Dynamics of alliance networks: development speed and its determinants analyzed for a sample of nanotechnology companies

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ABSTRACT

During the last years, networks of inter-organizational strategic alliances received both managerial and academic attention. Alliance networks are a complex phenomenon that still poses many questions. One of them is how to describe and explain their dynamics. This article discusses results of our research on the dynamics of alliance networks with focus on young technology-driven firms. We built on the literature about alliance formation during the life-cycle of the company. In the past, authors have found a non-linear pattern of alliance formation during the first years of a company's life and have linked the pattern to a model of development stages.

In an exploratory study based on a sample of product driven nanotechnology companies, we analyze the relationship between development stage and firm age and find it to approximate a linear function. Firms differed in the time needed to develop from one stage to the next. In order to describe these differences, we introduced a firm specific variable called development speed, which turned out to be a function of certain firm and industry specific factors. The factors with the strongest impact on development speed were maturity of applied technology and maturity of the target market. Our results add to the understanding of network development and of its business-related drivers.

INTRODUCTION

Inter-organizational cooperation and alliances of companies are topics that have received lots of managerial and academic attention. In many cases, the alliances of a firm can only be understood as an ensemble forming the alliance network of the given entity. Today, the literature about alliance networks adds up to a substantial amount of articles, most being published during the last ten years. So far, many diverse factors are known that shape alliance networks and many network properties that influence business success are identified. It has become clear that alliance networks are a multi-facetted phenomenon.

According to Gulati (1998), one of the main objectives of current research on alliance networks is to understand their dynamics. Little is known about how networks evolve, change and fall apart and what drives such processes. Network dynamics promise to be a topic providing interesting insights, but it is complex and difficult to handle empirically. Researchers need to obtain longitudinal data about the alliances of the focal companies and numerous factors of possible influence on the network.

Nevertheless, there is a significant number of single case studies about the dynamics of alliance networks that give first hand evidence about growth, path dependence and change processes (Håkansson 1992, Lundgren 1992, Hertz 1996). One of the few time-dependent factors that were investigated systematically with quantitative studies was firm age (Oliver 2001). Later, Klocke et al. (2002) refined the qualitative understanding of such phases with a detailed model proposing development stages. We built on the studies of Oliver and Klocke et al. and concentrate our research effort on the following questions: *How quickly do alliance networks of young technology-driven companies develop? What determines the speed of change?*

Many previous studies on alliance networks have taken the semiconductor or the biotechnology industry for analysis. In this paper, we investigate the alliance behavior of nanotechnology companies. Nanotechnology is a buzzword summarizing different technologies that deal with dimensions below 100 billionths of a meter (100 nanometers), which is about the dimension of very large molecules. Nanotechnology comprises many different sectors. It is heavily dependent on cooperation, yet has no established network structures and, as consequence, its alliances are very dynamic. Hence, the industry presents an interesting new test case for research on network dynamics.

DYNAMICS OF ALLIANCE NETWORKS

In the literature, the terms "alliance" or "strategic alliance" are used to describe collaboration based on certain agreements or specified goals. Gulati (1998) defines "strategic alliances as voluntary agreements between firms involving exchange, sharing, or co-development of products, technologies, or services." Most authors use the terms alliance and strategic alliance interchangeably. In this paper, we use the word alliance instead of strategic alliance in the definition of Gulati.

Citing Gulati (1998) again, alliances "can occur as a result of a wide range of motives and goals, take a variety of forms, and occur across vertical and horizontal boundaries."

In the past, authors used various dimensions to classify and compare alliances. In this paper, we use the function of the partner in the value chain as proposed by Gemünden et al. (1992) for classification in order to determine the development stage of alliance networks as suggested by Klocke et al. (2002).

While different inter-organizational theories might be used to explain the formation of alliances (Sydow 1992), it is the resource-based view and the knowledge-based view that are most often applied today. In the resource-based view, firms might use alliances to access complementary resources and to leverage internal resources better (Eisenhardt and Schoonhoven 1996). According to the knowledge-based view, firms use alliances to access knowledge, then internalize it by organizational learning and finally use it (Cohen and Levinthal 1990).

A firm has normally a set of relationships and these relationships are interconnected (Blankenburg and Johanson 1992, Cook and Emerson 1978, Ritter 2000). This wider structure of connected relationships has been termed network (Håkansson and Snehota 1995). Wasserman and Faust (1994) define a social network as a "finite set or sets of actors and the relation or relations defined on them". We were primarily interested in alliance networks, which consist of organizations (typically companies) as actors and the alliances among them as relations.

