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**Opportunity Spin-offs and
Necessity Spin-offs**

by

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Opportunity Spin-offs and Necessity Spin-offs

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Abstract:

Necessity spin-offs are organized by employees of incumbent firms to escape deteriorating job conditions. This paper proposes a conceptual model of the spin-off process. Necessity spin-offs are distinguished from opportunity spin-offs on the basis of their triggering events. An empirical analysis of German laser spin-offs traces differences in the performance and determinants of the two types of spin-offs. Necessity spin-offs are important to limit the devaluation of individual competences by the market process. They are particularly relevant in growth crises of innovative firms, and in the restructuring of economies with protected or state-owned companies.

JEL classifications: L25, L26, M13

Keywords: Spin-offs, necessity entrepreneurship, opportunity discovery, market process, laser industry

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1. Introduction

In 1972, five employees of IBM's German division quit their jobs and started a new venture called SAP. Their idea was to develop and market standard software for business administration. Their business model combined several challenges to established industry practices of the time: standardization instead of customer-specific programming, integrated modules addressing and linking the multiple data needs of business firms as well as real-time instead of batch computing (Meissner, 1997). 35 years later, SAP has grown into a global leader in business software with 40,000 employees and more than US\$ 10 billion in annual revenues (SAP, 2007).

The SAP history is far from unique. Corporate spin-offs like SAP have been identified as drivers of innovation and industry dynamics in a number of markets. Probably the most well-known ones, including Fairchild and Intel, have been spawned in Silicon Valley's semiconductor industry, and Klepper (2007) shows that they were often triggered by the parent firms' reluctance to pursue employee ideas for new products or processes. Evidence on the U.S. automobile (Klepper, 2002), laser (Klepper and Sleeper, 2005), and disc drive (Christensen, 1993) industries likewise indicates how frustrated attempts to pursue innovative opportunities at the parent firm are a major driving force of the spin-off process. As is evidenced by household names such as Ford, Intel, SAP, and Adobe (Chesbrough, 2003), the spin-off process frequently leads to great firms that change the history of their industries and sometimes home regions. This shows that spin-offs based on the pursuit of perceived new business opportunities – termed “opportunity spin-offs” in the following – play a crucial role in market economies: they commercialize ideas that would otherwise be shelved by the parent firm (Klepper and Thompson, 2006a).

The importance of opportunity-induced spin-offs has increasingly been realized in recent years. However, not all employee startups are triggered by the discovery and seizure of a promising new business opportunity. A second type of triggering events is related to adverse developments at the parent firm that render future employment at this firm less attractive or even impossible. A variety of events can trigger the emergence of “necessity spin-offs,” including changes in management, relocation of activities, takeovers, crises in profitability, or even bankruptcy of the parent firm.

Adverse developments at the parent firm have been recognized as triggers of spin-off events before, and there is some evidence suggesting that spin-offs induced by “push factors”

are less distinctive performers than those driven by employee innovations (Brittain and Freeman, 1986; Eriksson and Kuhn, 2006; Dahl and Reichstein, 2007). Against this backdrop, the objective of the present paper is twofold.

First, based on theoretical considerations and evidence from the German laser industry, differences and commonalities between opportunity spin-offs and necessity spin-offs are further explored. Not only did necessity spin-offs account for a substantial share of all spin-off dynamics in this industry, the analysis also suggests they built on knowledge bases comparable to those of opportunity spin-offs. And even though their performance did not match that of opportunity spin-offs, on average they did not perform less well than other types of entrants, including startups spawned by universities and public research organizations.

Second, based on these findings I propose that necessity spin-offs have not received the attention they deserve. Necessity spin-offs perform an important role in the dynamics of competitive markets: they limit the devaluation of human capital brought about by adverse shocks to individual firms. This role of spin-offs in reusing employee competences appears most relevant in situations where it is particularly hard for the respective individuals to find new employment in existing firms. These situations include growth crises of innovative firms, but also more macroeconomic crises such as the liberalization of formerly protected industries, including those in LDCs and emerging economies, and the transition from centrally planned economies to capitalist systems.

