4 Effects of patent and venture capital acquisition on partnering by young Dutch dedicated life sciences firms in 2002

4.1 Introduction

Over the past few decades the number of interorganisational collaborations has increased substantially, especially where R&D collaborations are concerned (Hagedoorn, 2002). For new technology-based industries such as the life sciences industry, such collaborations are regarded as going hand in hand with viable business development (Powell et al., 1996; Niosi, 2003).

In many West European countries, further development of the life sciences industry is supported by governmental programmes. Development of such a high technology, science-based industry is considered important in these countries for the industry's contribution to achieving a knowledge-based economy which is capable of sustaining future economic growth. For that reason, the Dutch Ministry of Economic Affairs started the BioPartner Network programme in 2000 (Ministry of Economic Affairs, 1999). In order to monitor the success of this programme, a register was set up of all Dutch dedicated life sciences firms (DDLSFs) based on the records of the Dutch Chamber of Commerce. This register is updated annually. Since 2002 a survey has been sent to the CEOs of the DDLSFs on an annual basis for the purpose of monitoring the development of the Dutch life sciences industry. This annual survey produces unique data on the population of DDLSFs, i.e. their collaborative relations with one another, and also with established diversified firms and research institutes and various firm-related characteristics.

Analysis of the collaboration network of DDLSFs in 2002 revealed an almost random distribution of collaborative relations indicative of a life sciences industry in its very early stage of development[8] (Chapter 3 of this thesis). Such an almost random distribution of partnering by DDLSFs is representative of an unstructured collaboration network in which there are virtually no endogenous network effects on that partnering. This implies that an explanation based on such endogenous effects is not obvious (Gulati and Gargiulo, 1999) and that an alternative explanation for partnering by DDLSFs in 2002 should be developed. In this chapter we develop a resource-based explanation, as is advocated by the resource-based and resource dependence views of the firm (Penrose, 1959; Pfeffer and Salancik, 1978; Wernerfelt, 1984). Consequently, the research question to be examined is formulated as:

What resource stocks affect interorganisational partnering by young Dutch dedicated life sciences firms?

In order to provide an answer to this research question a theoretical framework will be developed in the following section. Subsequently, a description will be given of the data collection method that was used and the measurement of the concepts discerned. Next, the statistical methods used for testing the hypotheses will also be discussed. After that, the results obtained will be presented and interpreted. Subsequently, the management and policy implications of the results for life sciences start-ups will be addressed. A discussion of the research carried out and the conclusions to be drawn from the results conclude this chapter.

4.2 Theoretical framework

In the Resource-Based View of the firm (RBV), a firm's resource portfolio is pivotal in explaining strategic firm behaviour. In this respect resources are defined as "those (tangible and intangible) assets which are tied semipermanently to the firm" (Wernerfelt, 1984: p. 172). This RBV provides a somewhat internally oriented view on firm behaviour as it is mainly focused on the development of distinctive resources within individual firms. It should therefore at least be complemented with the Resource Dependence perspective, in which explicit attention is given to obtaining access to complementary resources of other organisations within the environment of the focal firm (Pfeffer and Salancik, 1978). This notion of complementarities of resources of organisations is especially relevant in the study of organisational behaviour in high technology, science-based industries. One of the implications of operating in a high technology industry is that firms have to cope with rapid technological change, making it difficult for them to determine what technological fields to focus on. Also, the pace of technological change and the increasing complexity of successive technologies make it impossible for an individual firm to possess all the resources required to conduct R&D in-house. This results in a distribution of resources and capabilities across organisations within an industry. Access to complementary knowledge and resources then becomes pivotal rather than actual acquisition of knowledge and resources (Grant and Baden-Fuller, 2004). This distribution of resources drives the emergence of networks of collaboration among high technology organisations with many lateral relations. Firms operating in emerging high technology industries use networks of interorganisational collaboration to gain access to complementary resources and competences required for engaging in R&D. Consequently, the specific resources of individual organisations constitute a pivotal criterion in partner selection (Hitt et al., 2000).

When explaining the collaborative behaviour of starting organisations, aspects related to the liability of newness need to be addressed explicitly (Stinchcombe, 1965). Compared with established organisations, start-ups have to overcome several additional hurdles in order to become and remain successful. Among these hurdles are the lack of reputation and lack of visibility within a specific industry or sector. In sectors in which resources are heavily dispersed among actors, this liability of newness results in a liability of unconnectedness (Powell et al., 1996). Improving the reputation and visibility is therefore of critical importance to start-ups active in a high technology sector.

