The Impact of Collaborative Innovation between Established Industry and Academic Technology Spin-offs

Stephan Hess[1], Simon Suhrbeer[2] & Roland Y. Siegwart[2]

[1] Alstom Power Switzerland

[2] Swiss Federal Institute of Technology, Switzerland

Correspondence: Stephan Hess, Alstom Power Switzerland. Tel: 41-44-632-2634, Fax: 41-44-6321-184. E-mail: stephan.hess@alstom.com

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Abstract

When the market demands strong, active innovation screening, the established industry needs to consider efficient technology transfers and development alliances across industry boundaries. The importance of academic spin-offs as a transfer channel for breakthrough technological innovations between academia and established industries is increasing. Consequently, cooperation between an established industry and academic spin-offs are of potential interest. This investigation at Swiss Federal Institute of Technology Zürich (ETHZ) aims to explore the alliances between academic technology spin-offs and an established industry. More specifically, parameters that can increase the chances of a successful alliance are explored in depth. An alliance model to develop breakthrough technologies will be presented, based on the results of a multiple case study.

Keywords: Research & Development, Alliances, Spin-offs, Innovation management, Breakthrough technologies

JEL Classification Codes; O31, O32, O33, L2, L3, L64, L97

1. Theories and Background

Economic growth is not only dependent on existing knowledge and technological innovation; economic growth needs also the development of breakthrough technologies and their market diffusions. Research laboratories and universities count for a great many of these technological innovations. However, deficiencies in the commercialization of technologies by academic institutions are manifold (Brown, 1985; Sohn and Lee, 2011; Hall et al., 2001; O'Gorman, Byrne and Pandya, 2008). Owing to the entrepreneurial limitations of research organizations, technologies are transformed by established industries or academic spin-offs that incorporate the technology while it is under development from an academic parent organization.

Figure 1 illustrates the role of the transfer performer along a technological lifecycle curve. Small firms are suited to major breakthrough product innovations, while established firms focus on product diffusion and optimization. Bollinger, Hope and Utterback (1983, p. 4) found that "*Small companies see an invention as a major opportunity because it allows them to enter a marketplace. Conversely, large, established firms tend to view the small enterprises as a threat*."

With their technological expertise, internal flexibility, and agility, academic spin-offs have innovation advantages over incumbents and differentiations as a technological transfer channel to discover innovations (Hess and Zwicker, 2009; Autio, 1997; Fontes, 2005). Entrepreneurial researchers conduct research and development (R&D) projects and build new technology absorptive capacities (Vanhaverbeke et al., 2008). This leads to a prototype or pilot installation that can be used to test the production and market issues and accomplish the transformation of a research result into a technology or product.

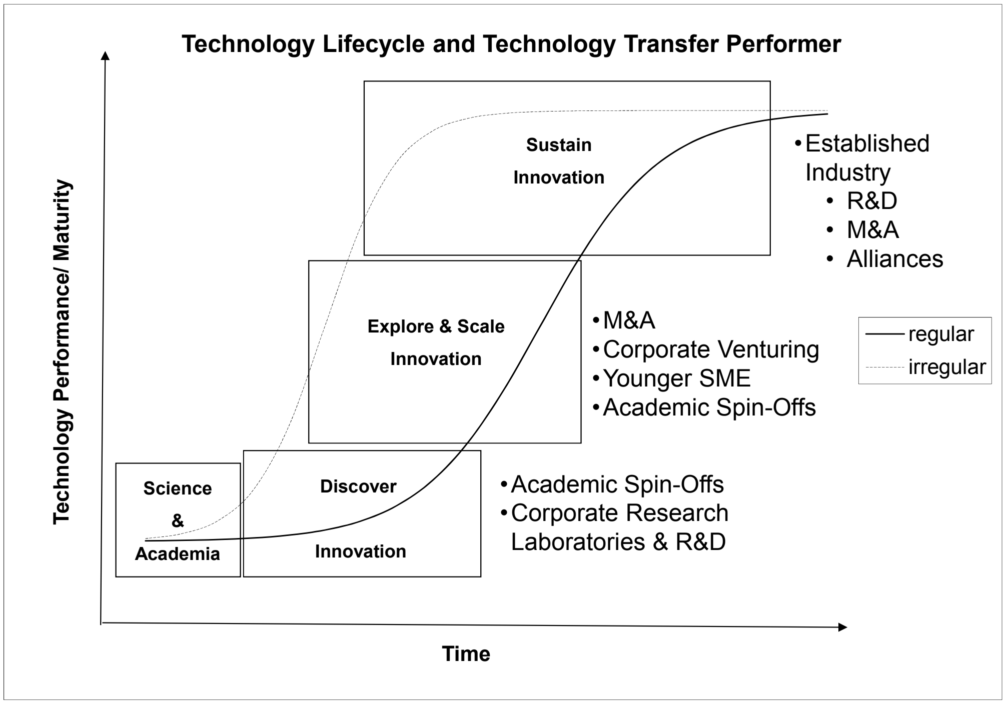


Figure 1. Schematic S-curve with regular and irregular behavior (Hess and Siegwart, 2012)

For established firms in times of sustainable innovation, the incremental behavior of a technological lifecycle can be controlled by their established technology absorptive capacity and the relationship with their academic partners (Christensen, 2003). In turbulent times, disruptive or breakthrough innovations may occur quickly in an irregular step function. In an industry experiencing a period of turbulent innovation, with many competing technologies pushing for position, this is a genuine challenge for established firm's external technology absorptive capacity (Cohen and Levinthal, 1989). This is also confirmed by the theory for large incumbents to become ambidextrous (Tushman and O'Reilly, 1996). Enterprises should actively increase their technology scanning behavior. Radical innovations then become possible. Open innovation theory (Chesbrough et al., 2006) suggests an "opening up" of R&D for an external breakthrough technology development (e.g., with spin-offs).

Di Guardo and Harrigan (2011, p. 10), in a comprehensive meta-analysis analysis, found a *"... technological change groups common theme is analysis of strategic alliances as a vehicle to speed capability development by acquiring and exploiting knowledge developed by others while minimizing firms exposures to technological uncertainties."* Firms need to increase innovation and technological screening behavior across firm boundaries to early technology lifecycle phases and increase cooperation with academia and its spin-offs as alliance partners.