To study the phenomenon of necessity spin-offs in more detail, the remainder of the paper proceeds as follows. In the next section, prior theoretical and empirical work is integrated into a conceptual model of the spin-off process. While the available evidence suggests that spin-offs transfer organizational capabilities, the model also recognizes that spin-off formation is an entrepreneurial activity performed by an individual or a group of individuals. It accordingly focuses on individual learning in an organizational context as well as on founder effects on the new venture. Based on the theoretical discussion, section 3 derives hypotheses on the determinants and performance of the alternative types of spin-offs. These are subsequently tested in section 4, using a unique dataset encompassing 40 years of evolution in the German laser industry. Section 5 places these findings within a broader context to discuss the relevance and implications of the necessity-based spin-off process, also drawing on exemplary prior research. Section 6 offers concluding remarks.

2. A conceptual model of the spin-off process

Firm organizations are loci of unique capabilities. Idiosyncratic firm capabilities give rise to differences in products, processes, and strategies pursued by the firms competing in an industry, thus generating heterogeneity in the firm population. For the individual firm, capabilities, including the dynamic capabilities (Teece et al., 1997) to adapt to a changing environment, provide the foundation of competitiveness. At the same time, the limited adaptability of capabilities results in the continuity of practices within the firm, as the set of existing capabilities conditions the firm's ability to develop and utilize new ones (Cohen and Levinthal, 1990).

Firm capabilities are reflected by the firm's capacity to deploy its resource base toward desirable ends through specific combinations of resources, information, and people (Amit and Shoemaker, 1993). They may derive from a variety of sources, but are ultimately based on the firm's knowledge base (Kogut and Zander, 1992; Langlois, 1992). The knowledge underlying a capability is often not consciously available to any single firm member. As suggested by Nelson and Winter (1982, ch. 5), it may rest in the firm's routines, i.e., the patterns of repeated interaction and behavior that are no longer questioned but taken for granted by firm members. Similar to the tacit, non-verbalized skills of individuals, organizational routines enable the smooth, efficient, and coordinated execution of repeated tasks in the firm.

Prior work suggests that spin-offs are able to transfer capabilities from the parent firm to their new organizational context (Helfat and Lieberman, 2002). This provides them with a competitive advantage vis-à-vis entrants that have no background in the industry. In the spin-off process, tested organizational knowledge can moreover be combined with new ideas and interpretations. Spin-offs are thus able to break up inertial tendencies and resistance to change limiting the existing firms in an industry.

The spin-off process operates through the mobility of (teams of) individual spin-off entrepreneurs. Accordingly, for the spin-off to benefit from its founders' backgrounds, the respective individuals first need to acquire knowledge within existing firm organizations and then transfer this knowledge to the spin-off. In addition, there is substantial evidence that spin-off activities require triggering events to lower the opportunity costs of spin-off formation. Earlier findings on spin-off formation and performance suggest the conceptual model of the spin-off process depicted in Table 1. In the remainder of this section, the elements of this conceptual model are discussed in more detail.

– Table 1 about here –

Employee learning in the existing organization

Employment in existing firms enables the acquisition of various kinds of useful knowledge. Specifically, employee learning may relate to technological knowledge, knowledge about markets, customer needs, and organizational processes, and also to the acquisition of personal skills.

Technology: Spin-off activities in high-technology industries are often initiated by R&D specialists who have acquired in-depth knowledge about the parent firm's technology base. For example, Christensen (1993) shows that most of the successful spin-offs in the disc drive industry were started by engineers. In other industries as well, spin-off founders are often employees in key R&D positions with detailed insight into the parent firm's technology. Learning about technologies and potential ways of using them is at the heart of R&D jobs, so this kind of knowledge acquisition is mostly based on deliberate learning efforts, which are informed by the employee's past education and employment history.

Markets and customer needs: Employees in the marketing and sales departments of incumbent firms make up another prominent group of spin-off founders. They are well-positioned to gain insights into customer needs and market niches that are currently not satisfied by the producers in the industry, possibly because customers have directly alerted those employees to these needs. Existing evidence also indicates that this kind of knowledge is relevant for spin-off performance. Sleeper (1998) finds that U.S. laser spin-offs with founders from marketing and sales positions tended to be more successful than those whose founders had an R&D background. In the German laser industry to be analyzed in more detail below, the importance of entrants' knowledge about markets and customer needs is evidenced by a number of laser distribution firms that subsequently integrated into laser manufacturing. In their performance, these firms were comparable to the most successful spin-offs (Buenstorf, 2007a).

