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Too much of a good thing: the role of alliance portfolio diversity for innovation output in the biotechnology industry

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Abstract

The purpose of this paper is to show the impact of heterogeneous partners in a biotechnology firm?s alliance portfolio on innovation output. Previous literature has stressed that investments into the heterogeneity of partners in an alliance portfolio is more important than just engaging in multiple collaborative agreements. The analysis of a unique panel dataset of 20 biotechnology firms and their 8502 alliances suggests that engaging in many alliances in general has a positive influence on a firms innovation output. Furthermore, maintaining diverse alliance portfolios has an inverted U-shaped influence on a firm?s innovation output, as managerial costs and complexity levels become too high.

Jelcodes:O32,O34

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Abstract

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Keywords: Alliances, alliance portfolio, biotechnology, innovation.

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Introduction

Firms that are able to seize technological opportunities by means of their innovation management are most likely to achieve or maintain competitive advantages. Innovation and effective R&D management are particularly important for firms in high-tech industries. Short product life cycles and rising costs of knowledge acquisition that characterize such industries, require fast action and effective guidance (Sampson, 2007). For firms in these industries it is thus inevitable to develop technologies quickly in order to capture first mover advantages, such as early cash flows, external visibility, legitimacy and early market share (Schoonhoven *et al.*, 1990). Importantly, technology can be developed either internally or externally. While large firms have significant resources to develop most technologies in-house, small firms often lack these resources, which they often compensate through alliances with external partners (Vanhaverbeke *et al.*, 2007). These alliances are defined as *'…co-operative agreements in which two or more separate organizations team up in order to share reciprocal inputs while maintaining their own corporate identities*' (De Man & Duysters, 2005: 1377) and range from loose and relational R&D partnerships to equity joint ventures (Contractor & Lorange, 2002). The impact of alliances on innovation has been analyzed extensively, and it is found that firms benefit by means of improved innovation and overall performance[1]. Recent studies found that firms profit most from heterogeneous partners in their alliance portfolio (e.g. Baum *et al.*, 2000; Duysters & Lokshin, 2011; Faems *et al.*, 2005). Still, empirical evidence how the diverse partners in an alliance portfolio influence a firm's innovation output is scarce, some mentionable expectations being the studies by Faems (2005) and Duysters (2011). However, only few studies so far have made an attempt to analyse the relationship between the alliance portfolio approach and a firm's innovative performance empirically. Thus, this paper attempts to fill this gap in the literature and addresses the main research

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[1] For a collection of papers that analyze the effect of alliances on innovation see De Man and Duysters (2005).

question of how the quantity of collaborative agreements and relationships with heterogeneous partners in a biotechnology firm’s alliance portfolio affect its innovation output.

To answer this question the analysis focuses on the development of the 20 most successful biotechnology firms (MedAdNews, 2004) and their alliance portfolios. The remainder of the paper is structured as follows: In the first part extant literature on the different dimensions of alliances and their effects on innovation are reviewed. Subsequently, testable hypotheses are derived. Thereafter, the data and the empirical setting used to test the hypotheses is described. Then the results are reported and discussed and concluding remarks are drawn.

Literature Review

In this section, the literature on the rationales underlying business alliances and the influence of alliances on innovation is reviewed. Furthermore, extant literature on challenges for alliances is discussed focusing on the influence of complexity on innovation and how effectively managed alliance portfolios may help to overcome difficulties. Last, theoretical literature on how alliances influence the innovation especially in newly established firms is required. These theories and concepts are essential to understand the impact of alliance portfolios on innovation in young firms and to derive testable hypotheses.

During the last three decades inter-firm relationships between firms have grown rapidly. Especially during the 1980s, firms have started to support their internal development through alliances, such as joint ventures, license agreements, technology alliances, and other collaborative relationships (De Man & Duysters, 2005). This development is driven by several advantages for firms that result from inter-firm collaboration. For instance, alliances give firms access to complementary assets (Hagedoorn, 1993; Hamel, 1991; Powell *et al.*, 1996; Teece, 1986), reduce risks, costs (e.g. Ciborra, 1991; Hagedoorn, 1993; Hagedoorn & Duysters, 2002; Harrigan, 1988a; Ohmae, 1985) and uncertainties (Dollinger & Golden, 1992), and promote the transfer of tacit and codified knowledge (Ahuja, 2000; Das & Teng, 1996; Doz & Hamel, 1997; Eisenhardt & Schoonhoven, 1996). These organizational, financial and technological advantages permit firms to improve their innovativeness (Ahuja & Lampert, 2001; Amabile, 1988; Vanhaverbeke *et al.*, 2002). Therefore, most studies find that successfully managed alliances have a positive effect on a firm's R&D activity (De Man & Duysters, 2005). However, if alliances are managed inadequately, severe consequences can follow and 60% of all alliances do indeed fail (Bleeke & Ernst, 1993; Harrigan, 1988b). Reasons for alliance failure are opportunistic behavior by partners (Pisano, 1990), unintended knowledge spillovers (Teece, 2002; Veugelers, 1998), differing intentions of the focal firms (Larsson *et al.*, 1998; Lorange & Roos, 1992), in particular in vertical agreements (e.g. supplier-manufacturer relationships), inferior flexibility to adapt to changeing management structures induced by the alliance (Doz, 1996), and increasing alliance complexity (Killing, 1988).

Specifically, the concept of alliance complexity is most central for the research focus of this paper and is relatively less frequently addressed in previous literature. Killing (1988) divides complexity into task and organizational complexity. Task complexity may be caused by the alliance scope, the environmental uncertainty and the skills of the alliance partners. Especially for environments of high uncertainty, such as the biotechnology industry, he finds tasks performed by the alliance to be most complex. Together with other factors, the task complexity influences the organizational complexity of an alliance, which is therefore highest for firms that are engaged in several alliances but have limited experience in managing them. Yet, engaging in several alliances simultaneously allows firms to benefit from access to a broader pool of technological opportunities and knowledge acquisitions, however, it increases task and organizational complexity (Duysters & Lokshin, 2011).