2. Research Objectives

Recognizing an established industry's ambidexterity question and the analysis of the existing literature opens up innovation indications for the early stages of a technology lifecycle. Consequently, development alliances with technology spin-offs are an option we know little about. This study aims to investigate the performance of partnering and alliances by applying an open innovation approach with established industry in the early stages of technology spin-offs. To accomplish this, an analysis of the various technology transfers and innovation demands and capabilities of the players will be conducted.

The authors will attempt to determine the answers to the following questions:

- Does collaborative innovation between academic technology spin-offs and an established industry improve both players' innovation capability?
- Which parameters can increase the chances of a successful alliance?

3. Methodology

The research presented here is based on qualitative empirical investigations into the technology transfer performance of Swiss technology enterprises. In pre-evaluation interviews and informal discussions with experienced spin-off coaches and technology transfer experts, it was recommended that we exclude life- and bio-science and service spin-offs from the study, because the technology R&D, industrial barriers and the overall spin-off positioning and industrial settings are very different. To specify technology, we introduced the NOGA (Nomenclature Générale des Activités économiques - Swiss branch code to systematically classify economic enterprises analogue the EU NACE classification) codes for materials, mechanical devices and electrical devices.

In the time frame of 2000-2012, the ETHZ launched ~30 spin-offs with the relevant characteristics. Twenty spin-offs CEO's were participating in a single 2-3 hour semi-structured interview investigating the actual spin-off situation in depth, with particular focus placed on industry alliances. We identified ten spin-offs from the ETHZ and its adjacent institutes that were willing to volunteer to participate in a longitudinal investigation. The research participants selected were spin-off founders in the role of a CEO or CTO of the young firm and representatives from the industry partner. We baseline our understanding of the spin-offs on a structured questionnaire. Subsequently, we met every two weeks for a two hour interview. We also conducted numerous workshops and informal discussions. The case study method was selected, as it allows for a detailed investigation and an analysis of a management problem (Eisenhardt and Graebner, 2007; Yin, 2009). This paper focuses on understanding the problems, patterns and construction processes to develop a spin-off alliance model with industry, which is the reason the case study as a method has been choosen.

We also began an investigation with a quantitative research study about the established Swiss industry innovation behavior and their knowledge transfer with academia. The basis for this investigation was the KOF, Swiss Economic Institute survey of a Swiss enterprise panel. The survey explores innovation and knowledge exchange and is executed every five years. The most recent quantitative sample of technology firms' knowledge exchange and innovation behavior is a structured questionnaire, which is dated from 2005 (Arvanitis et al., 2005), but it includes data for 1,370 firms. As the authors were particularly interested in longer-term behavior in R&D, innovation, and barriers in collaboration with academia, the authors assumed that the recentness of the available dataset would not fundamentally distort the results. With the respective NOGA codes, the technologies of interest were narrowed down to a sample of 674 firms, with 30 observations being statistical significant (Cochran, 1940; McClave et al., 2008, p. 478). Names of the participating spin-offs have been changed to protect the company's identities.

4. Performance of Academic Spin-Offs and the Impact of Alliances

A sample of spin-offs with the relevant characteristics from twenty out of thirty possible ETHZ spin-offs was available for interviews. To better understand the company performance, it was important to determine whether they were standalones spin-offs or already involved in an industry alliance. An industry alliance was defined as a longer-term commitment, primarily contractual, between the spin-off and an established industry player. This alliance was important in developing, producing and selling a technology. Eight spin-offs were identified as being engaged in an industry alliance, while 12 were standalone spin-offs.

The results from the spin-off firms were not statistically significant, so their performance has been compared with a conservative baseline scenario. Hess and Siegwart (2012), describe the development of technology spin-offs for the early phase (Marmer, Herrmann, Berman, 2011) based on this, the authors have assumed a minimum, conservative-growth scenario of variables to establish a spin-off:

- 30% annual growth on revenue after the 2nd year of R&D
- 3 full time equivalents (FTE) p.a. capability increase
- 1 patent p.a. intellectual property portfolio development
- 10% reduction of R&D share p.a.

a) b)

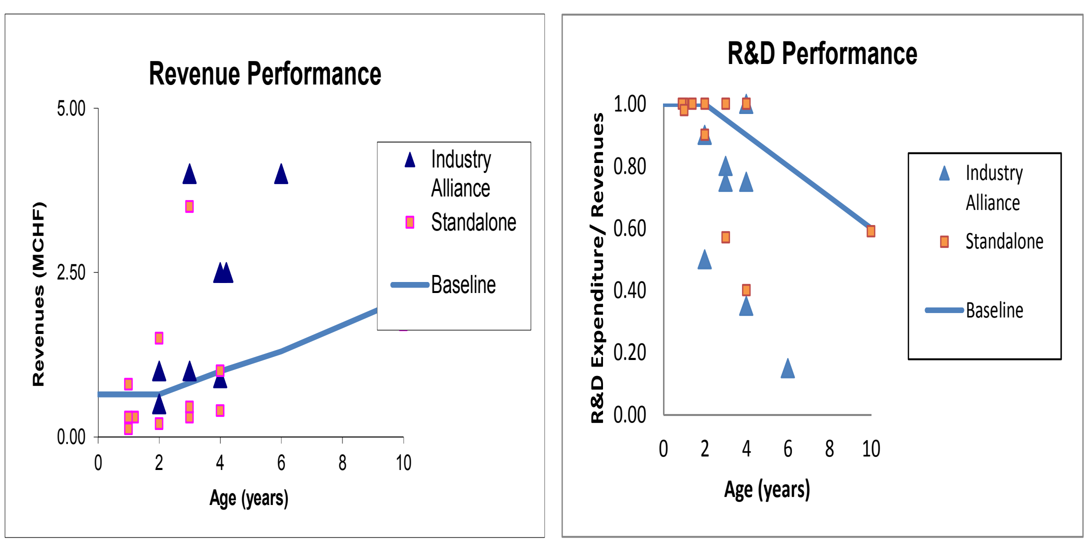
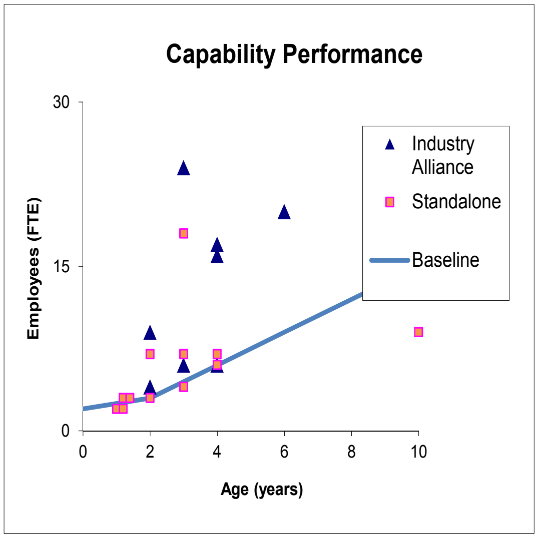