Organizational processes: Various studies have found spin-off performance to be directly correlated with the performance of the parent firm (Helfat and Lieberman, 2002). One interpretation of these findings is that employees learn more than just knowledge about

technologies and/or markets, the acquisition of which may owe more to an individual's specific position in the firm than to the firm's overall quality. Almost by necessity, employees develop an increasing familiarity with the organizational processes they are involved in; i.e., they increasingly get to know relevant aspects about how the firm operates. This kind of learning about organizational processes is both a by-product and a precondition of employees' ability to function in the organization. Theoretical and empirical contributions indicate that this learning operates at different degrees of awareness and deliberation.

Cohen (2006) suggests that, at the level of the individual employee, the basis of routinized processes lies in habituated skills conditioning the responses to signals from other members of the organization. This implies that employees internalize their roles in the routine and are able to behave accordingly without conscious deliberation (Cohen and Bacdayan, 1994). In other instances, organizational processes may be transferred through "templates," i.e., working examples of organizational processes that can be observed and memorized by an employee (Nelson and Winter, 1982). In setting up their new organization, spin-off founders may deliberately resort to the imitation of templates observed in the parent firm. Jensen and Szulanski (2007, p. 1727) define template use in knowledge transfer as "reliance on an organizational practice that is currently in existence, observable, composed of a single or connected set of processes, and consciously used in the replication process."

Personal skills: The previous paragraph related to how employees learn about practices of the organization that operate above the level of the individual firm member. However, one of the key roles of the organization is to structure the interactions between individuals within its boundaries, thus establishing patterns of repeated interaction and communication. These repeated interactions expose employees to the observable activities of other firm members and enable them to acquire individual knowledge and skills from them. In particular, important learning relationships are formed between senior and more junior employees, allowing juniors to benefit from the experience of their elders. This personal learning does not, or not exclusively, depend on the explicit communication of knowledge and strategies. It also involves less deliberate and often nonverbal learning processes based on the observation of role models and the subsequent reproduction of behaviors found to be working successfully for the role model (Bandura, 1986; Witt, 1998). Observational learning through the direct observation of role models seems particularly important in the firm context because individual expertise is often non-verbalized and accordingly cannot easily be communicated to others (Anderson, 2000).

Finally, personal on-the-job experience in the parent firm also affects the level and nature of the employee's skill set. For example, empirical evidence suggests that exposure to demanding field assignments, involving high degrees of autonomy and outcome responsibility, may instill entrepreneurial attitudes in junior employees, thus preparing them to take over leadership positions (Higgins, 2005).

Triggering events

It has often been observed that spin-offs do not “emerge” automatically whenever employees acquire valuable knowledge on the job. Employees generally try hard to apply their knowledge and skills in the context of the parent firm, resorting to spin-off activities only when they find that this is not, or no longer, feasible or supported by the firm's management (Garvin, 1983; Klepper, 2007).¹ Spin-offs tend to be triggered by specific events that alter the opportunity cost of departure from the parent firm and spin-off formation. Conceptually, three types of (possibly related) triggering events can be distinguished (Table 1): opportunity discovery,² adverse events at the parent firm as well as strategic and personal conflicts.

Opportunity discovery: The ability of employees to identify and pursue opportunities is intimately linked to their technological knowledge and/or knowledge about markets and customer needs. Shane (2000) has shown that opportunity discovery depends on related prior knowledge. In their work for the parent firm, potential spin-off founders are exposed to information about technological and/or market developments that open up opportunities for introducing new products, processes, or strategies.

Discovery of such opportunities is part of the normal tasks of R&D and sales staff. It does not in general lead to the creation of a spin-off firm but is inherent in the dynamic capabilities of the existing firm, allowing for its sustained competitiveness and growth. The exploitation of new opportunities by the existing firm would generally seem advantageous because the firm has established capabilities and complementary assets (Teece, 1986) that lower its costs of exploitation as compared to stand-alone exploitation by a spin-off.

However, in some situations, the existing firm is unwilling or unable to exploit all

¹ Based on this observation, it appears questionable to explain spin-off activities in terms of a principal-agent framework, with employees pursuing illegitimate learning activities hidden from the firm's management and defecting if arriving at successful solutions (e.g., Anton and Yao, 1995). See also Klepper (2001) for a more thorough discussion.