The literature refers in this context to alliance portfolios, which are defined as *"a firm's collection of direct alliances with partners"* (Lavie, 2007: 1188). To manage the increasing complexity in alliance portfolios, dedicated alliance management functions and alliance programs have to be established (Kale *et al.*, 2002). Many alliances do not only allow the accumulation of new resources and skills (Balakrishnan & Koza, 1993; Kogut, 2000), but also help a firm to gain experience in alliance portfolio management to effectively seize the full potential of its collaborative agreements (Powell *et al.*, 1996). Once efficient portfolio management is established, firms may benefit from relational rents based on synergy effects, which cannot be realized by dyadic alliances (Dyer & Singh, 1998). The composition of an alliance portfolio has attracted scholars' attention (Baum *et al.*, 2000; Goerzen & Beamish, 2005). Baum *et al.* (2000) finds that a combination of heterogeneous partners in an alliance portfolio is more important than to simply have many alliances. To access non-redundant resources through a diverse alliance portfolio leaves a firm with information advantages (Duysters & Lokshin, 2011) and puts it into a favorable position to achieve and sustain innovation (Cohen & Malerba, 2001; Faems *et al.*, 2005; Katila & Ahuja, 2002; Leiponen & Helfat, 2010). Furthermore, the access to information from different types of collaborative partners provides firms with a wide range of information on technological trends (Ahuja & Lampert, 2001; Freeman, 1991).

Internally, young firms lack important resources to organize extensive R&D projects and to benefit sufficiently from innovation. First, young firms do not have the internal financial resources to finance extensive R&D projects and to cope with the financial burden from project failure (Acs & Audretsch, 1992; Scherer & Ross, 1990). Second, young firms lack important marketing channels to quickly diffuse their innovation on the market

(Cassiman & Veugelers, 2006). Third, young firms face difficulties to profit from internal synergy effects as they have not developed important capacities through other R&D projects (Milgrom & Roberts, 1990). Therefore, young firms are often in the need of accessing complementary resources through external partners (Lerner & Merges, 1998). Benefits that stem from successfully managed alliances are most important for the growth and survival of young firms in high-tech industries (Powell *et al.*, 1996; Zahra *et al.*, 2000). They may complement lacking resources through capabilities from external partners (Baum *et al.*, 2000; Miles *et al.*, 1999). Hewitt-Dundas (2006) finds that a lack of collaborative agreements has no influence on the innovation output of older firms, but a negative impact on the innovativeness of young firms, making strategic alliances an important management tool for the latter. Thus, sophisticated partners enable young firms to access new knowledge, technical support, expertise, technological opportunities, and market requirements (Nieto & Santamaría, 2010). This makes the formation of strategic alliances valuable for young firms, especially in technology driven industries (Dickson *et al.*, 2006).

Summarizing extant literature on the question how heterogeneous alliances in an alliance portfolio affect a firm’s innovation output, alliances are, if managed effectively, a promising strategy tool to sustain innovation. Therefore, firms strive to engage in multiple collaborative agreements with heterogeneous partners which are combined in an alliance portfolio. This results in a trade-off between increased complexity, which often leads to alliance failure, and better innovative performance, by accessing a broader pool of complementary resources, skills and information. Furthermore, benefits that emerge from strategic alliances matter most to young firms in innovation-driven industries, as they lack these resources to grow and survive in competitive markets.

Development of Hypotheses

Fast product development has become an important strategy tool to capture first mover advantages, such as early cash flows, external visibility, legitimacy, and quick market share gains (Schoonhoven *et al.*, 1990). Especially in high-tech industries fast patenting of new technologies is important for firms to sustain competitive advantages. Deeds and Hill (1996) argue that one way to rapidly develop new technologies is to enter strategic alliances with complementary partners. The majority of empirical studies find that alliances have a positive effect on firm performance (De Man & Duysters, 2005). Powell *et al.* (1996) find that alliances can give firms access to resources in terms of new knowledge. Gulati (1998) argues that firms that are engaged in strategic alliances have higher growth rates and tend to be more profitable. Deeds and Hill (1996) analyze the impact of alliances on firm performance and find that firms with numerous collaborative agreements are more innovative and have higher rates of new product development. Furthermore, firms profit most if they maintain alliance portfolios with partners with diverse backgrounds and thus literature finds that efficient alliance portfolios consist of partners with heterogeneous expertise (Baum *et al.*, 2000; Duysters & Lokshin, 2011; Faems *et al.*, 2005; Goerzen & Beamish, 2005). This allows firms to access a diverse pool of skills and resources and provides them with information advantages by screening a broad number of technological developments (Ahuja, 2000; Duysters & Lokshin, 2011). Hence, proactive firms build and maintain extensive alliance portfolios with heterogeneous partners (Marino *et al.*, 2002), which protect them from environmental uncertainties (Dollinger & Golden, 1992). Therefore, firms that build an alliance portfolio with heterogeneous partners are assumed to have a high innovative performance. The resulting relational rents that stem from efficiently selected partners in an alliance portfolio can never be achieved through a single dyadic alliance (Dyer & Singh, 1998). This leads to the following hypothesis:

H1a: Alliance portfolio diversity relates positively to innovation output.

Whilst firms benefit from heterogeneous alliance portfolios in terms of complementing own resources by accessing a broad pool of technological opportunities, the management of a diverse alliance portfolio is clearly more demanding than of an alliance portfolio with similar alliance partners. Previous studies find that higher diversity of alliance partners increase the alliance portfolio complexity and thus management and appropriability efforts (Duysters & Lokshin, 2011; Marino *et al.*, 2002; Powell *et al.*, 1996). Therefore, an alliance portfolio that becomes too diverse increases complexity over-proportionally, which in turn negatively influences a firms innovation output (Hoang, 2001). Assuming that every firm has a certain level of heterogeneity of its alliance portfolio it can handle, an increasing diversity of alliance partners in a portfolio positively influences innovation output up to the threshold, after which marginal costs of handling complexity become higher than the associated margianl innovation benefits. This leads to the following hypothesis:

H1b: Alliance portfolio diversity has an inverted U-shaped relationship with innovation output.

Importantly, the management of alliances portfolios is not only influenced by their heterogeneity, but also by the number of simultaneous alliance partners. The management of a high quantity of alliances at given level of diversity is considerably more demanding than the management of only a few alliances. As described above, alliance portfolios that become too complex tend to fail, in particular those characterized by high quantities and high levels of partner heterogeneity are expected to increase complexity over-proportionally (Killing, 1988).