Figure 2. a) Revenue performance of evaluated academic technology spin-offs
Figure 2. b) R&D performance of evaluated academic technology spin-offs

Figure 2 a) illustrates that, in comparison with the baseline scenario, the spin-offs taking part in this study, which were already in an industrial alliance, tended to generate more revenue more quickly than the baseline scenario. Figure 2 b) shows that R&D is a key activity for academic spin-offs; R&D intensity is prominent and dependence on initial R&D funding is very high. However, compared to the baseline scenario, spin-offs in an alliance have the advantage that they can stabilize non-R&D revenues faster, based on an earlier market entry. In this way, spin-offs with large R&D expenditures per employer can build up their technology absorptive capacity.

a)



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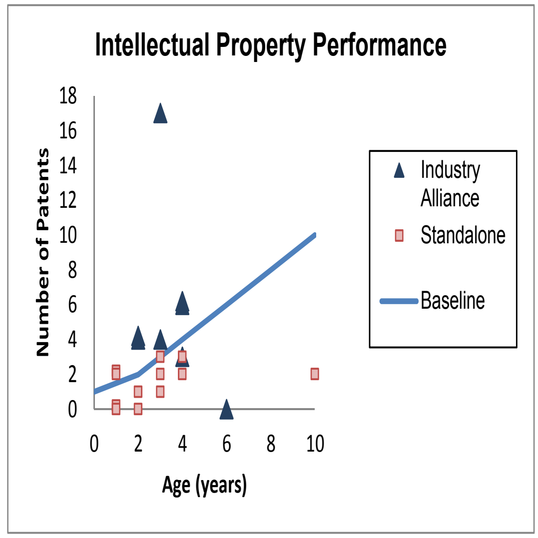

Figure 3. a) Capability performances of evaluated technology spin-offs in Full Time Equivalents

Figure 3. b) Intellectual property performance of evaluated technology spin-offs Intellectual

Figure 3 a) illustrates the build-up of capabilities and the increase of the technology absorptive capacity. In the interviews, the CEOs from the spin-offs confirmed a comfortable situation with access to academic talents, though it was more difficult to attract experienced personnel from the external market. However, alliance spin-offs seemed to have an advantage, compared to the baseline scenario, in being able to establish an initial base of employees with required capabilities more quickly than the baseline.

Figure 3 b) illustrates the spin-offs' performance relating to protecting their intellectual property. Interviews show that spin-offs in industry alliances focused on product development to their defined markets. Consequently, they protected specific product features. Most standalone spin-offs primarily concentrated on developing a technology demonstration without a clear product and market definition. Patents dated back to when the firms were founded.

All technology spin-offs interviewees were asked to self-assess and position their company's technology and product portfolios on a technology lifecycle curve. To accomplish this goal, they were first asked to select a dynamically "regular" or "irregular" lifecycle behavior and then to position their technology portfolios on a maturity scale.

The results in Figure 4 illustrate that technology spin-offs with industrial alliances rate themselves on an irregular technology lifecycle curve. Such ratings are subjective and driven by external effects and experience. These include public opinions, public awareness, and the importance of the technology discussed in public and scientific publications, as well as industry patenting activity, regulatory and market barriers, and the subjective strategic awareness of the industry or industry players.

For example, a spin-off might rate its own technology lifecycle as "regular", while an established player, because of its industry-specific strategic rationale, might consider the lifecycle to be "irregular", or vice versa. Indeed, in one interview, the CEO of a spin-off with technology for composite materials, who had completed an industry alliance contract with a car manufacturer, mentioned that while the contract was being negotiated, he noticed that the car manufacturer was positioning the spin-off technology much more "irregularly" than he himself was doing. Thus, because of the alliance development, the spin-offs perception moved from "regular" to "irregular" with the different notion of development progress and lifecycle dynamics.

From an established industry point of view, technologies following “regular” lifecycle behavior can be monitored from a distance, as they move according to normal industry dynamics. Depending on the degree of maturity achieved, they are considered an object of interest, for example, with an acquisition proposition, an alliance or just as a competitive threat. Technologies considered on an “irregular” technology lifecycle trajectory with high dynamics are usually of greater interest, because they can appear more quickly on the market and grow faster.

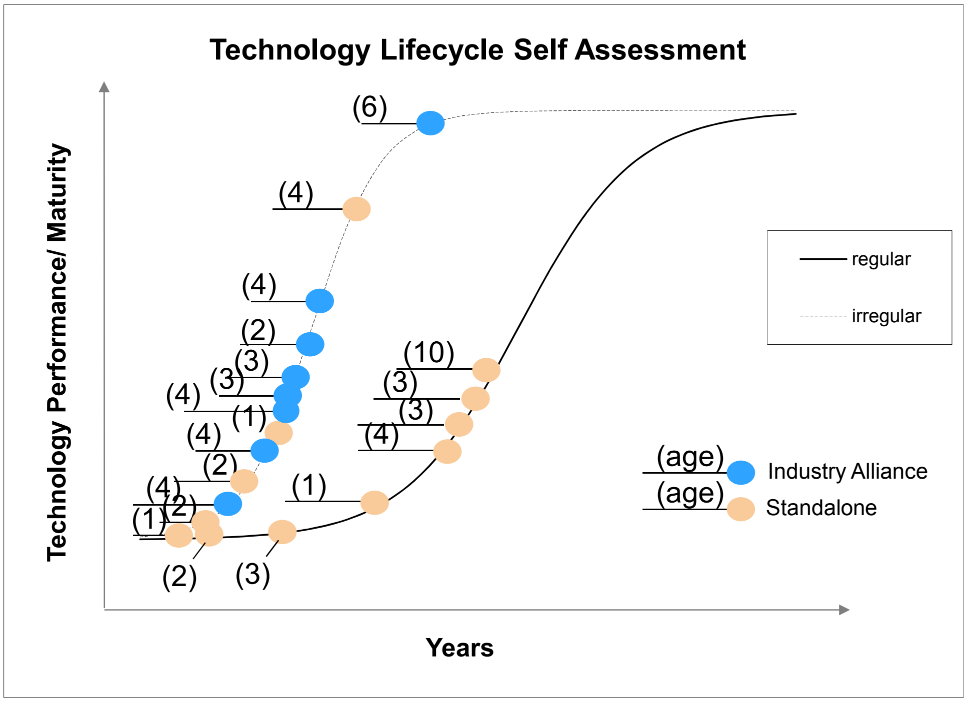

Figure 4. Technology lifecycle positioning of evaluated technology spin-offs; self-assessment

Experience A: Alliances

- Alliances positively impact a spin-offs performance and the building of a technology absorptive capacity.
- Spin-offs perception on the technology lifecycle curves impact occurrence of industry alliances and alliance spin-offs position themselves on an irregular technology lifecycle curve.