In the case of a new technology-based firm, the extent to which its technology is well known and regarded as being promising provides one mechanism by which the firm can gain visibility and establish a reputation for it to be considered as a potential partner by other organisations (Ahuja, 2000). In this respect, acquiring a patent is considered to be a prerequisite as this is an indicator of the quality of the underlying technological knowledge (Stuart et al., 1999; Niosi, 2003). The acquisition of a patent by a start-up therefore positively contributes to its reputation and visibility within a technology-based business field and thereby enables firms to partner (Mazzoleni and Nelson, 1998; Sakakibara, 2002; Baum and Silverman, 2004; Thumm, 2004).

To further improve its reputation, it is also important that the strategic choices made concerning the exploitation of a patent are considered to be both adequate and promising. The acquisition of venture capital may be conceived as a relevant indicator of the extent to which the proposals for exploitation of the firm's patent have obtained external approval and are considered promising[9] (Baum and Silverman, 2004). It needs to be noted, however, that in the process of due diligence of a venture capitalist, the question whether or not a firm has already obtained a patent is important as a venture capitalist has limited competences to evaluate the actual quality of a firm's technology portfolio. In this respect, patent acquisition represents a useful proxy for the evaluation of this quality by venture capitalists (Niosi, 2003; Baum and Silverman, 2004). Furthermore, the initial exploitation of the patent should be successful in terms of generating revenues. Both patent acquisition and successful initial patent exploitation demonstrate the viability of the start-up, which is crucial for further business development to be financed with venture capital (Tidd et al., 2001; Christensen and Raynor, 2003). Overall, it may be derived that the acquisition of a patent and venture capital both contribute to the reputation and visibility of a high technology start-up and therefore to partnering. In turn, venture capital acquisition is influenced by patent acquisition and exploitation.

Apart from the reputation and visibility enhancing effects ascribed to patent and venture capital acquisition, the partnering rate of start-ups will also depend on how much information they possess about their own and complementary fields of knowledge and about the organisations active in these fields that might be considered as potential partners. The amount and usage of this information will vary with the size of the management team of the start-up (Eisenhardt and Bird Schoonhoven, 1996) as the management team may be expected to be a firm's primary link with its environment. The ability of a start-up's management team to mobilise this source of information for deliberated selection of suitable partner organisations may be conceived as its social capital. This social capital acts as a directional profiler of the reputation-related effects of patent and venture capital acquisition towards other organisations, thereby stimulating partnering by a start-up. This is related to the idea that partner selection based on resource portfolios is conducted within the boundaries of the opportunity set of the firm (Seabright et al., 1992).

Further business development in the early development stage of a start-up primarily concerns improving the quality and strategic positioning of its product portfolio in order to expand the exploitation of its patent(s) and diversifying its markets (Christensen and Raynor, 2003). For improving its product portfolio, complementary knowledge and technologies that are not possessed by the start-up are necessary. As discussed before, partnering with other organisations can be used to fulfil this need for complementary resources. Consequently, the partnering rate of start-ups in high technology, science-based industries such as the life sciences indicates their involvement in further business development to strengthen their viability in the future. Establishing partnerships, however, requires visibility of a start-up as an interesting partner for other organisations in its environment. This visibility will be positively affected by their acquisition of patents and venture capital and the propagation thereof by the management team.

In the previous paragraphs four concepts were introduced that are regarded as playing an important role in the partnering by start-ups in high technology, science-based sectors such as the life sciences industry, namely patent acquisition, successful initial business development based on initial patent exploitation, venture capital acquisition and the management team. But how these concepts affect partnering and each other has only been partly addressed and will be further elaborated on below. In substantiating the explanations of these effects, we have mostly concentrated on referring to papers on high technology sectors as these may be considered to be the most relevant.

The effect of patent acquisition on partnering can be exerted through two different mechanisms. If patent acquisition exerts an opportunity-based reputation-related effect, as already explained above, then this effect will be positive (Ahuja, 2000; Baum et al., 2000). However, patent acquisition can also negatively influence partnering, namely if an increasing number of patents acquired decreases the need for obtaining external access to complementary knowledge and competences. In other words, a start-up that has one or a few patents may experience an inducement to partner in order to obtain access to complementary competences necessary for subsequent development and commercialisation of the patented technology (Mazzoleni and Nelson, 1998). This would imply that an inducement-related effect is dominant (Ahuja, 2000). Hence, the following opposite hypotheses are formulated.