Dynamics of alliance networks refers to changes in the set of alliances that are present in a network. There are different approaches to investigate the dynamics of alliance networks. One approach is to treat large networks as one system. Usually this research focuses on special phases of network development like formation or change (Håkansson 1992, Hertz 1996, Doz et al. 2000, Human and Provan 2000). In this paper, we follow another approach by giving most attention to firm-level effects, which takes the companies one by one for investigation of its networking behavior over time.

In the past, authors have analyzed various facets of alliance network dynamics. As a large variety of factors and relationships play a role, we introduce here a mathematical notation based on our own theoretical work to shed some light into the subject. Let $N(t)$ denote the alliance network of a focal company at a certain point of its age (time t). N can be understood as a multi-dimensional vector that describes all the details of the alliances and alliance partners. If we use $F(t_1,t_2)$ to describe all formations of alliances in the time interval (t_1,t_2), $C(t_1,t_2)$ to denote all changes in existing alliances and $T(t_1,t_2)$

to capture all terminations of alliances. As a result, we derive a formula for the network N at t_2 using basic relationships of network dynamics:

$$N(t_2) = N(t_1) + F(t_1, t_2) + C(t_1,t_2) - T(t_1,t_2).$$

Capital letters are used for vectors (in n-space) and small letters for regular numbers.

In this study, we use the typical approach in the literature to focus on the formation term F and treat neither the change not the termination part. Note that only an understanding of all terms F, C and T will give the complete understanding of network dynamics. We proceed by expressing alliance formation F with the current direction of formation development D, the formation velocity p and the (small) time interval *Ät* = $t_2 - t_1$:

$$F(t_1,t_2) = D(t_1) \cdot p(t_1) \cdot \text{Ä}t.$$

The direction part is normalized (D = 1). For large intervals *Ä*t, the formula has to be written as an integral.

The formation velocity p is an alliance formation probability. While many authors like Pisano (1990) analyzed the influence of internal and external factors of formation probability, to our knowledge, the only detailed analysis about the influence of firm age was done by Oliver (2001). Oliver showed that for young biotechnology firms, formation probability p was a function of firm age t with inverted U-shape for the first 11 years and with a second increase afterwards. Building on the work of Nootebohm (1999), Oliver interpreted this relationship as the influence of learning cycles with exploration and exploitation phases. However, eleven years may not be a constant for all companies, industries and economic circumstances. We generalize Oliver's result by stating that formation probability p is a function of some development stage y of the company ($p = p(y)$). Furthermore, the development stage y depends on t and possibly some other factors x_i ($y = y(t,x_1, x_2,\ldots)$.

The direction of development D captures the kind of alliances formed. In a rather static picture, Gemünden and Heydebreck (1995) showed that D was a function of firm strategy. Kogut et al. (1992) and Gulati (1995) analyzed the influence of the past firm network on the direction of development D and concluded that focal companies favor past alliance partners and companies close to them for new alliances. Powell et al. (1996) detected a reinforcing pattern of R&D and non-R&D alliances. Klocke et al. (2002) showed that companies follow a particular pattern of forming technology-oriented alliances first and of market-oriented alliances later. Klocke et al. linked the qualitative pattern to the quantitative pattern found by Oliver (2001), hence the direction of development *D*, like *p*, can be represented as a function of development stage *y* also ($D = D(y)$).

From the analysis of literature, it becomes clear that expressing the development stage as a function of firm age and additional factors has a key role for the thorough understanding of alliance dynamics. If we know $y = y(t,x_1,x_2,\ldots)$, we will get the direction of development $D = D(t,x_1,x_2,\ldots)$, the generalized alliance formation probability $p = p(t,x_1,x_2,\ldots)$ and, finally, the network formation term $F = F(t_1,t_2,x_1,x_2,\ldots)$.

DEVELOPMENT SPEED

The network development models used by Oliver (2001) and Klocke et al. (2002) describe exploration and exploitation phases in the development of a firm. Their models can be linked to a general growth model for technology firms introduced by Kazanjian (1988) and later tested by Kazanjian and Drazin (1989). Kazanjian and Drazin use four development stages and give the average firm age in each stage for their sample. From their data, we inferred our first hypothesis that lays the foundation for a definition of development speed.

Hypothesis 1: In good approximation, the development stage of a technology-driven company is a positive and linear function of firm age.

Using consecutive integers for the development stages *y*, this hypothesis can be expressed in a formula as $y = at + y_0$, while $a, y_0 = const. > 0$. Regarding the development stage at foundation (intercept y_0, foundation defined as start of business operations), Klocke et al. argued that companies typically enter stage 2 with foundation yet this result was not reproduced for other industries (Kazanjian and Drazin 1989).

Kazanjian and Drazin observe that not all companies proceed linearly through the stages but sometimes companies slide back to a lower stage. Thus there are (short-term) deviations from the formula. However, it holds true for the long-term average development of a company. Note that in the formula the slope *a* has the notion of development speed.