5. Evaluation of Innovation Performance and Knowledge Exchange of Established Swiss Technology Enterprises and Academic Technology Spin-Offs

To better understand the basic technology transfer performance of established technology firms in Switzerland, the KOF Survey Data 2005, in a quantitative research study with a sample of 674 observations, was broken up and evaluated in terms of size and age. Size is a common means (Harhoff et al., 1996) of investigating innovation and technology transfer performance. Age has been introduced, because the focus of this research is on academic spin-offs, which are young and usually focused on a limited number of technological fields, and therefore, small and medium enterprises (SME). It was assumed that since the number of mature technologies and products increases with age in a firm’s portfolio, the development effort for incremental innovation with product improvement and modification also rises. The number of technological fields (Harhoff et al., 1996, p. 15) explored and exploited by firms may also increase with age.

The questionnaire focus was on the spin-offs’ employees and the number of graduates, the nature of the innovation, cooperation behavior, R&D, and intellectual property performance.twentyspin-off firms from the qualitative case study were found to not be statistically significant; however, to discuss trends, their answers have been listed against the quantitative results, but discussed separately. The results are shown in Tables 1 and 2. This allows for the initial positioning of academic spin-offs, when compared with established Swiss technology firms.

Table 1. Innovation behavior of Swiss technology firms compared with scientific spin-off evaluations (qualitative study results are shaded)

	Large corporation (≥250 employees)	SME (<250 employees; 20-50 years)	SME (<250 employees; 10-20 years)	SME (<250 employees and ≤10 years)	Spin-Offs ≤10years
Observations	*113*	*389*	*136*	*36*	*20*
Revenues (million CHF)	199	17	18	28	1.3
Employees (N)	610	56	53	76	9
Graduates (%)	8	4	5	6	89
Introduced innovations (%)	92	**68**	69	71	100
product innovation (%)	90	**56**	58	60	72
process innovation (%)	72	**46**	42	49	38
co-operation with academic institutions (%)	51	**16**	23	28	100
Share of sales by products (%)	100	**100**	**100**	**100**	100
newly introduced (%)	17	**16**	20.5	21	65
considerably improved (%)	24	**20**	20.6	24	35
insignificantly modified (%)	59	**64**	58.9	55	-
R&D-activity (%)	87	**45**	50	54	91
R&D-expenditure (million CHF)	14	0.9	1.1	1.4	0.8
R&D-expenditure/Revenues	0.07	0.05	0.06	0.05	0.62
Filing of patents (%)	69	21	24	27	74
Knowledge exchange with academic institutions (%)	73	28	30	31	100

Table 2. Constraints of knowledge exchange (mean value) rated on a scale of 1 (not important) to 5 (important) between Swiss technology firms and academic partners compared with scientific spin-off evaluations (qualitative study results are shaded)

	Large corporation (≥250 employees)	SME (<250 employees; 20-50 years)	SME (<250 employees; 10-20 years)	SME (<250 employees and ≤10 years)	Spin-Offs ≤10years
Constraints for knowledge exchange					
lack of entrepreneurial spirit	2.58	2.08	2.19	2.21	3.4
lack of financial resources	2.37	2.64	2.72	2.97	2.9
Uncertainty of co-operational relationship	2.57	2.14	2.22	2.18	2.2
Different notion of urgency	2.92	2.1	2.17	1.97	3

The evaluation of the KOF data in Tables 1 and 2 illustrate the following quantitative results for Swiss technology firms shown in Table 3. The large number of academic graduates and the size of R&D activities increase the absorptive capacity (Harhoff et al., 1996, pp. 63-67) of large enterprises' technology, and therefore, their cooperation with academic institutions. However, the picture may be distorted: the size of their R&D can partly be explained by the higher number of technological fields in which large enterprises are likely engaged (Polt et al., 2001). The focus of the established SME is on technological diffusion, and therefore, more on incremental improvements and the modification of products in a limited number of technological fields (Harhoff et al., 1996, p. 49). This could explain the difference in performance in regards to cooperation with academic institutions. The evaluation of the KOF data in Tables 1 and 2 illustrates the following quantitative results for Swiss technology firms shown in Table 3.

Table 3. Quantitative results for Swiss technology firms

Co-operation with academia	Large enterprises cooperate nearly twice as often with academic institutions as SMEs do. However, younger SMEs are more likely to cooperate with academic institutions than older ones.
R&D activity	More than 50% of younger SMEs are active in R&D. 87% of large corporations are active in R&D and invest more into R&D than SMEs.
Product innovation	In terms of product innovation, large corporations considerably improve their product portfolio, while older SMEs show an insignificant modification of products. Younger SMEs tend to introduce new products.
Patenting	Younger SMEs illustrate more patenting activity than older ones. However, large corporations are far more active in patenting than SMEs.
Co-operation barriers	Owing to constraints in knowledge exchange, large corporations rate significantly: less entrepreneurial spirit, more uncertainty in co-operational relationships, and widely differing notions of urgency compared to SMEs. SMEs consider a lack of financial resources to be the main constraint for knowledge exchange.

An analysis of the qualitative academic spin-off experience of thetwentyspin-offs sample in Tables 1 and 2 illustrate the following results:

Table 4. Qualitative results of academic spin-off firms

Co-operation with academia	Even if academic spin-offs are very small, they have a significantly higher proportion (89%) of graduates and 100% of the spin-offs cooperate with academic institutions based on knowledge exchange.
R&D activity	With around 90% of spin-offs having R&D activities, they are highly innovative, which is also illustrated by their patent filing activites.
Product innovation	Spin-offs focus on new technology and product development (65%) and introduction.
Patenting	Spin-offs are active in patenting; they have a similar percentage of filing patents when compared to large corporations. Patenting activity (74%) is far higher for spin-offs than with an SME.
Co-operation barriers	Regarding constraints on knowledge exchange, spin-offs rate significantly: less entrepreneurial spirit and different notions of urgency than SMEs, as well as similar or stronger rates than large corporations. Like SMEs, spin-offs consider their lack of financial resources to be the main constraint for knowledge exchange.