Therefore, and in line with the study of Hoang (2001) it is expected that firms with portfolios characterized by both multiple alliances and high levels of partner diversity perform less good in terms of innovation output. This leads to the following hypothesis:

> *H2: Alliance portfolio diversity negatively moderates the relationship between the number of alliances and innovation output.*

Finally, a carefully chosen alliance portfolio is most relevant for young firms (and thus more relevant than for older and sophisticated firms) in innovation-driven industries (Lerner & Merges, 1998). Barney (1991) finds resources to be heterogeneously distributed among competitors and stresses that only resources that are valuable and rare may enhance a firm's competitive position. Young firms still have to develop such capacities to survive in the highly competitive high-tech industries. Innovativeness and technological diversity considerably help to develop such capacities (Almeida & Kogut, 1997; Gilsing *et al.*, 2008; Griliches, 1990). While older firms have already developed technological capabilities, which allow them to focus on fields where they already have expertise, young firms still have to develop such capacities and hence take a broader technological perspective (Giuri *et al.*, 2004; Vanhaverbeke *et al.*, 2007). An effectively chosen alliance portfolio with multiple and diverse partners helps a young firm to acquire information, skills and resources from various sources, which should positively influence its innovation output (Baum *et al.*, 2000; Duysters & Lokshin, 2011; Marino *et al.*, 2002). Due to the resulting spillover and synergy effects which are larger than for older firms, young firms should therefore benefit most from heterogeneous partners in their alliance portfolio (Duysters & Lokshin, 2011; Dyer & Singh, 1998). Therefore, alliance diversity should especially help younger firms new to the market, which leads to the following hypothesis:

H3: Alliance portfolio diversity positively moderates the relationship between firm newness and innovation output.

Methodology

Sample selection

To test these hypotheses, data of the 20 most successful biotechnology firms (MedAdNews, 2004) has been acquired, which ranges from 1980 to 2008. In this industry an increasing complexity of allying behavior and the relevance of patents by means to effectively protect intellectual property rights are both well established. Furthermore, the biotechnology industry shows a representative setting of a high-technology industry, where R&D processes are considered to be of highest importance (Khilji *et al.*, 2006). Measuring patenting activity among firms within the same industry is clearly more informative than data on patenting across industries or countries (Basberg, 1984). Additionally, a focus on one industry helps to control for industry trends, such as scale economies or new technologies (Pangarkar, 2003).

Table 1 provides an overview on the biotechnology firms of interest. In the sample Amgen has the highest average annual sales (USD 4.1 billion), whereas MGI Pharmaceuticals the lowest (USD 43.2 million). From a descriptive perspective, the alliance portfolio diversity is similar for most focal firms. That is to say, the biotechnology firms in the sample generally prefer to have heterogeneous partners in their alliance portfolio. Some expectations are Celgene, Imclone Systems and Nabi Biopharmaceuticals, which have below-average alliance portfolio diversity, which however still reflects a relatively high degree of diversity among their alliance partners. Firms with average sales below USD 300 million have reluctant patenting strategies. No clear patenting pattern can be observed for firms that exceed this amount of average sales.

Insert Table 1 about here

Variables and measures

Table 2 presents the definitions and a short description of the dependent variable as well as the independent and control variables.

Insert Table 2 about here

Dependent Variables

To measure the innovation output of each biotechnology firm, a two year moving average of patents granted to the focal firms by the USPTO is used and forms the dependent variable *Patents* for the analysis. Only patent applications of granted patents are used, since they are most likely to represent successful research of the biotechnology firms of interest. Following the convention, granted patents are assigned to the application year.

Independent Variables

To determine the age of each firm, the year of its establishment for each firm has been identified and is captured by the variable *Firm Age*. To measure the effect of alliances on the patenting behavior of firms, data from RECAP is involved, which is a longitudinal dataset containing cooperation event dates of biotechnological firms, ranging from 1980 to 2008. All alliance events for one focal firm are counted for each year and are captured by the variable *Alliances*[2]. The variable *Portfolio Diversity (PD)* is created using RECAP information on 27 different types of alliances. The dataset provides information when a specific alliance event

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[2] Mergers have been identified and eliminated.

has occurred, which allows to aggregate all alliance events one annual total of a firm in the sample. Based on the total number of firm's alliances in a specific year, the relative number of events for each alliance type is calculated. The inverted Herfindahl index is then used to measure if a firm concentrates on a small number of alliance types, or whether it has a heterogeneous alliance portfolio (i.e. measure of PD) and is more formally described as follows:

$$PD_{j,t} = 1 - \sum_{i=1}^{27} \bar{a}_{j,i,t}^{2} \qquad with\ \bar{a}_{j,i,t} = \frac{a_{j,i,t}}{\sum_{i=1}^{27} a_{j,i,t}} \ , j = [1,20],\ t = [1,28]$$

Values for *PD* can range from 0 to 1, where 1 indicates a heterogeneous alliance portfolio and 0 stands for a homogenous portfolio of firm *j* in period *t*. In other words, if firm *j* focuses on similar alliances within period *t*, then *PD* reaches low values, if the alliance portfolio of firm *j* in period *i* is heterogeneous, high values for *PD* are reached. Additionally, the variable *Portfolio Diversity (PD)* is squared to test a non-linear relationship between the diversity of alliance portfolios and a firm's innovation output.

To test for the hypotheses derived above an interaction variable *Alliances*PD* is created. Here, both constituting variables are centered to prevent issues of multicolliniarity. Following the same logic, the variable *Firm Age* PD* is created.

Control Variables

Three additional variables are used to control for *Size,* which is the logarithm of total firm sales, *Tobin's Q*, which represents the market to book value of a focal firm, and *R&D intensity*, which is the ratio between R&D expenditures and a firm's total assets. Firms with a high R&D intensity are more likely to benefit from economies of scale by more effectively processing R&D resources, which in turn increase a firm’s innovation (e.g. Griliches, 1990; Leten *et al.*, 2007). Furthermore, large firms have more resources to handle multiple and diverse alliance portfolios (Belderbos *et al.*, 2006; Harrigan, 1988a). To control for a firm’s wider expansion strategy, the variable *Acquisitions*, that is defined as the annual count of acquisitions of a focal firm, is included in the models. De Man and Duysters (2005) find that acquisitions have a neutral or negative effects on innovation output. Changes in a firm’s knowledge base are controlled by the variable *Patenting*, which is defined as the depreciated patent stock of a focal firm. In line with extant literature, the knowledge represented by these patents is depreciated with 15% each year (Ernst, 1998; Hall, 1990). Griliches (1979) argues that a firm’s knowledge stock depreciates sharply and that it has considerably reduced its economic value after five years. Therefore, firms that sustain a well equipped knowledge stock are assumed to benefit from economies of scope which should increase their innovation output.