The development speed *a* might be different for each company. Greiner (1972) argued that companies in high growth industries take development stages more quickly than companies in low growth industries. Extending those thoughts, companies might make the transition from a technology (or market) exploration stage to a technology (or market) exploitation stage more quickly if the technology (or market) is more mature. We generalized those arguments and posited

Hypothesis 2a: Factors at industry level might slow down or speed up the progression of a company in the development stages.

It is known from Gundry and Welsch (2001) and Lee and Tsang (2001), that growth drive of the founder, their industry and business experience, fosters the growth of young companies. In addition, Gemünden and Heydebreck (1996) showed that employment of venture capital leads to an increase in the number of alliances. Unfortunately, the literature does not seem to cover the distinction between firm growth (i.e., network growth) and development speed in detail. Although there is a difference between growth and the development speed of the network, firm-level factors that influence growth might still have an impact on the development of the network as well. We posit that;

Hypothesis 2b: Factors at firm level might slow down or speed up the progression of a company in the development stages.

To summarize hypotheses 2a and 2b, development speed is given as function of other underlying factors x_i at firm or industry level ($a = a(x_1,x_2,\ldots)$). Table 1 lists main factors that might influence development speed. Figure 1 summarizes the hypotheses in a general diagram.

DATA AND METHOD

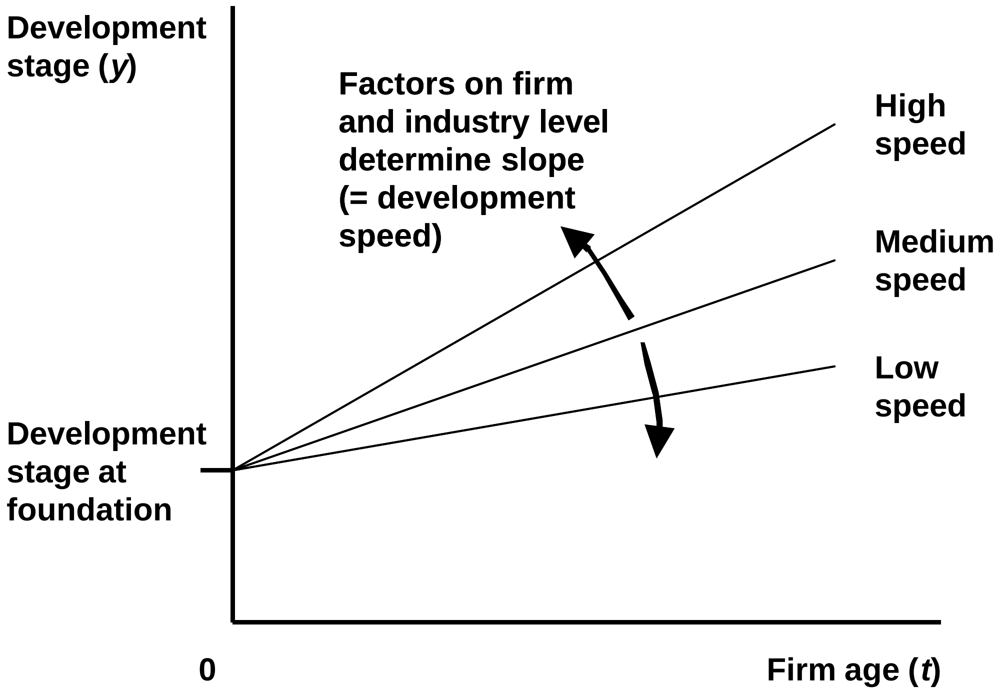
Sample

To test the hypotheses, we analyzed companies that apply nanotechnology to a significant extent, which typically includes those companies highly dependent on R&D. Our sample comprises three main groups: components with nanostructures or nanoprecision (e.g., small-sized paint additives, smooth surfaces, molecular capsules for drug delivery); production techniques with nanoresolution (nanorobotics, nanoimprint and extreme ultra-violet lithography for semiconductor production) and characterization techniques with nanoresolution (scanning probe microscopy, electron microscopy). However, it is not necessary that the companies have already sales with these products.