Academic spin-offs are closely linked to academia: they are spun off from science, primarily with scientists in leading roles, who are thought to have a complete overview of the scientific landscape in their fields. Also important, however, is the situation in regard to R&D, and the generation of intellectual property for technology spin-offs. In the early stages of a technology's lifecycle, product development and building a technology absorptive capacity is the main activity of the enterprise, possibly contradicting the wider opinion that the key focus is on marketing or sales activities. Hurdles to cooperate with academia are few, in contrast to SMEs, and clearly differentiate academic spin-offs for industrial cooperation.

The primary learning experiences from this chapter are as follows:

Experience B: Lack of new product introduction

- An established industry enjoys market access with a strong focus on product improvement and modification. However, product diffusion activity of established industry is higher than new product introductions.
- With their limited R&D resources and effort, SMEs lack the building of technology absorptive capacity with academic cooperation and knowledge transfer.

Experience C: Limited academic overview

- An established industry has a limited overview in the academic world, with reduced efficiency in cooperation with academia.

Experience D: Spin-offs: new product introduction with low academic barriers

- Academic spin-offs demonstrate clear R&D focus for the introduction of new products; this is related to their size and high technology absorptive capacity.
- Low cooperation barriers with academia differentiate spin-offs in playing a role in improving technology transfer efficiency.

6. Investigation of Academic Technology Standalone Spin-Offs

Ten spin-offs from the investigation volunteered to take part in a qualitative research program and were analyzed in detail over a multi-year time frame, beginning in 2006. Seven spin-offs were standalones (Table 5), while three were in industry alliances (Table 6).

6.1 Strategy and Management

These spin-offs were financed by banks, business angels, and public research funds. Hence, they could only rely on a two to three-year time frame to establish their businesses. Their boards were primarily made up of management, business angels, academics, and financiers; industrial representatives seldom had a seat. Most of these spin-offs lacked a business strategy based on a specific market analysis and technology or product roadmaps.

Table 5. Table of scientific technology spin-offs investigated

Company	Alpha	Beta	Gamma	Delta	Epsilon	Zeta	Eta
Industry	• Machines	• Energy Systems	• Materials & Process Technology	• Robotics	• Process Engineering	• Machines	• Information Technology
Technology Level	• Demonstrator	• Demonstrator	• Demonstrator	• Industrialization	• Pre-Demonstrator	• Demonstrator	• Industrialization
Technology	• Adaptive Mechanisms and Systems as Robotic Grippers, or Surgical Tools	• Thermoelectric Generators to Produce Electricity from Heat or Vice Versa with Application in Batteries, Solar	• Ceramic Process Technology & Engineering	• Intelligent Navigation Systems	• Gas Capturing Systems	• Actuation Systems	• Medical Devices
Foundation	• 2010	• 2009	• 2007	• 2001	• 2009	• 2001	• 2010
Ownership	• Mgmt. 67% • Academia 33%	• Mgmt. 100 % • Bus. Angle & Financier with Convertible Bond	• Mgmt. 90% • Academia 10%	• Mgmt. 45% • Academia 15% • Bus. Angle 45%	• Mgmt. 66% • Bus. Angle 34%	• Mgmt. 100%	• Mgmt. 80% • Academia 20%
Employees	• 2	• 11	• 7	• 9	• 4	• 2	• 3
Patents	• 2	• 2	• 1	-1	-2	• 2	-

The documents available focused rather on the founding stage, with external presentation towards potential financiers or customers, than on a strategy with an internal development program, illustrating the business implementation approach. In addition, internal skills like project management, budgeting or process and documentation implementation were basically always newly invented or theoretically trained. As such, the firms could not rely on prepared methods or schemes. Overall management skills and experience in this area was lacking.

Each "talent" the authors met with over the multi-year time frame was highly motivated to work in a spin-off as an entrepreneur and shareholder. Their willingness and readiness to cooperate with established industry players was also evident. All standalone spin-offs were looking for market opportunities and actively seeking cooperation, trying to promote their technology and capabilities. However, a consistent appearance as a "Broker for Technologies" (Fontes, 2005) towards established industry was not apparent. No clear concept was available to show how potential partners should be approached or what partnerships could be negotiated or could look like.

6.2 Technology and Products

The standalone spin-offs in our sample owned or licensed technology which covered a wide range of potential product applications in a variety of markets. The focus was on the introduction of highly innovative technologies and products. Even if the technology is well known, these products are in the early pre-demonstrator phase, and research and development activity is significant. With a stable financial situation of about two to three years to market from technology development, product industrialization and a new product market launch are the crucial factors for the spin-off's survival. However, patenting schemes for these standalone spin-offs are primarily based on academic invention, often licensed from the academic parent organization. The spin-offs were not very active regarding product market protection because, on the whole, detailed market specifications were as yet unclear and product features had not yet been actively patented.

6.3 Market

At the time of this investigation, none of the firms could sell products or count on product revenue. Product roadmaps and clear, market-oriented product development targets were not available. In addition, most of the spin-offs presented challengingly high market expectations with an often unclear scenario base. This may be put down to deficiencies in market information, and also to the attempt to introduce products which lead to unrealistically high, often aggressively fast, anticipated revenue. To overcome this lack of information, the spin-offs usually tried to approach the market proactively with ideas for technologies and potential products, using their networks, visiting fairs, or directly contacting market players as potential customers. If established players were interested in the technology and lacked an immediate product to sell, the spin-offs regularly executed a product application study for, and with, the industry player. This may be responsible for the fact that spin-offs are often conceived as R&D service providers (Stankiewicz, 1994), usually generating their first revenues in this business field.

6.4 Capabilities & Resources

In all cases, the spin-offs' management teams owned, or were part of, the founding teams, with strong technological or scientific backgrounds and prior related knowledge. They were significantly involved in technology and product development. Everyone whom the authors met was highly committed to working with the technology subject; however, the number of employees with industry experience was scarce. The spin-offs primarily relied on the support of university employees, who, in the event of a successful economic ramp-up, transferred to the spin-off staff. Attracting talent from academia is easy for most spin-offs; engaging experienced resources from the external market is difficult, as standalone spin-offs are considered a risky undertaking.