Descriptive Analysis

Descriptive statistics and correlations for all variables matrix are provided in Table 3. The average biotechnology firm of the sample receives 28.65 patents each year and is 16.2 years old. The firms of interest show high diversity in the types of collaborative agreements in their alliance portfolios. This follows from the mean of 0.89 of the variable *Portfolio Diversity (PD).* High variance inflation factors are only found for the variables *Portfolio Diversity (PD)* and its squared term. However the low correlation levels between the other variables and the moderate values for the variance inflation factor (VIF) indicate no issue of multicollinearity.

Insert Table 3 about here

Model specification and econometric issues

The dependent variable, *Patents,* is a count variable, which is strongly skewed to the right, which makes the use of a GLS regression inappropriate. A more appropriate approach to analyze effects on a count variable offers a poisson regression (Hausman *et al.*, 1984; Henderson & Cockburn, 1996). However, one basic assumption of the poisson regression is that the mean and the variance of the count variable distribution take an equal value. In particular for panel data, this assumption is often violated owing to overdispersion. In the case of the dependent variable, *Patents,* the variance is remarkably higher than the mean and the highly significant likelihood-ratio test for all models in the poisson regression confirms overdispersion. As an alternative a negative binominal regression is applied to test the hypotheses derived above, which permits the variance of the count variable to exceed the mean. More precisely, a fixed effects negative binomial model, which controls for unobserved heterogeneity among firms, is applied. The Hausman test (Hausman *et al.*, 1984) that compares between the coefficients of a fixed effects and random effects model could reject the equality of the coefficients, making a fixed effects model the preferred choice.

Results

The estimation is based on 290 observations, which represent unbalanced panel data on 20 biotechnology firms and their 8502 alliances. The Log-Likelihood and the Wald test values indicate good overall model fit.

Results of estimating the regression models are presented in Table 4. Model 0 is a baseline model, which only takes the effects of the control variables on the dependent variable *Patents* into account. Unlike *Size* that has a negative effect on the dependent variable at a 1% significance level, the control variables *Tobin's Q, Acquisitions* and *Patent Stock* have a positive effect. In line with previous studies the results show that larger firms tend to be less successful in terms of innovation than small firms (e.g. Acs & Audretsch, 1992; Cassiman & Veugelers, 2006; Scherer & Ross, 1990). Firms that are highly market valued have a higher innovation output at a 10% significance level. Furthermore, acquisitions have a positive impact on the dependent variable at a 5% significance level. This is consistent with earlier studies that find acquisition to be more certain than own R&D and to increase innovation output (Wagner, 2010). The last control variable, *Patent Stock*, shows an impact on a firm's innovation output at a significance level of 1%. Firms that have already developed an extensive patent portfolio might benefit from synergy effects with previous R&D projects or can exploit former research.

When additional variables are included in the model there is no sign change of the control variables, but the positive effect of the variable *R&D intensity* becomes significant and the impact of the variable *Acquisitions* become insignificant. As alliance effects are now included into the model, this suggests positive effects of these after controlling for the level of acquisitions. More specifically, Model 1 includes the effects of a firm's age, its number of alliances and the degree of alliance portfolio diversity on the dependent variable. While the variable *Alliances* has a positive effect, the variables *Firm Age* and *Portfolio Diversity (PD)* have a negative impact on the innovation output of a focal biotechnology firm. This would reject H1a, but when the squared term of alliance portfolio diversity is included, like in Model 2, then an inverted U-shaped relationship between a firm's increasing portfolio diversity is found. This supports H1a and H1b. In Model 3 the interaction variable *Alliances*PD* is added. In this model, the variable *Alliances* continues to have a positive effect on the dependent variable while the variables *Firm Age* and *Portfolio Diversity (PD)* still have a negative impact on a biotechnology firm's innovation output. The interaction between the two independent variables *Alliances* and *Portfolio Diversity (PD)* does not show a significant effect and thus no inference can be made on H2. The interaction variable *Firm Age*PD* in

Model 4 shows that increasing partner heterogeneity of a young biotechnology firm's alliance portfolio has a positive effect on the firm's innovation output, which supports H3. Finally, the full Model 5 confirms all these mentioned results, in turn indicating their stability beyond single specifications.

Insert Table 4 about here

In summary, H1a and H1b that assume a positive but non-linear effect of increasing diversity of alliances partners on the patenting firms are supported. H2 that proposes biotechnology firms to simultaneously increase both quantity and diversity of alliances in their portfolio are less successful in terms of innovation is not confirmed. H3 that assumes that young firms with a high diversity of partners within their alliance portfolio have higher patent output than firms with homogenous alliance partners, which is supported through Model 4.

Discussion

One novel insight of this paper is that young firms with more diverse alliance portfolios have a higher innovation output than younger firms with less diverse portfolios. One explanation for this phenomenon is that these firms are still flexible through loose organizational structures that enable them to react faster on the challenges of increasing alliance diversity.

Furthermore, the results show a non-linear influence of portfolio diversity on innovation output. In general, firms profit from increasingly more heterogeneous alliance portfolios up to a threshold. While firms with a more heterogeneous alliance portfolio have access to a broader pool of technological opportunities, resulting for example in beneficial synergy effects, they also face higher complexity and rising management challenges (Duysters & Lokshin, 2011). When the complexity reaches a point where more managerial capacity is required, than in a firm immediately available, then the positive effect turns into a negative impact on innovation output.

Especially young firms have decreasing returns when managerial costs and complexity become too high (Gilsing, 2005; Rothaermel & Deeds, 2004). However, young firms that are also able to react faster in terms of effective alliance management, potentially profit longer in terms of improved innovative performance from diverse alliance partners within their portfolio. An explanation for this finding could be that firms that have diverse alliance portfolios have access to resources from a wide range and are more likely to seize technological opportunities (Ahuja, 2000; Duysters & Lokshin, 2011).