Table 1. Variables with potential influence on development speed

Additional variable	**Notation**	**Description**
Industry-level		
Maturity of technology	x_1	Maturity of technology is based on expert interviews with 0 for immature and unexplored technologies and 1 for rather mature and explored technologies.
Maturity of market	x_2	Maturity of the market is based on expert interviews. 0 denotes markets where the customers are not ready to use the innovative product right away, whereas 1 stands for rather mature markets where customers can easily integrate the new product into their business.
Firm-level		
Previous business experience	x_3	Previous business experience refers to business experience of the top management. The variable is 0 if the top management has no previous business experience and 1 if the whole management has intensive previous experience.
Growth drive	x_4	Growth drive refers to the growth aspirations of the top management. It is 0,5 for regular cases, 0 for growth aversion of the top management and 1 for exceptionally high growth drive.
Active professional financing	x_5	The variable reflects whether the company has professional financing partners that play an active role in management control and counseling like venture capitalists usually do. The variable is 0 if no such financing is present and 1 otherwise.
Product focus	X_6	Product focus is 1 if the company concentrates on one single product and 0 if the company lacks product focus and pushes a huge variety of different product ideas or product lines.
Direct sales contacts	X_7	The variable gives the percentage of sales that are not done with mediators like wholesalers or distributors.
Customer sharing	X_8	Customer sharing gives the percentage of sales that are done with the customer base of established partners as stated by customer sharing agreements.

Figure 1. Theoretical approach



The development model that this study applies refers to product-oriented companies (i.e., manufacturers) only. Consequently, wholesalers, distributors, corporate business development, venture capitalists and other types of service companies are not included in our study. We selected cases that covered a wide range of ages and diverse sectors. The final sample consisted of 11 companies from Germany and 2 companies from Switzerland and the U.S., with ages ranging from 1.5 to 12.5 years. The sample did not contain any companies that had undertaken any substantial merger and acquisition activities that may have speeded up their development compared to their peers.

Little of the data we needed was available to the public because the nanotechnology industry is quite young and fragmented. So we had to rely on multiple data collection methods. The main information source were interviews, which we conducted with suitable representatives of the companies. We used additional data sources like expert interviews, press articles and Internet homepages to supplement the interview data afterwards.

Variables

The dependent variable of our model is the *current development stage* of the company network. We used the classification of development stages that were proposed by Klocke et al. (2002) and used the past and recent alliance formation activities of each company to determine its development stage (Figure 2).

The phases were coded with increasing numbers from 1 for the beginning of the first phase to 5 for termination of the last one. We used decimal point notation with a step width of 0.25 to specify the position inside the development stage more precisely.

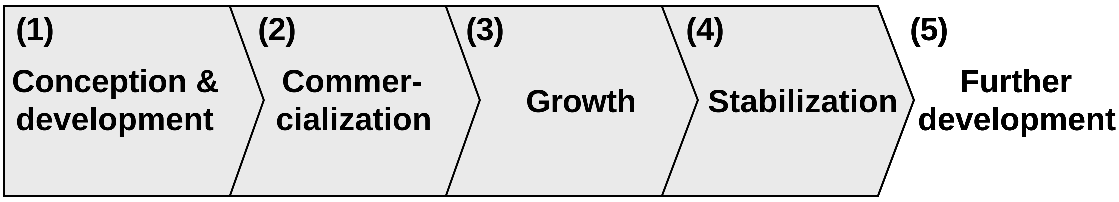
The independent variable of our model was *firm age*. Firm age was given in years with a resolution of 0.5 years.

We used eight additional variables to describe variance in development speed that were either inferred from literature or mentioned in our interviews (Table 1). Two variables, *maturity of technology* and *maturity of market*, refer to the industry-level. The remaining six variables are *previous business experience*, *growth drive*, *active professional financing*, *product focus*, *direct sales contacts* and *sharing of customers*. They capture potential firm-level factors influencing the development speed of the companies. In general, we used numbers from 0 (extensive) to 1 (intensive) as values for the additional variables. In cases when a firm-level variable changed over the past history of the company, we used its average value weighted by the length of the associated time intervals.

Development stage at foundation is a variable that accounts for differences in the starting point among our sample. It is an estimation referring to the start of business operations with the same coding like for the dependent variable. As in many cases, this situation dates back several years. Here the information given by the interviewees presents relatively crude estimates compared to the rest of the data.

Almost all data was generated by rating schemes according to Table 1. In general, it was the interviewer who decided about the rating while comparing interview results and additional data. The raw data was then compared across the companies to correct for rating discrepancies.

Figure 2. Development stages based on alliance formation activities



← Technology exploration → ← Technology exploitation →

Formation of technology alliances:

• Research institutes and other companies for general research • Suppliers for special single parts	• Research institutes for additional know-how and quality analysis • Suppliers for upscaling production and improving parts	• (none)	• Research institutes and com-panies to acquire best-practice know-how (sometimes acquisitions)

← Market exploration → ← Market exploitation →

Formation of market alliances:

• (none)	• Institutes and high-tech com-panies as customers or system integrators • Wholesalers and distribu-tors for sales	• Customers and institutes for application know-how • Market leaders and well-known institutes for setting standards	• A few most important customers for special joint development (often offering exclusivity)

Source: Klocke et al. (2002)

MODEL AND DATA ANALYSIS

We based the general model on the hypotheses from the theoretical part above. In addition, we assumed that the development speed a was a linear combination of the underlying factors. We derived;

$$y = (a_0 + a_1 x_1 + \ldots + a_8 x_8)\, t + y_0$$

The formula is an equation that is linear with respect to the firm age t. The dependent variable is y (the current development stage) and y_0 is the development stage at foundation. x_1 to x_8 are the additional variables that influence the development speed, which is given by the whole term in brackets. a_0 to a_8 are constants, which we determined later by linear regression.