7. Investigation of Academic Technology Spin-Offs in an Industry Alliance

Table 6 illustrates the spin-offs Theta, Iota and Kappa, which are in an industry alliance with an established player in the power industry and various academic parent organizations. These were selected for a case study starting in 2006 to investigate the specific phases of development of an industry alliance between spin-offs, industry partners, and academic partners (Hess and Siegwart, 2012).

7.1 Strategy and Management

In the cases discussed, the industry alliances were formed because the industry partner considered the spin-off technologies to be leading edge and were interested in developing applications directly with them for the power market. Not having the necessary technology capabilities in-house, the industry R&D partner proposed a research and product development alliance. The alliance spin-offs joined up in R&D programs with the industry partner, taking a direct way towards product demonstration. A multi-year product strategy and business cases with defined R&D targets were commonly set. Standard processes and instruments for management control (e.g., finance budgets and project management) were implemented. The initial business case for the alliance spin-offs showed a strong technology and product opportunity in adjacent non-industry partner markets, which allowed the alliance spin-offs to leverage the lessons learned.

Product needs, market access and industrialization ability were all brought into the alliance by the industry partner, while the spin-offs delivered the agility and speed connected to deep technology know-how, plus an academic network with access to laboratories and the relevant technology talents.

Table 6. Table of technology alliance spin-offs investigated

Company	Theta	Iota	Kappa
Industry	• Robotics	• Machines	• Electronics and Sensors
Technology Level	• Industrialisation/ Scaling	• Industrialisation/ Scaling	• Industrialisation/ Scaling
Technology	• Industrial Inspection Robotics	• Waterjet Cleaning & Cutting Technology	• Sensor & Non Destructive Testing Technology
Foundation	• Founded in 2006 as an Alliance Spin-Off	• Founded in 2007 as Spin Off and turned into an Alliance Spin-Off in 2008	• Founded in 2009 by Management; Alliance Spin-Off in negotiation
Ownership	• Management 25% • Academia 24% • Industry Partner 51%	• Management 41% • Academia 10% • SMI-Partner 19% • Industry Partner 30%	• Management 57% • Academia 43%
Employees	• 20	• 6	• 4
Patents	• 6	• 6	• 4

7.2 Technology and Products

Figure 5 illustrates the alliance spin-off development process. The three spin-offs were part of a technology development network for inspection robotic systems; they owned their technology, which had applications in robotics, sensors, water-jet cleaning and cutting technology. All three spin-offs delivered their technology applications into a robotic inspection system of the network, but also had their own technologies and products on the market. The left-hand graph in Figure 5 starts with a direct R&D workload increase, while the technology delivery increased as planned. Also, as forecasted, product sales were provided with a reasonable time gap. Estimated budgets were executed, as promised, until the effects of an underestimated industrialization workload were felt.

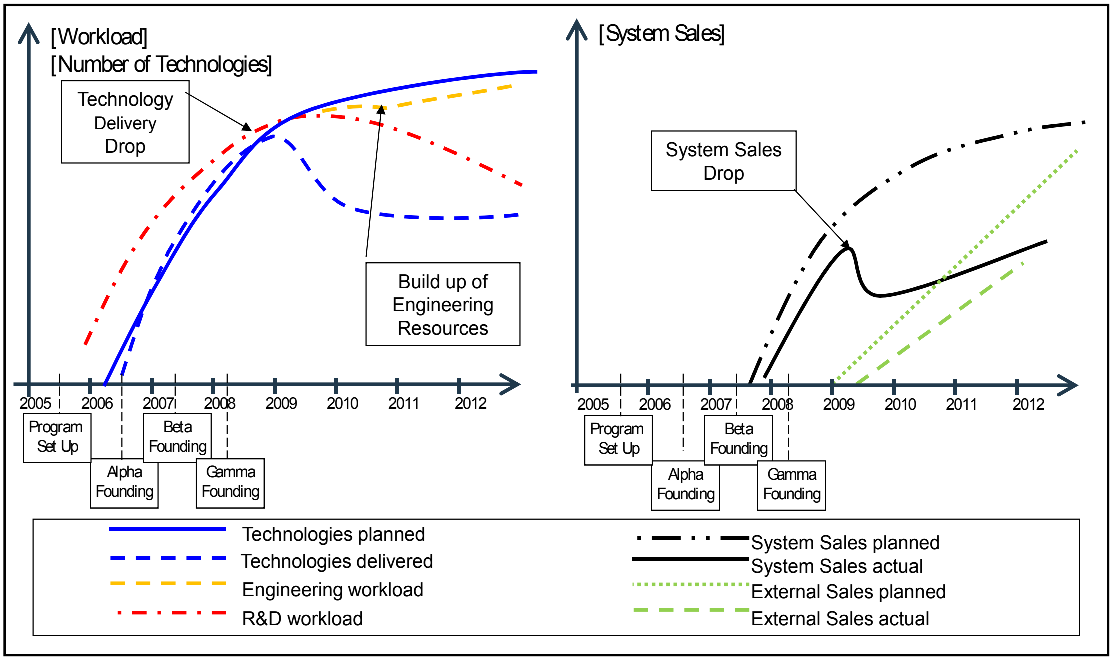

Figure 5. Planned and achieved qualitative development of the alliance spin-off network between 2005 and 2012 (Hess and Siegwart, 2012)

The additional industrialization effort required, resulted in a two year drop in technology delivery and product sales, because of the restricted capacity of resources and the challenge to keep to the business plan. For breakthrough innovations, these restrictions could not be compensated simply with an increased budget or more resources. In the early stages of technology development, dependence on single resources and their capability is high, limiting the speed of innovation. Smaller standalone spin-offs might not be able to survive this planning gap. Without the industry partner's ability to support industrialization, with field-testing capability and engineering know-how, this phase might well have been longer. However, this phase is important for product performance increases, flaw correction and risk control before the scaling phase to avoid premature scaling. An established industry has experience with product industrialization, but not for breakthrough technologies; therefore, costs can spiral uncontrollably. A spin-off`s cost structure is transparent and limited by the original business case.

7.3 Market

The spin-offs successfully acquired an order backlog of relevant product revenues in the adjacent oil & gas, marine, food, automotive and jet engine industries. Interviews with the customers confirmed a highly professional approach of spin-offs to market. All technologies are tested with the industry partner and are carefully industrialized. The exposure of the alliance spin-offs to a professional environment was educational right from the start. With the setting of customer relations, particularly with the acquisition of multi-year contracts, confidence in the products and their delivery increased.

