studies should go beyond the prevailing user perspective. Other market participants such as suppliers, competitors etc. can also be sources for valuable market information for new ventures. Finally, learning seems to be differently important in different environments, hence environmental factors such as e.g. technological dynamism are also be taken into account when defining a spin-off’s appropriate learning strategy.

From a managerial perspective the results underscore the necessity that academic spin-offs must learn about markets already at an early stage in order to realise marketable products and to succeed in the market place. However, there are different ways of learning and their impact differs significantly. Concerning knowledge acquisition a person-based way of learning is more effective than studying information from codified sources. Thus, the early integration of potential customers and suppliers in product development is mandatory as well as the close interaction with market experts from the start. Comprehensive exchange with different market partners is crucial to gain a sense for markets and close collaboration is necessary to get valuable market information that otherwise could not be acquired. Market research or any other public available sources are less effective devices to learn about markets at an early stage. This is particularly the case in technologically dynamic environments in which current publicized data is not up-to-date any more within a short period of time. Moreover, comprehensive knowledge integration is a precondition to realize performance effects. For this purpose academic founders should establish processes that facilitate knowledge flows within the organization and set up structures that foster open communication and constructive dialogue between organizational members in order to fully tap the potential of what has been learnt.

Although this study provides some interesting results, some limitations are to be mentioned. Our study used a subjective performance measurement, which might give rise to biased responses. As our data builds on two key informants we managed to minimize the risk of an informant bias, at least to some extent, which is also confirmed by the MTMM analysis that indicates validity of results. Further, our data derives from a cross-sectional study. As learning is inherently dynamic in nature, e.g. relevant market knowledge may change over time according to current needs and requirements, future research should investigate the development of learning processes in spin-offs and their performance impact in a longitudinal study. Finally, the role of further context factors on the effectiveness of entrepreneurial learning would be a promising field of research. Future studies should therefore investigate the influence of spin-offs’ different start-up configurations in terms of their resources and entrepreneurial culture to complete our understanding of learning processes in academic spin-offs.

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REFERENCES


Figure 1: Basic Research Model

![Diagram showing the relationships between Personal Learning (PL), Codified Learning (CL), Knowledge Integration (KI), Technological Dynamism (DYN), and Market Performance (MP).]

- Personal Learning (PL) influences Technological Dynamism (DYN) through Hypothesis 1 (H1).
- Codified Learning (CL) influences Market Performance (MP) through Hypothesis 2 (H2).
- Knowledge Integration (KI) influences Market Performance (MP) through Hypothesis 3 (H3).
- Technological Dynamism (DYN) influences Market Performance (MP) through Hypothesis 4a-e (H4a-e).
### Table 1: Descriptive Statistics and Correlations of Main Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>MP</th>
<th>PL</th>
<th>CL</th>
<th>KI</th>
<th>DYN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Market Performance (MP)</td>
<td>5.19</td>
<td>0.79</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>2. Personal Learning (PL)</td>
<td>4.01</td>
<td>1.20</td>
<td>.33</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
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<td>3. Codified Learning (CL)</td>
<td>3.81</td>
<td>1.15</td>
<td>.17</td>
<td>.46</td>
<td>.31</td>
<td></td>
<td>1.0</td>
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<tr>
<td>4. Knowledge Integration (KI)</td>
<td>4.85</td>
<td>0.91</td>
<td>.34</td>
<td>.43</td>
<td>.31</td>
<td>.31</td>
<td>1.0</td>
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<tr>
<td>5. Technological Dynamism (DYN)</td>
<td>3.53</td>
<td>1.67</td>
<td>-.02</td>
<td>.16</td>
<td>.10</td>
<td>.09</td>
<td>1.0</td>
</tr>
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</table>

### Table 2: Regression Results (Standardized Coefficients)

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Market Performance</th>
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<tbody>
<tr>
<td><strong>Main effects:</strong></td>
<td></td>
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<tr>
<td>Personal Learning (PL)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.20&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Codified Learning (CL)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.12</td>
</tr>
<tr>
<td>Knowledge Integration (KI)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.20&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td><strong>Interaction effects:</strong></td>
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<tr>
<td>PL x Technological Dynamism</td>
<td>.20&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>CL x Technological Dynamism</td>
<td>-.25&lt;sup&gt;**&lt;/sup&gt;</td>
</tr>
<tr>
<td>KI x Technological Dynamism</td>
<td>-.58</td>
</tr>
<tr>
<td><strong>Control variables:</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Prior Knowledge&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-.03</td>
</tr>
<tr>
<td>Existing Customers&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.40&lt;sup&gt;**&lt;/sup&gt;</td>
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<td>Founders Teamsize&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-.27&lt;sup&gt;t&lt;/sup&gt;</td>
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<td>Time Start-up to Launch</td>
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<td>F</td>
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</tr>
</tbody>
</table>

<sup>** p ≤ .01; * p ≤ .05; † p ≤ .10 (one-tailed test of coefficients)</sup>

<sup>a</sup> Data was provided by second key informant (e.g. project manager)
<sup>b</sup> Industry and technology field dummies not reported.
<sup>c</sup> Data provided for the time of start-up.
Figure 2: Interaction Plot of Personal Learning and Technological Dynamism

Figure 3: Interaction Plot of Codified Learning and Technological Dynamism