As the first step of our analysis, all additional variables were normalized to an average of 0 and a variance of 1. This had no effect on the shape of the model, and allowed us to compare the relative strength of influence on the development speed by looking at the constants a_1 to a_8. Thereby a_0 became the average development speed.

As second step, we checked the correlation matrix of the independent variable and all additional variables (Table 2). We dropped highly correlated variables so that at the end all remaining variables were independent.

Table 2. Correlation matrix

	y	y_0	t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000										
y_0	0.471	1.000									
t	0.863	0.093	1.000								
x_1	0.580	0.880	0.309	1.000							
x_2	0.199	0.429	-0.155	0.417	1.000						
x_3	0.735	0.143	0.700	0.305	0.220	1.000					
x_4	-0.175	0.305	-0.301	0.144	-0.241	-0.311	1.000				
x_5	0.500	0.217	0.270	0.291	0.262	0.408	0.348	1.000			
x_6	0.430	0.507	0.284	0.781	0.340	0.431	0.150	0.490	1.000		
x_7	0.018	0.071	-0.182	0.000	0.282	0.048	-0.305	-0.048	0.049	1.000	
x_8	0.677	0.503	0.482	0.439	0.192	0.342	-0.076	0.195	0.009	-0.146	1.000

Afterwards, we applied a transformation (factoring out the sum in brackets) to obtain the standard form of a multi-dimensional linear equation. In subsequent regression analysis, we checked for normal distribution of the residuals and dropped variables that had abnormally high *P*-values.

RESULTS

Figure 3a shows a plot of current development stage y as a function of firm age t.

The straight line in the figure is the result of a simple regression with $a_1,\dots,a_8 = 0$, which takes out the influence of the additional variables x_i. A linear relationship between development stage y and firm age t seems to be a decent approximation ($R^2 = 0.75$). However, some companies deviate significantly from the straight line, which indicates that additional factors need to be included in order to build a good model for y.

All 8 additional factors in Table 1 might help to explain the deviations of the data from the straight line in Figure 3a. We took out the two variables product focus and business experience because they were highly correlated with other variables. Product focus correlates strongly with technology maturity (corr = 0.781), which makes sense because in technological uncertainty companies might explore more than one product opportunity. Previous business experience of top management correlates strongly with firm age (corr = 0.700), which makes sense because most mature firms were started by founders from technical fields without business experience but later additional managers with such experience get hired.

In the first regressions with all remaining variables, y_0 was set to the development stage at foundation. We could not attain any stable results for this type of model. A reason might be that the estimated values for development stage at foundation were too crude. We proceeded by making the intercept y_0 a constant to be determined by the regression. Such an approach can be justified because no companies in our sample started with a merger or a large-scale spin-off and hence might have faced roughly similar founding conditions and development issues.

In all models, high *P*-values above 0.5 for the variables active professional financing and growth drive indicated that those factors had no significant explanatory effect.

Figure 3a. Linear approximation (one-dimensional regression)