A further result shows that alliances have a positive effect on a firm's innovation output. The various benefits that stem from access to complementary assets (Hagedoorn, 1993; Hamel, 1991; Powell *et al.*, 1996; Teece, 1986), decreasing risk (e.g. Ciborra, 1991; Hagedoorn, 1993; Hagedoorn & Duysters, 2002; Harrigan, 1988a; Ohmae, 1985) and uncertainty (Dollinger & Golden, 1992) and the promotion of the transfer of tacit and codified knowledge (Ahuja, 2000; Das & Teng, 1996; Doz & Hamel, 1997; Eisenhardt & Schoonhoven, 1996) can explain this finding.

To emphasis again the main result of this paper, the inverted U-shaped relationship between alliance portfolio diversity and innovation output, is a novel contribution to the field since non-linearity has not been addressed for biotechnology firms. Alliances that become too complex tend to fail (Killing, 1988). Diversity increase managerial costs and complexity over-proportionally and results in inferior firm performance (Deeds & Hill, 1996; Gilsing, 2005; Rothaermel & Deeds, 2004).

Conclusions

This paper focuses on the research question how an increasing number of heterogeneous partners in a firm’s alliance portfolio influence a firm’s innovative performance. Despite first attempts in literature to link alliance portfolio performance to innovativeness, only few empirical studies are provided that address this research question, yet so far without considering non-linear relationships (Duysters & Lokshin, 2011; Faems *et al.*, 2005). Furthermore, previous studies fail to combine the issue of firm age and heterogeneity of partners in an alliance portfolio (Duysters & Lokshin, 2011). However, young firms are more likely to benefit from alliances, since these have still to develop capacities to survive in the competitive biotechnology industry (Baum *et al.,* 2000; Suarez-Villa, 1998; Vanhaverbeke *et al.*, 2007). This paper seeks to close gaps in literature by focusing on the quantity and heterogeneity of partners in a firm’s alliance portfolio. A set of hypotheses on the relationship between a young firm’s alliance portfolio and its R&D activity is derived and then tested. It is shown that a positive effect of alliancing on innovation output is strongest if firms maintain a selection of heterogeneous partners in their alliance portfolios.

Specifically, the empirical results show that firms engaging in diverse alliances have a higher innovation output than firms that have a less diverse alliance portfolio, which is in line with earlier works (Baum *et al.*, 2000; Dollinger & Golden, 1992; Stuart, 2000).

However, a further result shows that firms in the biotechnology industry only benefit by means of innovation from increasing diversity of their partners in their alliance portfolio up to a threshold. After that, increasing complexity of heterogeneous alliance portfolios requires over-proportionally management attention, which leads to a negative impact on innovation output. A similar effect has been found by Duysters and Lokshin (2011) and it further confirms Hoang (2001) study that finds a negative impact of increasing diversity on a firm’s innovative performance.

Furthermore it is shown that not only diverse alliances increases complexity of portfolios, but also an increasing number of alliances in general which thus additionally increases complexity. The simultaneously increase of both causes managerial costs and complexity to increase rapidly and with it the risk of alliance failure (Gilsing, 2005). Nevertheless, firms that effectively manage increasing complexity levels, (e.g. allying with less opportunistic partners), benefit from alliances with multiple partners (Belderbos *et al.*, 2006).

This study has important managerial implications. Specifically, the literature has so far frequently argued that the locus of innovation lies in the composition of a firm’s alliance portfolio, since engaging in diverse alliances reduces risk, costs and uncertainties, provides access to complementary resources, and serve as a radar function to screen promising new technologies (Ahuja, 2000; Powell & Brantley, 1992). Hence, extant literature associates alliance diversity with increasing innovation output, and ultimately positively effects firm performance. However, this study provides a more fine-grained perspective, since the analysis suggests that firms profit most by means of innovation from a heterogeneous alliance portfolio, which complements existing empirical evidence on this topic (e.g. Baum *et al.*, 2000; Duysters & Lokshin, 2011). Ultimately it shows that management has to be careful when selecting alliance partners and it should always take care that engagement with additional alliance partners does not exceed its capacity to effectively manage their alliance portfolio.

Despite these novel and differentiating findings it needs to be also acknowledged that the research contains some limitations. This study is based almost entirely on data from one country. On the one hand the most successful biotechnology firms are located in the United States and thus the sample represents the population. On the other hand country specific characteristics that could limit the generalization of the results cannot be addressed in this setting. Therefore, the data should be extended to biotechnology firms in other countries as far as possible. Furthermore, some firms of interest have not been public throughout their whole economic life, which makes financial data unavailable and their inclusion in our sample impossible. Therefore, survey research should be used to extent the database. Finally, to get a better view on alliance portfolios, more information about the diversity of the alliance partners of the focal firms would be beneficial and again survey research could be an approach to accomplish this.

As a final extension, further research could relate theories about alliance portfolios with the concept of ambidextrous innovation. In this context different types of alliances may either lead to explorative or exploitative R&D activity or to both, since only scarce and unsystematic empirical evidence by means of innovation output exists on this topic. Future research using more qualitative approaches could develop further the core managerial implications emerging from this paper in that it could identify specific alliancing or knowledge management capabilities that help to overcome the issue that startups may overdo their alliancing activities, leading to too much of a good thing overloading their management capacities.

References

Acs ZJ, Audretsch DB. 1992. *Innovationen durch kleine Unternehmen*. Edition Sigma: Berlin.

Ahuja G. 2000. The duality of collaboration: inducements and opportunities in the formation of interfirm linkages. *Strategic Management Journal* **21**(3): 317-343.

Ahuja G, Lampert CM. 2001. Entrepreneurship in a large corporation: a longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal* **22**(6-7): 521-543.

Almeida P, Kogut B. 1997. The exploration of technological diversity and geographic localization in innovation: start-up firms in the semiconductor industry. *Small Business Economics* **9**(1): 21-31.

Amabile T. 1988. A model of creativity and innovation in organizations. In *Research and Organizational Behavior.* Straw BM, Cummings L (eds.), JAE Press.