7.4 Capabilities & Resources

In such an alliance, set up interdependence is vital to maintain the speed and agility of innovation and ensure a controlled and secure capability ramp-up. Initially, the spin-offs started by hiring core teams, mostly with R&D capabilities and talents from the academic network. By further developing the spin-offs, external industry experience could be attracted without major problems. All network partners share knowledge. Interviews state that the partners' exchange of R&D experience, product strategy and product development was absolutely crucial for the innovation speed. The strong interaction with experts from the industrial partner, particularly within the fields of service and engineering, was of great importance for the alliance spin-offs to deliver the industrialized technology and product applications.

8. Comparison of Academic Technology Spin-Offs in an Industry Alliance and Standalone

Comparing standalone and alliance spin-offs shows a number of advantages for the latter. Table 7 summarizes the findings.

In an alliance, spin-offs will speed up development time with a clear and early product development target definition and a fast, planned product demonstrator approach, followed by industrialization with field testing and product engineering. Assuming the readiness of spin-offs to make alliances is key in developing a product strategy, including alliance partners and actively seeking partners with a convincing alliance approach. The ability to illustrate a professional set-up with all relevant capabilities, processes and documentation is particularly necessary to persuade potential partners to agree to a long-term partnership, and to mitigate risk. A business case that shows the commitment and capability of the spin-off to stay agile and its readiness both to adopt all relevant technology and product skills, technology absorptive capacity and to reliably support product introduction with the industrial partner, is mandatory. In addition, revealing wider technology applications that can be followed up by leveraging adopted capabilities learned from the industry partner, helps to build a trusting, interesting alliance for both parties.

Table 7. Comparison of characteristic practice experience found for scientific standalone and alliance spin-offs

	Standalone Spin-Offs	Industrial Alliance Spin-Offs
Strategy & Management:	• Secure financing for 2-3 years and board set up mostly management, academics and financiers • Lack of business strategy & technology or product roadmaps verified by market player • Business cases are focused on external marketing • Processes mostly not applied or "Greenfield Approach" & lack of general management experience & skills • Interested in industry alliance , but do not act as "Broker of Technology"	• Financing is longer-term & linked with company business case and technology development • Board set up mostly management, academics and industry partner • Commonly developed business/ product strategy with development alliance and leverage for other markets • Basic processes (HR, Finance, Quality, EHS, R&D) implemented induced by industry partner • Gain professionalism & management experience from interaction with industry partner
Technology & Product:	• Lack of R&D target setting or product roadmaps • Focus on new technology introduction with wide market application opportunity • Low patenting activity, inventor type patents • Defensive technology positioning	• Product development strategy available with R&D targets set • Conservative business case internal driven as an instrument of management control • Speed to demonstration & technology industrialization focus with strong product IP activities
Market :	• No product sales and credentials • Customer are approached with technology or premature products • Rather alliance than sales discussion with customer followed by R&D studies	• Spin-offs are in development mode towards products to market with product sales to industry partner • Customer approach with industrialized product followed by sales
Capabilities & Resources:	• Strong technology know how • Build technology absorption capacity in a staged model	• Build up to increase technology absorption capacity • Knowledge sharing with industry partner

Learning experiences from the evaluations of this chapter are as follows:

Experience E: Spin-offs Representation

- Estimation of industrialization time is critical, as spin-offs are financially secured for two to three years, without immediate product sales. Spin-off openness to alliances is evident, but spin-offs communicate defensively on technology and aggressively on market assumptions, and are not prepared to act as a broker for their technology towards the established industry.

Experience F: Standalone spin-offs lack of R&D targets and high market barriers

- Standalone spin-offs lack clear product development target definition, field-testing capability and face high market barriers. Their efficiency in time to market is therefore poor. This can be compensated with an industry alliance.

9. Proposition of a Role for Academic Technology Spin-Offs in Industry Alliances

The results indicate that academic spin-offs can fill a gap in cooperation between academia and an established industry when they engage in partnering along the early technology lifecycle. Recognizing the role of spin-offs in the technology transfer process - not only in receiving technology from an academic parent organization, but also in transferring it to customers, licensing or alliance partners (Carayannis et al., 1998; Fontes, 2005) - encourages the development of a model for spin-offs to build alliances. The gaps identified in technology and knowledge transfer between the established industry and academia are supported by a number of research studies (Harhoff et al., 1996; Polt et al., 2001; Arvanitis et al., 2008). The particular spin-off attributes in cooperation capability with academia, technology know-how, focus on new product introduction, and readiness to cooperate, all support the reconsideration of the role of spin-offs in the technology transfer process.

To overcome mutual concerns and threats between partners (Bollinger, Hope and Utterback, 1983), building acceptance of cooperation between academic spin-offs and the established industry demands a well-defined model and implementation propositions. To position themselves appropriately in an alliance discussion, spin-offs may select an approach and positioning according to two spin-off types, as shown in Table 8.

Table 8. Role model and positioning of standalone spin-offs versus alliance spin-offs

Standalone Spin-Off	**versus**	**Alliance Spin-Off**
• Independent entrepreneurial attitude		• Alliance partner attitude
• Product to market		• Technology transfer between academia & industry
• Aggressive market scenario		• Conservative market scenario
• Defensive technology statement		• “Broker of Technology”
• Focus on market capabilities		• Focus on building technology absorptive capacity
• Risk of premature scale		• Risk mitigation approach

A characterization of spin-offs as an alliance partner for industry is illustrated in Figure 6. A generic technology maturity S-curve development over time has been underlaid with a qualitative technology development process. The phases describing the S-curve are derived and adapted from the literature (Marmer et al., 2011).

The process starts with the discovery phase, often in close cooperation with science and academia, where partners screen and identify potential innovation opportunities. In the validation and efficiency phase, innovation assessment and incubation of the technology are critical. The potential value of the innovation is estimated and business cases are evaluated (Galbraith, Ehrlich and DeNoble, 2006).