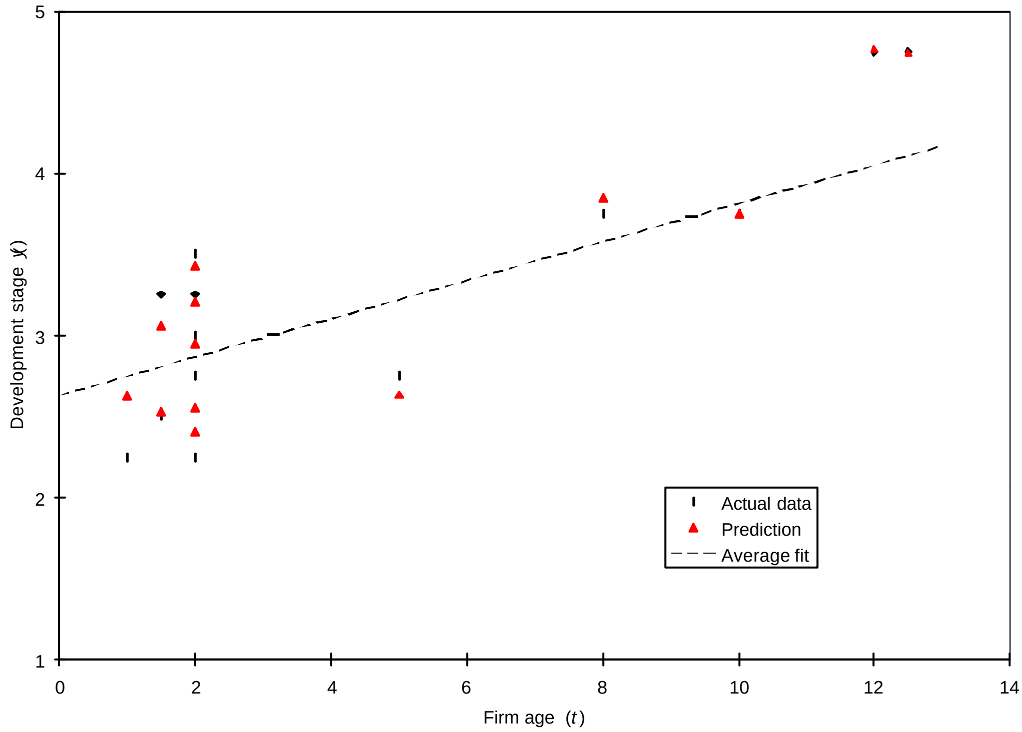
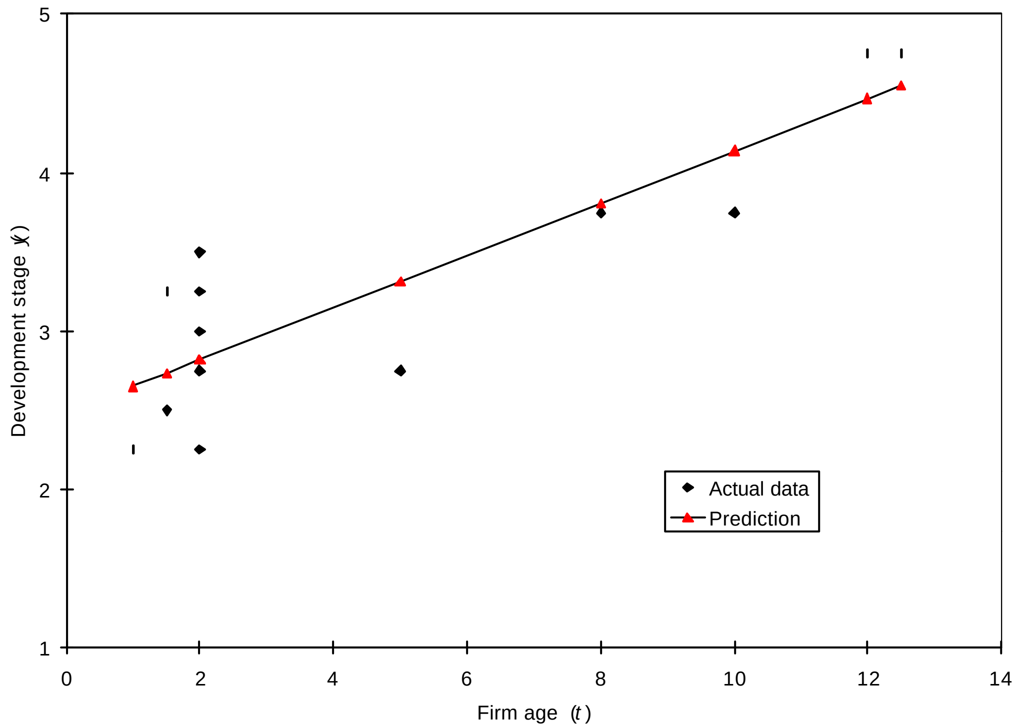


Figure 3b. Final model (multi-dimensional regression)



We dropped those variables and got the final model with the equation

current development stage = *development speed* · *firm age* + 2.63,

where *development speed* = 0.12 + 0.06 *maturity of technology* + 0.08 *maturity of market* + 0.04 *direct sales contacts* + 0.04 *customer sharing*.

The results are visualized in Figure 3b. The model fits the actual data quite well (R^2 = 0.95). This result is in accordance with Hypothesis 1 that a linear relationship is a good approximation for the relationship between firm age and current development stage. Please note that we did not intend to test whether some non-linear approximation is even better and did not perform any analysis to do the test.

The intercept y_0 = 2.63 gives the development stage at foundation. The intercept seems to be too high compared with the estimates of development stage at foundation ranging from 1.5 to 2.5 with an average of 2.1.

The final model proposes an average development speed of a_0 = 0.12 stages per year. This translates roughly into 20 years that the average company needs to reach the end of Stage Four, which is the end of the first learning circle. This result seems to be high compared with results of Oliver (2001) and Klocke et al. (2002) of about 11 years.