Balakrishnan S, Koza MP. 1993. Information asymmetry, adverse selection and joint-ventures: theory and evidence. *Journal of Economic Behavior & Organization* **20**(1): 99-117.

Barney JB. 1991. Firm resources and sustained competitive advantage. *Journal of Management* **17**(1): 99–120.

Basberg BL. 1984. Patent statistics and the measurement of technological change - an assessment of the Norwegian patent data, 1840-1980. *World Patent Information* **6**(4): 158-164.

Baum JAC, Calabrese T, Silverman BS. 2000. Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal* **21**(3): 267-294.

Belderbos R, Carree M, Lokshin B. 2006. Complementarity in R&D cooperation strategies. *Review of Industrial Organization* **28**(4): 401-426.

Bleeke J, Ernst D. 1993. *Collaborating to Compete: Using Strategic Alliances and Acquisitions in the Global Marketplace*. John Wiley: New York.

Cassiman B, Veugelers R. 2006. In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. *Management Science* **52**(1): 68-82.

Ciborra CU. 1991. Alliances as learning experiments: cooperation, competition and change in high-tech industries. In *Strategic Partnerships: States, Firms and International Competition.* Mytelka LK (ed.), Pinter Publishers: London.

Cohen WM, Malerba F. 2001. Is the tendency to variation a chief cause of progress? *Industrial and Corporate Change* **10**(3): 587-608.

Contractor FJ, Lorange P. 2002. *Cooperative Strategies in International Business* (2nd ed.). Elsevier Science: Oxford.

Das TK, Teng B-S. 1996. Risk types and inter-firm alliance structures. *Journal of Management Studies* **33**(6): 827-843.

De Man AP, Duysters G. 2005. Collaboration and innovation: a review of the effects of mergers, acquisitions and alliances on innovation. *Technovation* **25**(12): 1377-1387.

Deeds DL, Hill CW. 1996. Strategic alliances and the rate of new product development: an empirical study of entrepreneurial biotechnology firms. *Journal of Business Venturing* **11**(1): 41-55.

Dickson PH, Weaver KM, Hoy F. 2006. Opportunism in the R&D alliances of SMEs: the roles of the institutional environment and SME size. *Journal of Business Venturing* **21**(4): 487-513.

Dollinger MJ, Golden PA. 1992. Interorganizational and collective strategies in small firms: environmental effects and performance. *Journal of Management* **18**(4): 695.

Doz Y, Hamel G. 1997. The use of alliances in implementing technology strategies. In *Managing Strategic Innovation and Change: A Collection of Readings.* Tushman ML, Anderson P (eds.), Oxford University Press: New York.

Doz YL. 1996. The evolution of cooperation in strategic alliances: initial conditions or learning processes? *Strategic Management Journal* **17**(S1): 55-83.

Duysters G, Lokshin B. 2011. Determinants of alliance portfolio complexity and its effect on innovative performance of companies. *Journal of Product Innovation Management* **28**(4): 570-585.

Dyer JH, Singh H. 1998. The relational view: cooperative strategy and sources of interorgaizational competitive advantage. *Academy of Management Review* **23**(4): 660-679.

Eisenhardt KM, Schoonhoven CB. 1996. Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms. *Organization Science* **7**(2): 136–150.

Ernst H. 1998. Patent portfolios for strategic R&D planning. *Journal of Engineering and Technology Management* **15**(4): 279-308.

Faems D, van Looy B, Debackere K. 2005. Interorganizational collaboration and innovation: towards a portfolio approach. *Journal of Product Innovation Management* **22**(3): 238-250.

Freeman C. 1991. Networks of innovators: a synthesis of research issues. *Research Policy* **20**(5): 499-514.

Gilsing VA. 2005. *The Dynamics of Innovation and Interfirm Networks, Exploration, Eploitation and Co-Evolution*. Edward Elgar: Cheltenham.

Gilsing VA, Nooteboom B, Vanhaverbeke WP, Duysters G, van den Oord A. 2008. Network embeddedness and the exploration of novel technologies: technological distance, betweenness centrality and density. *Research Policy* **37**(10): 1717-1731.

Giuri P, Hagedoorn J, Mariani M. 2004. Technological diversification and strategic alliances. In *The Economies and Management of Technological Diversification.* Cantwell J, Garmbardella A, Granstrand O (eds.), Routledge: London

Goerzen A, Beamish PW. 2005. The effect of alliance network diversity on multinational enterprise performance. *Strategic Management Journal* **26**(4): 333-354.

Griliches Z. 1979. Issues in assessing the contribution of research and development to productivity growth. *Bell Journal of Economics* **10**(1): 92-116.

Griliches Z. 1990. Patent statistics as economic indicators: a survey. *Journal of Economic Literature* **28**(4): 1661-1707.

Gulati R. 1998. Alliances and networks. *Strategic Management Journal* **19**(4): 293-317.

Hagedoorn J. 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal* **14**(5): 371-385.

Hagedoorn J, Duysters G. 2002. External sources of innovative capabilities: the preferences for strategic alliances or mergers and acquisitions. *Journal of Management Studies* **39**(2): 167-188.

Hall BH. 1990. The impact of corporate restructuring on industrial research and development. *Brookings Papers on Economic Activity*: 85-136.

Hamel G. 1991. Competition for competence and inter-partner learning within international strategic alliances. *Strategic Management Journal* **12**(Summer Special Issue): 83-103.

Harrigan KR. 1988a. Joint ventures and competitive strategy. *Strategic Management Journal* **9**(2): 141-158.

Harrigan KR. 1988b. Strategic alliances and partner asymmetries. In *Cooperative Strategies in International Business.* Contractor F, Lorange P (eds.), Lexington Books: Lexington, MA.

Hausman J, Hall BH, Griliches Z. 1984. Econometric models for count data with an application to the patents-R&D relationship. *Econometrica* **52**(4): 909-938.

Henderson R, Cockburn I. 1996. Scale, scope, and spillovers: the determinants of research productivity in drug discovery. *RAND Journal of Economics* **27**(1): 32-59.

Hewitt-Dundas N. 2006. Resource and capability constraints to innovation in small and large plants. *Small Business Economics* **26**(3): 257-277.

Hoang HT. 2001. The impact of organizational and alliance based complexity on the development of alliance capacity. *INESAD Working paper series* **No. 2001/93/EST**.