H1a: *A larger number of patents stimulates the partnering rate.*
H1b: *A smaller number of patents stimulates the partnering rate.*

A unique technological basis reflected in patent acquisition is considered a prerequisite for a start-up to initiate a business in the life sciences industry. On the one hand, the size of this technological basis, reflected in the number of patents, can positively affect the scale of initial business operations as it increases the number of technological options that can be commercialised. On the other hand, an extensive technological basis also increases the technological complexity to be dealt with by a start-up, which may limit the scale of initial business operations deployed. Since, due to lack of empirical evidence it cannot be decided beforehand which of these two effects is dominant, two opposite hypotheses are formulated.

H2a: *A larger number of patents stimulates the scale of initial business development.*
H2b: *A larger number of patents limits the scale of initial business development.*

Patent acquisition and successful initial business development have been argued before to stimulate venture capital acquisition. In turn, venture capital acquisition is likely to have a positive effect on the partnering rate of a start-up. Hence, three hypotheses can be formulated.

H3: *A larger number of patents stimulates venture capital acquisition.*
H4: *More successful initial business development stimulates venture capital acquisition.*
H5: *More venture capital acquisition stimulates the partnering rate.*

The effect described in Hypothesis 3 already has empirical support (Baum and Silverman, 2004). With respect to the fifth hypothesis it should be noted that the expected positive effect of venture capital acquisition on the partnering rate represents an inducement as well as an opportunity for partnering. The inducement consists of the obligation to successfully expand the business operations of the start-up after venture capital acquisition by engaging in partnerships.

The opportunity consists of the increased attractiveness of the start-up as a partner of other organisations after venture capital acquisition by that start-up.

It is argued that the degree to which a start-up has information about its business environment and interesting partner organisations therein varies with the size of the start-up's management team (Eisenhardt and Bird Schoonhoven, 1996). Having access to such information is believed to have a positive effect on partnering by the start-up because it helps to find and contact potentially interesting partner organisations and increases a start-up's chances of being found by these potential partners (Eisenhardt and Bird Schoonhoven, 1996). Hence, the following hypothesis can be formulated:

H6: *A larger management team stimulates the partnering rate.*

Subsequently, the question arises what factors determine the size of a start-up's management team. The size of the management team is likely to grow along with a growth of the scale of business activities employed by a firm. In this respect, two factors have already been mentioned: the scale of initial business development and the complexity of the technological basis of the start-up reflected in its number of patents. As the degree of complexity of the technological basis of a start-up in the life sciences industry is assumed to vary positively with the size of this technological basis (i.e. the number of patents), a direct positive effect of its number of patents on the size of its management team may be expected. The scale of initial business development may be expected to have a similar, positive influence on the size of the management team. Therefore, two hypotheses can be formulated.

H7: *More successful initial business development stimulates the size of the management team.*
H8: *A larger number of patents stimulates the size of the management team.*

Combining the eight hypotheses about the causal effects among the five concepts mentioned therein gives the conceptual model of partnering behaviour by start-ups in the life sciences industry depicted below in Figure 4.1. In the following section, the empirical data used to test the hypothesised relations in this model will be discussed.

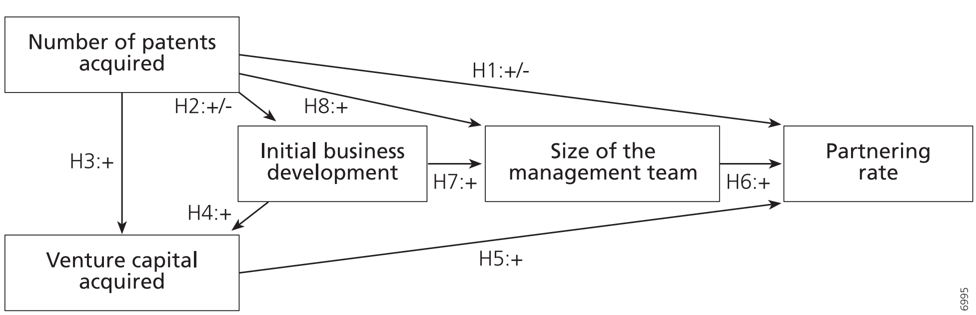

Figure 4.1 Conceptual model of the partnering rate of start-ups in the life sciences industry