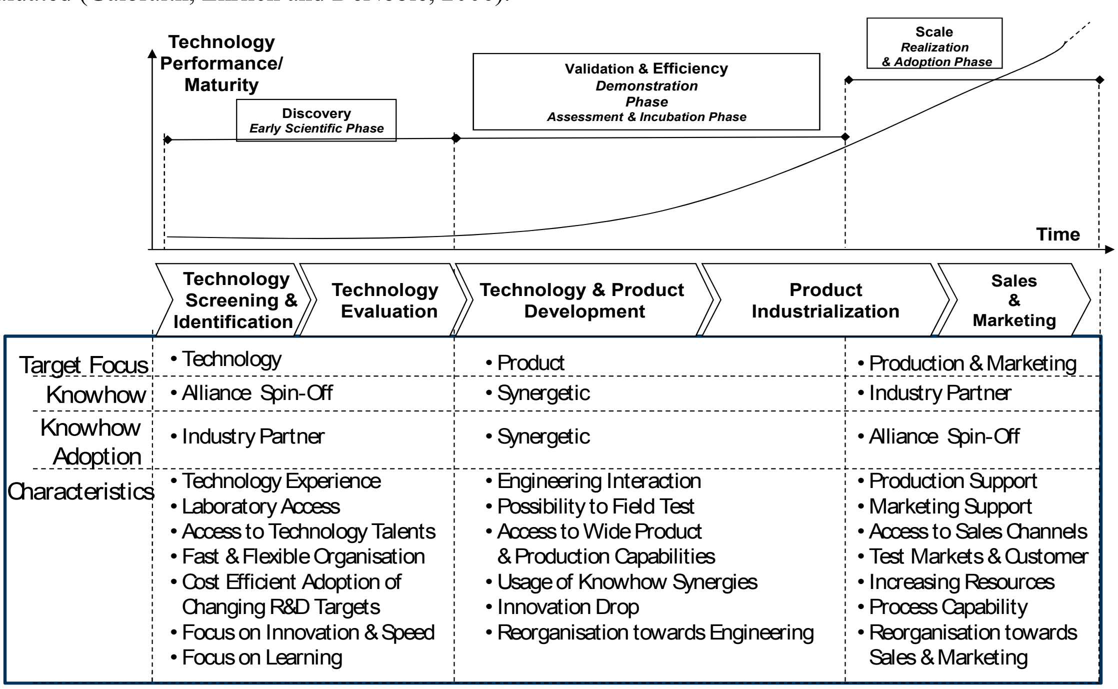

Figure 6. Conceptual framework to characterize industry alliance spin-offs and know how transfer adapted from Hess and Siegwart (2012)

The main target is the refinement of the product in the demonstration and test phases to prepare a risk-mitigated scaling of the technology. The scaling phase accelerates the production, industrialization, supply chain, and marketing of the new technology launch. Each of these phases has a specific and important task to fulfill; the underlying processes rely on R&D experience and control. A badly managed process will usually result in high-risk exposure, often with product failure or costs resulting from poor quality after market introduction (Marmer et al., 2011).

With product industrialization, a highly synergetic phase sets in where the industry partner supports the alliance spin-off with industrialization know-how, engineering interaction, and field-testing. Finally, in the scaling phase, the alliance spin-off builds a production, marketing and sales acumen from the product launch with the industry partner, which the spin-off then leverages to customers from adjacent markets. Industry partners can thus build up trust and technology and absorptive capacity while spin-offs develop competences, expertise and professionalism. The following set of propositions derived from the previous discussions should allow for the preparing of an environment appropriate for alliance discussions and implementation.

Proposition I:

Academic spin-offs open for industry alliances should pay attention to their technology lifecycle curve positioning to generate interest and communicate their technology transfer role to gain credibility by showing a technology absorptive capacity build up.

An academic spin-off that can see the advantages of an industry alliance in the early phase of breakthrough technology development, according to Experience A “Alliances” needs to prepare a convincing position along a technology lifecycle curve, illustrating its commitment to becoming a reliable, credible partner. Given that the established industry may ignore small innovative firms or else perceive them as a threat (Bollinger, Hope and Utterback, 1983), the focus should be on generating interest in their own technology and then introducing a cooperative scenario as a “broker of the technology” (Fontes, 2005). Effectively communicating the lifecycle positioning of the spin-off’s technology is especially key to the active search for an alliance partner. The scenario should convincingly show the risk-mitigation efforts that the spin-off is willing to make to build a reliable technology absorptive capacity, an R&D cooperation model illustrating speed to demonstration (Stankiewicz, 1994), and credible, conservative business and commercialization planning (Chiesa and Piccaluga, 2000). In this case, R&D consultancy is not a lack of funding (Chiesa and Piccaluga, 2000), but a success factor.

Proposition II:

Because of spin-off innovation performance, the established industry should consider the external build-up of technology absorptive capacity and cooperation with academic spin-offs to build the technology absorptive capacity for breakthrough technologies, to be in their interests.

Low cooperation rates of innovative enterprises with science (Polt et al., 2001) and a number of cooperation barriers are shown in this report in Experience C “Limited academic overview” and supported by the literature (Harhoff et al., 1996; Arvanitis et al., 2005). In turbulent times, with considerable innovation activity within an industry, disruptive or breakthrough innovation may occur quickly in an irregular step function. It is a challenge for industry to maintain entrepreneurial intensity (Tornatzky and Fleischer, 1990), to screen new entrants (Suarez and Lanzolla, 2007), and to improve cooperation with academia. Experience D “Spin-Offs: new product focus & low academic barriers” illustrates that agile spin-offs, with their thorough technology acumen, R&D capability (Stankiewicz, 1994), and low barriers to academia, are potential alliance partners.

Proposition III:

Development of a common alliance business case with clear definition of product development targets, thorough estimation of the industrialization phase, cooperative product introduction, and an estimated business opportunity for adjacent markets to be exploited by the spin-off.

Our investigation has shown that spin-offs often own or license a technology that covers a wide range of potential product applications for a variety of markets. There are a number of technological factors influencing the spin-off’s effort at commercialization: technology and market uncertainty, maturity of technology, and duration of development time in a technology lifecycle (Fontes, 2005, Stankiewicz, 1994). Premature scaling of technologies is the prime reason for spin-offs to perform worse (Marmer et al., 2011). Experiences E and F illustrate that a business case developed by partners who assume technology and market acumen for one market application can overcome these deficiencies when the focus is on the following: speed to product demonstration with a clear development target definition; cooperation in field-testing and industrialization avoiding a premature product scale; and cooperative product introduction.

10. Expected Contributions

Ambidexterity phenomena of industry challenged by rapid innovation cycles with breakthrough technologies in the early lifecycle are demanding. Open innovation theory indicates to open up industry for external cooperation. With this research, the authors expect to contribute to an increased understanding of development alliances between academic technology spin-offs and industry. This study shows that continuous innovation in alliances results in an improved innovation capability of spin-offs and the established industry and aims to enhance the understanding of performance criteria for spin-offs in industry alliances.

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