Kale P, Dyer JH, Singh H. 2002. Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. *Strategic Management Journal* **23**(8): 747-767.

Katila R, Ahuja G. 2002. Something old, something new: a longitudinal study of search behavior and new production introduction. *Academy of Management Journal* **45**(6): 1183-1194.

Khilji SE, Mroczkowski T, Bernstein B. 2006. From invention to innovation: toward developing an integrated innovation model for biotech firms. *Journal of Product Innovation Management* **23**(6): 528-540.

Killing JP. 1988. Understanding alliances: the role of task and organizational complexity. In *Cooperative Strategies in International Business*. Contractor FJ, Lorange P (eds.), Lexington Books: Lexington, MA.

Kogut B. 2000. The network as knowledge: generative rules and the emergence of structure. *Strategic Management Journal* **21**(3): 405.

Larsson R, Bengtsson L, Henriksson K, Sparks J. 1998. The interorganizational learning dilemma: collective knowledge development in strategic alliances. *Organization Science* **9**(3): 285–305.

Lavie D. 2007. Alliance portfolios and firm performance: a study of value creation and appropriation in the U.S. software industry. *Strategic Management Journal* **28**(12): 1187-1212.

Leiponen A, Helfat CE. 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal* **31**(2): 224-236.

Lerner J, Merges RP. 1998. The control of technology alliances: an empirical analysis of the biotechnology industry. *The Journal of Industrial Economics* **46**(2): 125-156.

Leten B, Belderbos R, Van Looy B. 2007. Technological diversification, coherence, and performance of firms. *Journal of Product Innovation Management* **24**(6): 567-579.

Lorange P, Roos J. 1992. *Strategic Alliances: Formation, Implementation, and Evolution*. Blackwell: Oxford.

Marino LK, Strandholm HK, Steensma, Weaver KM. 2002. Harnessing complexity: the moderating effect of national culture on entrepreneurial orientation and strategic alliance portfolio complexity. *Entrepreneurship Theory and Practice* **26**(4): 145-161.

MedAdNews. 2004. Top 100 biotechnology companies. http://www.pharmalive.com/magazines/archive.cfm?mag=medad&year=2004 (7 November 2006).

Miles G, Preece SB, Baetz MC. 1999. Dangers of dependence: The impact of strategic alliance use by small technology-based firms. *Journal of Small Business Management* **37**(2): 20-29.

Milgrom P, Roberts J. 1990. The economics of modern manufacturing: technology, strategy, and organization. *The American Economic Review* **80**(3): 511-528.

Nieto MJ, Santamaría L. 2010. Technological collaboration: bridging the innovation gap between small and large firms. *Journal of Small Business Management* **48**(1): 44-69.

Ohmae K. 1985. *Triad power: The coming Shape of global Competition*. Free Press: New York.

Pangarkar N. 2003. Determinants of alliance duration in uncertain environments: the case of the biotechnology sector. *Long Range Planning* **36**(3): 269-284.

Pisano GP. 1990. The R&D boundaries of the firm: an empirical analysis. *Administrative Science Quarterly* **35**(1): 153-176.

Powell W, Brantley P. 1992. Competitive cooperation in biotechnology: learning through networks? In *Networks and Organizations.* Nohria N, Eccles R (eds.), Harvard Business School Press: Boston.

Powell WW, Koput K, Smith-Doerr L. 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. *Administrative Science Quarterly* **41**(1): 116-145.

Rothaermel FT, Deeds DL. 2004. Exploration and exploitation alliances in biotechnology: a system of new product development. *Strategic Management Journal* **25**(3): 201-221.

Sampson RC. 2007. R&D alliances and firm performance: the impact of technological diversity and alliance organization on innovation. *Academy of Management Journal* **50**(2): 364-386.

Scherer F, Ross D. 1990. *Industrial Market Structure and Economic Performance* (2nd ed.). Houghton Mifflin Company: Boston, MA.

Schoonhoven CB, Eisenhardt KM, Lyman K. 1990. Speeding products to market: waiting time to first product introduction in new firms. *Administrative Science Quarterly* **35**(1): 177-207.

Stuart TE. 2000. Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal* **21**(8): 791-811.

Suarez-Villa L. 1998. The structures of cooperation: downscaling, outsourcing and the networked alliance. *Small Business Economics* **10**(1): 5-16.

Teece DJ. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy* **15**(6): 285-305.

Teece DJ. 2002. *Managing Intellectual Capital*. Oxford University Press: Oxford.

Vanhaverbeke W, Duysters G, Beerkens B. 2002. Technological capability building through network strategies within high-tech industries. Paper presented at the Academy of Management Best Paper Proceedings, Denver, CO, August 2002.

Vanhaverbeke W, Gilsing V, Duysters G. 2007. Exploration and exploitation in technology-based alliance network. *UNU-MERIT Working Paper Series 2007-018*.

Veugelers R. 1998. Collaboration in R&D: an assessment of theoretical and empirical findings. *Economist* **149**(3): 419–443.

Wagner M. 2010. Acquisitions as a means of innovation sourcing by incumbents and growth of technology-oriented ventures. *International Journal of Technology Management* **52**(1): 118-134.

Zahra SA, Ireland RD, Hitt MA. 2000. International expansion by new venture firms: international diversity, mode of market entry, technological learning, and performance. *The Academy of Management Journal* **43**(5): 925-950.