4.3 Research methods

The data used to test the conceptual model are obtained from the survey distributed among the known population of DDLSFs in 2002. The questionnaire was sent to 126 DDLSFs and contained questions on possible indicators of the concepts in Figure 4.1, such as the number of collaborative relations a respondent is engaged in, the amount of venture capital acquired, the number of patents acquired, the number of managers, the change in turnover since 2001, as well as data on the total number of employees, the change in number of employees since 2001, and the year of founding. However, the data on the amount of acquired venture capital and the number of acquired patents represent accumulations over time as many DDLSFs were established before 2002. In order to check for contamination of test results due to differences in firm and business development over time, control variables are added to the conceptual model, namely 'firm age' and 'firm size in 2001'. The control variable 'firm size in 2001' is a proxy of business development before 2002 as it merely represents its condensate reflecting previously built up financial, human and technological capabilities. By regressing the concepts in Figure 4.1 on both control variables the effects of accumulation over time due to earlier firm establishment and business development before 2002 can be separated from the effects contained in H1-H8. Furthermore, only DDLSFs not older than five years are selected from the set of DDLSFs giving the intended sample of young DDLSFs or start-ups.

The 2002 BioPartner Network questionnaire sent to 126 registered DDLSFs was (partly) completed and returned by 110 DDLSFs. Imposing the five years restriction reduced the set of respondents to 81 DDLSFs. Sorting out respondents that failed to answer one of the questions on the indicators mentioned above using listwise deletion resulted in a reduced set of 39 DDLSFs; that is a response rate of (39/81)*(110/126)*100% = 42%. The distribution of the 39 selected young DDLSFs over the no/yes categories of patent and venture capital acquisition is shown in Table 4.1 below.

This distribution is not random as its Chi-square value is 7.122 with 1 degree of freedom is larger than the critical Chi-square of 6.635 for a 99% confidence interval around zero (Wonnacott and Wonnacott, 1990).[10] This test shows that both patent and venture capital acquisition were desired by young DDLSFs. This already reflects the expected reputation-related effects of the acquisition of at least one patent and venture capital as prerequisites for survival of a start-up in the life sciences.

The concepts in Figure 4.1 and the control variables mentioned before are operationalised for all the selected young DDLSF as follows:

- 'number of patents' is measured as the number of patents acquired on December 31, 2002,
- 'venture capital' is measured as the amount of venture capital acquired on December 31, 2002 in ten thousands of euros,

Table 4.1 The distribution of 39 young DDLSFs with and/or without patents and venture capital in 2002

		venture capital	
		no	**yes**
patents	**no**	8	4
	yes	6	21

- 'current business development' is measured as the yearly change in turnover on December 31, 2002 in ten thousands of euros,
- 'size of the management team' is measured as the number of managers on December 31, 2002,
- 'partnering rate' is measured as the number of collaborative relations actively engaged in on December 31, 2002,
- 'firm age' is measured as the age in years, calculated as 2002 minus the year of establishment, and
- 'firm size in 2001' is measured as the number of employees on December 31, 2002 minus the yearly change in number of employees during 2002.

Additionally, the empirical variables acting as indicators of the concepts in Figure 4.1 are expected to vary positively with the previously defined indicators of the control variables 'firm age' and 'firm size in 2001'. These effects and those specified in H1-H8 will be tested using the data derived from the Dutch BioPartner Network survey 2002 discussed earlier.

4.4 Methods of analysis

In order to test the hypotheses H1-H8 and the effects of the control variables a linear model can be specified consisting of the equations given in Table 4.2.

This linear model is specified in the computer program LISREL® (Jöreskog and Sörbom, 1993) in order to obtain minimum variance unbiased estimates of the unknown constant parameters b_1-b_8, f_1-f_5 and a_1-a_5 by using the maximum likelihood (ML) method. Apart from these optimal estimates and the associated standard errors and t-values, LISREL also estimates the fit of the model to the input matrix S by means of a Chi-square (χ^2)-based goodness of fit measure and its associated number of degrees of freedom df and probability p. Additionally, LISREL produces modification indices for non-specified effects fixed at a value equal to zero. These modification indices are estimates of the decrease of the Chi-square value of goodness of fit for individual

Table 4.2 Parameters to be estimated (corresponding hypothesis with proposed effect is given between brackets)

Dependent variables	**Firm size 2001**	**Firm age**	**Number of patents**	**Current business development**	**Venture capital**	**Size of the management team**
Number of patents	f_1	a_1				
Current business development	f_2	a_2	b_1 (H2: +/-)			
Venture capital	f_3	a_3	b_2 (H3: +)	b_3 (H4: +)		
Size of the management team	f_4	a_4	b_4 (H8: +)	b_5 (H7: +)		
Partnering rate	f_5	a_5	b_6 (H1: +/-)		b_7 (H5: +)	b_8 (H6: +)

non-specified fixed parameters when they are also specified to be estimated. Modification indices are given by LISREL for improving the estimated model's specification on statistical grounds.