The low slope in the final model seems to be related to the high intercept, and both together may be caused by three very young companies in our sample (see data points in the upper left corner of Figure 3b) that operate in an exceptional sector with high readiness and need for the product. The values in the variable maturity of market might not capture the cases well enough and may fail to compensate for the early deviation towards high development stages. In addition, the results may be influenced by a relatively small sample size of 13 and a predominance of mostly younger companies. However, the applied linear regression is a stable technique that seems to have worked well in giving the major trends for our limited sample.

The final model contains four variables that account for differences in the development speed among the companies. In accordance with Hypothesis 2a, there are industry-level factors, namely maturity of technology and maturity of market that influence the development speed. In accordance with Hypothesis 2b, the final model contains firm level factors as well, namely direct sales contacts and customer sharing. These two variables mediate market learning and growth. Overall, the influence of market related factors on development speed predominate.

CONCLUSION AND FUTURE RESEARCH OPPORTUNITIES

Our study started with the research question how quickly alliance networks of young technology-driven firms develop and what determines the speed of change. We applied a framework suggested by Klocke et al. (2002) to distinguish development stages of alliance networks and to measure the speed of change. Based on previous work by Kazanjian and Drazin (1989) and Greiner (1972), we hypothesized that development stage is a linear function of firm age and that development speed is a function of different industry-level and firm-level variables.

We analyzed the network dynamics of a sample of nanotechnology companies to test the hypotheses and obtained a mathematical model that describes the relationship between development stage and firm age in our sample. In a long-term view, the relationship is well described by a linear function and the slope holds the notion of development speed. Development speed depends on various industry-level and firm-level factors called speeding factors. We identified four speeding factors that had a significant impact on development speed: maturity of technology; maturity of market; and, to a smaller extent, direct sales contact and customer sharing. All speeding factors are positively related to the development speed.

In our sample, the firm-level factor product focus was highly correlated to maturity of technology. Consequently, we could not test whether it has an additional influence on top of maturity of technology. The results did not support the influence of active professional financing (e.g., venture capital) and previous professional experience of top management. However, the number of observations in our sample was too small to rule out their influence.

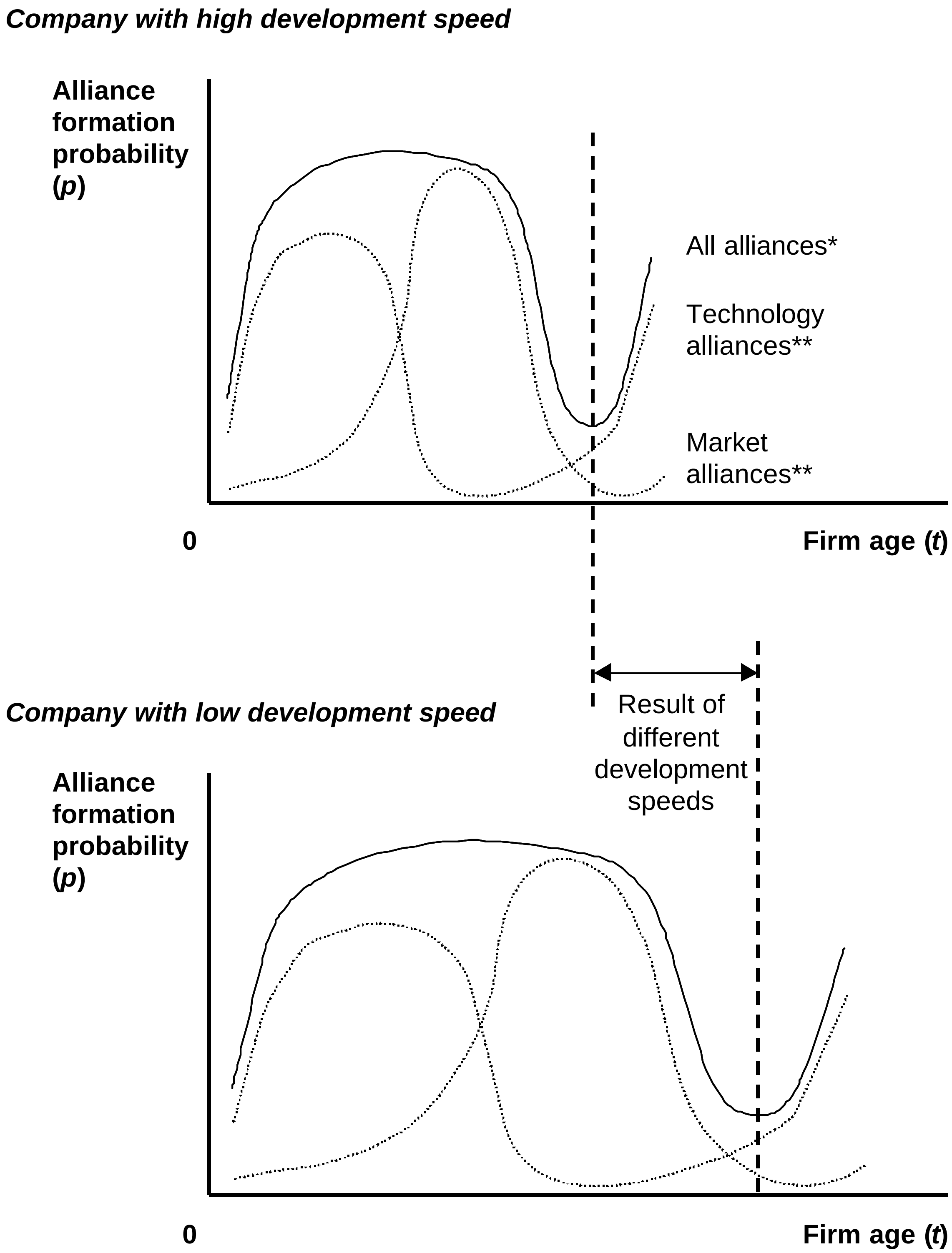
In conclusion, the alliance network of a young technology-driven company has to go through several general development phases. We see evidence that transition speed (development speed) depends mainly on the technology applied by the firm and the chosen market. In addition, the company might speed up its development by strengthening its learning. For example, faster market learning can be achieved by direct sales contact to customers (no intensive use of wholesalers, distributors, etc.) and by agreements to serve established customer groups of alliance partners.