Table 1: Sample overview

Firm	**Years of observation**	**Sales** *(in Million US$)*	**Alliance Portfolio Diversity** *(in %)*	**Granted Patents**
Amgen	24	4104.956	93.90	45.23
Genentech	23	2897.525	93.24	91.84
Merck Serono	5	1870.945	91.51	2.81
Genzyme	11	1806.716	92.92	27.10
CSL	13	1520.477	86.69	2.19
Gilead Science	16	1000.145	90.47	11.90
Life Technologies	8	875.799	90.63	13.35
Actelion	6	650.172	93.42	0.81
Biogen	19	638.172	90.88	22.97
Chiron	22	600.235	91.67	59.26
Cephalon	16	529.457	94.00	9.68
Medimmune	15	469.848	90.20	9.32
Genencor International	4	356.481	91.73	32.81
Millennium Pharmaceuticals	6	307.428	82.54	3.84
Celgene	20	277.569	78.03	0.10
Imclone Systems	16	131.699	74.37	3.32
Nabi Biopharmaceuticals	11	109.832	77.48	1.32
QLT	19	66.646	86.56	2.45
Regeneron Pharmaceuticals	16	56.292	85.54	8.97
MGI Pharmaceuticals	23	43.214	90.04	0.45

Notes: Average values per year

Table 2: Variables definitions

Variable name	Variable description	Data source
Dependent Variable		
Patents	Two year moving average of granted patents a firm i holds during period t and t+1	USPTO
Independent Variables		
Firm Age	Age of focal firm since founding year	Firm profiles
Alliances	Number of alliances of firm i in period t-1	RECAP
Portfolio Diversity (PD)	Level of heterogeneity within a firm's alliance portfolio	RECAP
PD Squared	Level of heterogeneity within a firm's alliance portfolio squared	RECAP
Alliances*PD	Interaction variable between the variables Alliances and Portfolio Diversity	RECAP
Firm age*PD	Interaction variable between the variables Young and Portfolio Diversity	Firm profiles RECAP
Control Variables		
Size	Logarithm of total sales of firm i in period t-1	COMPUSTAT COMPUSTAT Global CRSP
Tobin's Q	Market to book value of firm i in period t-1	COMPUSTAT COMPUSTAT Global CRSP
R&D intensity	Ratio of R&D expenditures to total assets of firm i in period t-1	COMPUSTAT COMPUSTAT Global CRSP
Acquisitions	Number of acquisitions of firm i in period t-1	RECAP
Patent Stock	Logarithm of accumulated (depreciated) number of patents a firm has gathered from the beginning to the time of observation	USPTO

Table 3: Descriptive statistics and correlation matrix

		Mean	S. D.	1	2	3	4	5	6	7	8	9	10	11	VIF
1	Patents	28.65	44.78												
2	Firm Age	16.20	7.50	0.22*											1.38
3	Alliances	23.68	21.79	0.60*	0.23*										2.83
4	Portfolio Diversity (PD)	0.89	0.14	0.13*	-0.06	0.25*									38.55
5	PD Squared	0.81	0.17	0.13*	-0.05	0.28*	0.96*								18.22
6	Alliances*PD (centered)	0.79	2.82	0.06	0.12*	0.12*	-0.86*	-0.76*							8.81
7	Young* PD (centered)	0.01	0.07	-0.09	0.04	-0.13*	-0.45*	-0.35*	0.33*						1.54
8	Size	4.98	2.38	0.38*	0.49*	0.45*	0.07	0.13*	0.08	-0.01					2.19
9	Tobin's Q	4.25	5.81	0.04	0.08	0.04	0.03	0.05	-0.03	0.05	-0.10				1.16
10	R&D intensity	0.19	0.16	-0.20*	-0.19*	-0.13*	0.07	0.09	-0.09	0.04	-0.44*	0.30*			1.45
11	Acquisitions	0.42	0.96	0.18*	0.16*	0.36*	0.10	0.11	0.01	-0.09	0.30*	-0.06	-0.17*		1.20
12	Patent Stock	3.92	1.72	0.64*	0.28*	0.56*	0.21*	0.23*	-0.02	-0.15*	0.55*	0.03	-0.32*	0.27*	1.85

Notes: * p<0.05; *n*=290

Table 4: Impact of alliance portfolio diversity on innovation output (number of patents) of biotechnology firms: 1984 - 2007

	Model 0			**Model 1**			**Model 2**			**Model 3**			**Model 4**			**Model 5**		
	Coeff.	(SE)		Coeff.	(SE)		Coeff.	(SE)		Coeff.	(SE)		Coeff.	(SE)		Coeff.	(SE)	
Independent Variables																		
Firm Age				-0.03	(0.01)	*	-0.03	(0.01)	**	-0.03	(0.01)	**	-0.03	(0.01)	**	-0.03	(0.01)	**
Alliances				0.01	(0.002)	***	0.01	(0.002)	***	0.01	(0.003)	***	0.01	(0.002)	***	0.01	(0.003)	***
Portfolio Diversity (PD)				-0.97	(0.31)	***	2.71	(1.43)	*	2.31	(1.88)		4.41	(1.58)	***	5.61	(2.05)	***
PD Squared							-3.04	(1.06)	***	-2.85	(1.20)	**	-4.08	(1.10)	***	-4.65	(1.26)	***
Alliances*PD										-0.01	(0.03)					0.03	(0.03)	
Firm Age*PD													2.68	(0.94)	***	2.93	(0.97)	***
Control Variables																		
Size	-0.16	(0.03)	***	-0.15	(0.04)	***	-0.12	(0.04)	***	-0.14	(0.04)	***	-0.15	(0.04)	***	-0.13	(0.04)	***
Tobin's Q	0.01	(0.01)	*	0.02	(0.01)	**	0.02	(0.01)	**	0.02	(0.01)	**	0.02	(0.01)	**	0.02	(0.01)	**
R&D intensity	-0.52	(0.42)		-0.69	(0.39)	*	-0.70	(0.39)	*	-0.68	(0.40)	*	-0.70	(0.40)	*	-0.76	(0.39)	*
Acquisitions	0.10	(0.04)	**	0.05	(0.04)		0.05	(0.04)		0.05	(0.04)		0.06	(0.04)		0.06	(0.04)	
Patent Stock	0.39	(0.07)	***	0.40	(0.08)	***	0.41	(0.08)	***	0.41	(0.08)	***	0.42	(0.08)	***	0.44	(0.08)	***
Constant	-0.17	(0.23)		0.82	(0.34)	**	-0.08	(0.55)		1.51	(0.53)		0.60	(0.37)		-1.41	(0.95)	
Observations (Groups)	290 (20)			290 (20)			290 (20)			290 (20)			290 (20)			290 (20)		
Log Likelihood	-941.24			-915.97			-911.23			-911.17			-906.17			-905.76		
Wald Chi^{2} (df)	51.49 (5) ***			143.17 (8) ***			158.48 (9) ***			159.32 (10) ***			170.56 (10) ***			169.34 (11) ***		

Notes: *** p<0.01; ** p<0.05; *p<0.1 (two sided tests). Results of a fixed effects negative binomial model. Standard deviations in parentheses.