However, it can be argued that the measurement scales of the empirical variables are mostly different from the interval and ratio scales required for linear models and that the specification of H1-H8 and the effects of the control variables as linear relations is incorrect therefore. 'number of patents', 'size of the management team', 'partnering rate' and 'firm age' are typical discrete count variables with many replications of values in the data set. 'venture capital' and 'firm size in 2001' are censored variables with a lower threshold at zero. Only 'current business development' is measured on an interval scale. So, there are discrete, censored and continuous variables in the data set. Fortunately, LISREL's pre-processor PRELIS™ (Jöreskog and Sörbom, 1995) contains ML correlation estimation procedures for such variables based on the polychoric correlation for two discrete variables (Olsson, 1979), the polyserial correlation for discrete and continuous variables (Olsson et al., 1982), the Pearson correlation for two continuous variables (Wonnacott and Wonnacott, 1990) and combinations thereof for estimating the correlation between a discrete or continuous variable and a censored variable (Faber, 1991). These procedures calculate ML estimates of correlations based on the assumption of underlying normally distributed continuous variables. The resulting estimated correlations are shown to be superior to any other measure of association (Jöreskog and Sörbom, 1995: 8-18). The correlation matrix resulting from applying the procedures programmed in PRELIS can then be used as the input matrix S in LISREL for the ML estimation of the equations presented in Table 4.2.

4.5 Results

The ML estimation conducted produces the estimates of the unknown constant parameters b_1-b_8, f_1-f_5 and a_1-a_5 (with t-values) given in Table 4.3. With a correlation of 'firm size 2001' and 'firm age' of 0.15 (t-value: 0.93) and a Chi-square value of 4.79 (df=4) giving a probability of 0.31 for the goodness of fit. The critical absolute t-value for a one-tailed test with a 95% confidence interval of the estimated regression coefficients is $t_{0.05}=1.69$.

The results show that 'firm age' has a significant negative effect on the 'size of the management team' whereas a positive effect was expected. As 'firm age' is unrelated to all other variables in the model, no plausible argument can be given for this negative effect. Consequently, 'firm age' is removed from the model after which it is ML estimated again. After that, still two insignificant effects remain, namely the effect of 'firm size in 2001' on the 'size of the management team' and the effect of the 'size of the management team' on the 'partnering rate'. Again these insignificant effects are removed before the next ML estimation is carried out. Now, all remaining specified effects are significant. Furthermore, the modification index of the effect of the 'size of the management team' on 'venture capital' indicates a significant positive effect. This effect implies that the knowledge of and contacts with other organisations held by the management team is utilised to find venture capitalists providing additional financing, which in turn stimulates partnering. After specification of this effect in the model its final estimation produces the results depicted in Figure 4.2[11].

A Chi-square value of 1.02 (df =5) giving a probability of 0.96 makes the fit of the estimated model to the input matrix S excellent. Figure 4.2 shows that hypotheses H1b, H2b, H3, H4, H5, H7 and H8 are confirmed as well as the expected positive effects of the control variable 'firm

Table 4.3 Estimation of the parameters

Dependent variables	**Firm size 2001**	**Firm age**	**Number of patents**	**Current business development**	**Venture capital**	**Size of the management team**	**R^2**
Number of patents	0.71 (5.90)	-0.17 (-1.43)					0.49
Current business development	0.80 (4.35)	0.13 (0.98)	-0.49 (-2.71)				0.40
Venture capital	0.29 (1.70)	-0.14 (-1.40)	0.41 (2.74)	0.36 (2.89)			0.66
Size of the management team	0.10 (0.56)	-0.24 (-2.36)	0.22 (1.49)	0.73 (5.84)			0.66
Partnering rate	0.17 (0.94)	0.10 (0.98)	-0.42 (-2.83)		0.78 (4.81)	0.12 (0.96)	0.63