It is noteworthy that progression in the phase model that we used describes an attitude transition in the company from technology focus to market orientation (according to the definition of Narver and Slater 1990). Hence, development speed becomes a driver of market orientation and vice versa. The factors influencing the development speed reveal that the drive towards market orientation has a strong component of market exposure. In other words, market orientation is increased by market exposure. In Oliver's (2001) interpretation, development refers to an initial learning cycle for the young company. In consequence, development speed gets the meaning of learning speed, which is similar to the argument of increasing market orientation by market exposure.

Taken together with Oliver's (2001) intensity curve for alliance formation and the phase model of Klocke et al. (2002), the results of this study allow us to better understand the timing of quantitative and qualitative changes in the alliance network of young technology driven, product-oriented companies. As mentioned in the theoretical part of this paper, our model for development speed is able to explain company-specific variance of network development (Figure 4). Moreover, the model can be used to analyze general business development of young companies because the alliance formation activities that we examined relate directly to other business activities, issues and basic financials (Klocke et al. 2002).

It is important to differentiate between development speed and firm growth. A company operating in a niche might develop at high speed and reach the end of development Stage 4 quickly with only moderate employee and sales growth. On the other hand, a company with high size aspirations might experience high growth in employees and sales, but still need many years to reach end of Stage 4. Moreover, development speed and formation intensity are independent variables and have to be distinguished as well. For example, a company might shift its alliance formation activities from research institutes to companies yet hold the level of new alliances per year constant.

Our rather exploratory study has to face some limitations because we based the analysis only on relatively few companies. In consequence, some speeding factors with actual influence on the development speed might have been not significant in our data and were dropped. Furthermore, we might have missed some other speeding factors altogether even though our final model explains already 80% of the variance from the straight-line model.



* Oliver (2001)

** Klocke et al. (2002)

In further research, new factors might be identified by using a larger sample and by including more potential speeding factors. At the same time, a more comprehensive data set might help to determine average development speed and individual development stage at foundation more precisely.

We assumed that the development phase is linear in firm age and that the development speed is a linear combination of the speeding factors. Although these are straight-forward assumptions, they that might not hold at close inspection. A larger, longitudinal sample would be helpful to analyze the type of relationship further, yet the gain in further theoretical understanding might be small. In addition, further research might analyze why some companies slide backwards in their development stages before they continue to progress as pointed out in the life-cycle literature (Kazanjian and Drazin 1989, Eggers and Leahy 1994).

Future research might answer as well, whether high development speed is coupled with high formation probability. Do firms with high development speed build the necessary alliances in a shorter time than their peers, or do they use their alliances more efficiently so that less of them are needed?

In the theoretical part, the change term and the termination term in the general formula for network dynamics were mentioned. So far, change in alliances and their termination have not been included in many studies about network dynamics (see Hertz 1996 for a study that does include termination effects). These topics provide very different and novel research opportunities while this study concentrated on alliance formation only.

Practitioners might learn from this study how important maturity of applied technology and maturity (or readiness) of markets are for the quick development of their company. Thus, such factors should play a big role when quick development (and profitability) is imperative. After technology and markets have been chosen, the company can still increase its development speed by pushing technology and market learning. Two main levers to be pulled for market learning are direct sales contacts to the end users and customer sharing agreements with established partners.

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