size in 2001' except for its effect on the 'size of the management team'. Apparently, the 'size of the management team' depends solely on 'current business development' and the size of the technological basis (i.e. 'number of patents acquired') of the start-up. Furthermore, the expected direct positive effect of the 'size of the management team' on the 'partnering rate' turns out to be insignificant thereby rejecting Hypothesis 6. This effect is indicated by LISREL to be exerted through the variable 'venture capital acquired'. In sum, the validation of all but one hypothesis specified in the conceptual model indicates that the conceptual model provides a substantial but not complete explanation for the partnering rate of young DDLSFs with other organisations (R^2=0.62). The dominant role of patent and venture capital acquisition in this partnering by

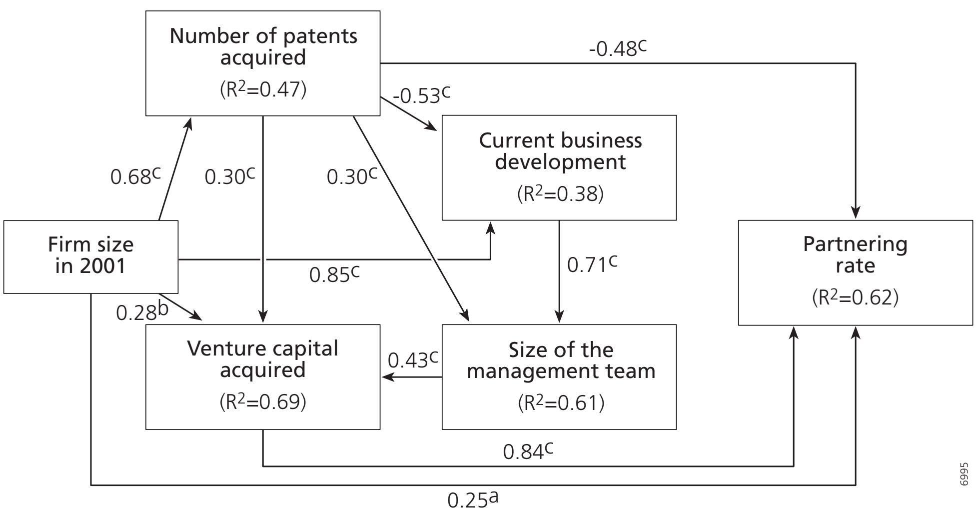

Figure 4.2 Estimated model of the partnering rate of Dutch dedicated life sciences firms in 2002 (N=39) (with [a]: p<0.10, [b]: p<0.05 and [c]: p<0.01)

young DDLSFs, which is undertaken for further business development, is now evident as is the minor role of prior business development.

Next to the estimated direct effects discussed above, it is also possible to estimate all indirect effects operating in Figure 4.2[12]. Variables initiating sequences of indirect effects might play a larger role in explaining partnering by DDLSFs than is apparent from just the direct effects given in Figure 4.2. The total effect of variables having both a direct and indirect effect on a specific dependent variable is given, which is calculated by adding the direct and indirect effects. The values of direct effects listed in Table 4.4 are equal to those in Figure 4.2.

Table 4.4 shows that the total inducement to partner generated by having only a few patents is weaker than its direct effect suggests. Furthermore, it can be derived that prior business development (Firm size 2001), current business development and the size of the management team make a significant indirect contribution to the partnering rate of young DDLSFs. Thus, business development and knowledge of the environment are more important for partnering by young DDLSFs than shown by the direct effects in Figure 4.2. The amount of venture capital acquired by a start-up largely depends on prior business development (Firm size 2001) as well as on the size of the management team. Moreover, the positive effect of current business development on venture capital acquisition is also substantial, whereas venture capital acquisition is least determined by patent acquisition. Hence, it seems that venture capital acquisition is more dependent on successful business development than on unique technological competences. Table 4.4 also shows that the size of the management team not only depends on current business development but also on prior business development (Firm size 2001) as may be expected, but indirectly. Furthermore, the direct effect of the number of patents acquired on the size of the management team is neutralised by the indirect effects through current business development. The total effect of prior business development (Firm size 2001) on current business development is also lower than suggested by the direct effect due to the negative direct effect of patent acquisition on current business development.

Table 4.4 Total effects of each explanatory variable on all dependent variables in the estimated model of the partnering rate of DDLSFs in 2002 (N=39)

Dependent Variables	**Explanatory variables**				
	Venture capital	**Size of the management team**	**Current business development**	**Number of patents**	**Firm size in 2001**
Partnering rate	0.84 (d)	0.36 (i)	0.25 (i)	-0.25	0.53
Venture capital		0.43 (d)	0.30 (i)	0.27	0.72
Size of the management team			0.71 (d)	-0.07 ^{ns}	0.55 (i)
Current business development				-0.53 (d)	0.48
Number of patents					0.68 (d)

(d) only direct effect; (i) only indirect effect; ^{ns} *p>0.10*.

4.6 Management and policy implications

The results presented in Figure 4.2 show two negative effects in the model of partnering by individual young DDLSFs, namely those of acquired patents on the number of collaborative relations and acquired patents on current business development. These effects put a maximum on the number of collaborative relations actively engaged in by young DDLSFs.

From the perspective of managing a young DDLSF this implies that focusing on expanding the technological basis of the firm in terms of more patents in order to acquire more venture capital for future business development through partnering inherently entails the risk of neglecting the urgency of current business development. Such a strategy can be pursued when founding the firm, but over the course of time this strategy should be changed into a strategy that aims at boosting sales and revenues in existing and new markets with services and products based on a medium-sized and not maximised technology portfolio. In other words, commercialisation is necessary for future viability. In biotechnology, this is reflected in the trend of increasing proliferation of hybrid business models that include services or out-licensing activities which are used to secure short term revenues (Ernst & Young, 2004; Willemstein et al., 2007)

From the perspective of venture capitalist policy, the negative effects mentioned imply that the financing proposals of young DDLSFs to further extend the technological basis by means of the acquisition of additional patents should be assessed relative to the number of patents already acquired and recent business development in terms of change in turnover. Financing additional technology-based business opportunities of any young DDLSF above a certain threshold value will jeopardise the venture capitalist's future returns on investment because of declining and ultimately negative changes in turnover of the young DDLSF.

4.7 Discussion

In this chapter, we have attempted to explain the extent to which dedicated life sciences start-ups engage in partnering. To do this, we attributed a central role to the possible sequence of events leading to overcoming the liability of newness, as defined by Stinchcombe (1965). This implies that we have focused on factors stimulating the visibility and reputation of the start-up. In doing so, we have also explicitly taken into account the relationships among the explanatory variables, which have been specified in other studies as independent variables. In other words, this chapter presents a dynamic model of subsequent activities and events leading to partnering by start-ups as opposed to a single static explanatory equation for partnering presented in the studies referred to below. Moreover, this enabled us to take into account the indirect effects among the variables in the model. Comparison of the direct effects in Figure 4.2 and the total effects in Table 4.4 shows that the estimated direct effects on partnering by young DDLSFs provide only a partial explanation and that the direct effects among the explanatory variables must also be specified on theoretical grounds in order to arrive at a more comprehensive explanation. In other words, not single, seemingly independent activities and events but sequences of activities and events determine the partnering rate of young DDLSFs. This outcome validates Niosi's conclusion (stated without direct statistical support) about the existence of such sequences of activities and events in the development of high technology firms (Niosi, 2003).

The results presented in this chapter support various effects found in other studies on partnering by high technology start-ups of Eisenhardt and Bird Schoonhoven (1996), Baum et al. (2000), Niosi (2003) and Baum and Silverman (2004), although these studies have only addressed direct effects between variables. A comparison of the results obtained in these studies and the results obtained here can be found in Table 4.5.

While Baum et al. (2000) found a direct positive reputation-related effect of patenting on the partnering rate of firms, we found such a reputation-related effect of patenting on partnering to be indirect, namely through venture capital acquisition. The direct effect of patenting on partnering is shown to be a negative, inducement-related effect. Apparently, DDLSFs engage in partnering because of the inducement to complement their own knowledge and competences and this need for additional competences decreases as the patent portfolio of the firm expands. Additionally, Eisenhardt and Bird Schoonhoven (1996) also found a significant effect of management team size on partnering but as a direct effect and not as an indirect effect through venture capital acquisition. Niosi (2003) also reports that venture capital acquisition and efficient R&D (reflecting current business development) depends on patent acquisition. Baum and Silverman (2004) also found a positive influence of patent acquisition on venture capital acquisition and a positive influence of management team size on venture capital acquisition. However, they did not assess the important role of both patent and venture capital acquisition in partnering by start-ups.

The results obtained here show that young DDLSFs are tempted to engage in partnering to obtain additional knowledge and attract partners by showing successful business development and successful venture capital acquisition. An additional explanation for the positive effect of venture capital acquisition on the partnering rate might be that such acquisition stimulates start-ups to initiate further development of their (patented) technological knowledge. While other studies have not found a significant effect of finance-related variables on partnering (Gulati, 1999; Ahuja, 2000), this study shows that the financial functioning of a start-up (i.e. initial business development) does play an important but indirect role in developing other resources that do affect partnering directly. The results thus indicate that an analysis of the partnering rate

Table 4.5 A comparison of the results obtained here and in other studies addressing partnering by high-technology start-ups

Direct effects found in other studies	**Results of this study**	
	Direct effects	**Indirect effects**
Number of patents → Partnering rate (+) (Baum et al., 2000)	Number of patents → Partnering rate (-)	Number of patents → Partnering rate (+)
Number of patents → Venture capital (+) (Niosi, 2003; Baum & Silverman, 2004)	Number of patents → Venture capital (+)	Number of patents → Venture capital (+)
Number of patents → Current business development (+) (Niosi, 2003)	Number of patents → Current business development (-)	–
Size management team → Venture capital (+) (Baum & Silverman, 2004)	Size of the management team → Venture capital (+)	–

of start-ups based on their resources can benefit from a dynamic, sequential conceptualisation. Moreover, this is also relevant for examining the development of firms' resource portfolios.

Whereas the Resource-Based View initially restricted opportunities of firms to the exploitation of current resources and development of new resources in-house (Wernerfelt, 1984), various recent studies have examined the option of sharing resources with other organisations shaped by the emergence of interorganisational collaborations (see for instance Ahuja, 2000). This study has substantiated this notion of resource sharing by indicating that technology development induces partnering, whereas business development generates opportunities for partnering. The mediating role of the size of the management team indicates that DDLSFs use this team to influence, and to some extent to possibly control their environment, as proposed by the resource dependence perspective (Pfeffer and Salancik, 1978; Lewin et al., 2004)[13].

Finally, a methodological note. The Chi-square based measures of fit of the specified model to the input data and the R^2 measures of the explained variance of dependent variables presented for Figure 4.2 show that Chi-square based measures of fit are not good indicators of the explanatory power of the models specified by the authors cited above. The probability of fit increased from 0.31 for the equation given in Table 4.2 to 0.96 for Figure 4.2 whereas the R^2 remained virtually the same for the partnering rate in the equation given in Table 4.2 and Figure 4.2, namely 0.63 and 0.62, respectively. Hence, the predictive power of the discrete regression equations estimated by the authors mentioned remains unknown. This problem has been overcome in this study by the statistical methods used.

4.8 Conclusion

The research question addressed in this chapter was: "*What resource stocks affect interorganisational partnering by young Dutch dedicated life sciences firms?*". To answer this question we focused on the relevance of effects of patent and venture capital acquisition. After specification and operationalisation of a theoretical model of these influences, the model was tested using appropriate statistical methods. The statistical results validate the theoretical model and 62% of the variance of the dependent variable 'number of collaborative relations' was predicted correctly. Partnering is influenced most by venture capital acquisition, less by prior business development and least by patent acquisition. Current business development and management act as important intermediary variables between patent acquisition and venture capital acquisition. This indicates the need of current patent exploitation for additional venture capital acquisition, which in turn stimulates partnering. Consequently, reputation-related effects of patent and venture capital acquisition play a very important role in partnering by dedicated life sciences start-ups aiming to achieve further business development and growth. With regard to venture capital acquisition, such reputation-related effects directly influence partnering, whereas with regard to patent acquisition these effects are indirect.

This study shows that not only taking into account the direct effects of explanatory variables on a dependent variable but also the indirect effects specified on theoretical grounds improves the explanation provided. Furthermore, incorporating these indirect effects in the statistical analysis of the explanatory model provides valuable insights into important management and financing issues concerning business development by start-ups in the life sciences industry.

Future research based on more refined indicators of the concepts used and/or additional explanatory concepts should focus on a further reduction of the 38% unexplained variance of partnering by start-ups. Also, future research should provide insight into the extent to which the effects found in this study are also valid in other populations of high technology start-ups, thereby producing some insight into the reliability of these effects[14].