² The use of this terminology does not reflect a commitment to the view that opportunities are necessarily discovered rather than created (cf. Sarasvathy et al., 2003, for a discussion). As argued elsewhere, a case can be made that, in the final analysis, all opportunities are created, but they are not always created by the same individual who pursues them (Buenstorf, 2007b).

opportunities identified by its employees. Unwillingness to exploit may result from the management's inability to appreciate the value of a particular opportunity (Agarwal et al., 2004). This inability may in turn be due to the technological nature of the opportunity (Henderson and Clark, 1990) or the fact that it addresses demand segments outside the firm's current customer base (Christensen, 1993).

However, not all refusals to pursue opportunities identified by employees are necessarily pathological. If some of the demand raised by introducing a new product would reduce sales of the existing product portfolio, the opportunity may not have a positive net value for the incumbent firm (Klepper and Sleeper, 2005). Also, in highly dynamic industries, established firms may simply face more opportunities than they can exploit (Moore and Davis, 2004). Pursuing all identified potential product and process innovations may require more capital than can be raised, it may exceed the firm's ability to grow in terms of finding suitable employees and broadening its managerial resource base (Penrose, 1959) or endanger the firm's coherence because different projects would require the modification of existing processes in mutually inconsistent ways.

If an employer refrains from exploiting the ideas of its employees, spin-off formation may be the only channel of commercialization available to these employees, as other existing firms are unlikely to take up ideas developed but rejected by a competitor (Garvin, 1983). At the same time, for opportunity exploitation in a spin-off to be viable, the opportunity needs to provide a foundation of unique firm capabilities (or at least the prospective spin-off founders have to believe it does). This is what turns the opportunity into an *entrepreneurial* opportunity.

Adverse events at the parent firm: There is substantial evidence that the emergence of spin-offs is not always triggered by employees' opportunity discovery. Rates of spin-offs out of existing firms are also influenced by developments and events affecting the firm more generally, particularly by adverse shocks it experiences. This suggests that employees may be "pushed" rather than "pulled" into spin-off entrepreneurship (Eriksson and Kuhn, 2006).

The most negative event that may affect an existing business is involuntary exit. Parent firm exit has been identified as a significant driver of spin-off activities in a broad sample of Danish firms (Eriksson and Kuhn, 2006). In an industry context, spin-off rates have increased during the time of the parent firm's exit from the industry in both the U.S. and German laser industries (Klepper and Sleeper, 2005; Buenstorf, 2007a). In this situation, spin-

off entrepreneurship provides new employment opportunities for employees whose jobs are eliminated by the parent firm.

Other events at the parent firm may have adverse consequences for individual employees or departments, even though they are not necessarily adverse to the entire firm. One important event of this kind is acquisition by a competitor, which may help strengthen the acquired firm's market position and cost structure. Acquisitions are often accompanied by the discontinuation of specific activities because of their redundancy or lacking fit with the new company's overall strategy. They may therefore endanger the jobs of some employees, thus triggering spin-off activities by those affected. A similar argument holds for changes at the top management level, which have also been shown to increase spin-off rates (Brittain and Freeman, 1986; Eriksson and Kuhn, 2006), as well as for other events that entail a shift in the prospects of employees in the firm (e.g., changes in the firm's location patterns).

Strategic disagreement: Conflict is a recurrent theme in the discussion on spin-offs. Clearly, conflicts can be the *result* of spin-off activities. For example, Intel is well known for its hostile stance vis-à-vis (potential) spin-offs. Based on their experience at Fairchild, Intel's founder-managers adopted this position to limit what they perceived as a dangerous outflow of technological knowledge through spin-off activities (Moore and Davis, 2004). Klepper and Thompson (2006b) shift the focus to conflict as a *driver* of spin-off activities. They document numerous instances of spin-offs originating from strategic disagreements between an employee and the incumbent firm's management and present a formal model of the spin-off process driven by such strategic disagreements.

The key assumption in the model developed by Klepper and Thompson (2006b) is that all firm members receive and communicate private information. Some employees receive better (less noisy) information than all others, or have a superior ability to evaluate the information they are exposed to. However, they are unable to convince the firm's management of this superiority. This leads to a discrepancy between their preferred strategy and the actual strategy adopted by the firm, lowering their subjective assessment of the firm's value. In addition, external investors are available to finance the spin-offs organized by departing employees. These are therefore able to leave their present employment and start a new venture whenever their cost of disagreement with the current firm strategy (their assessment of the foregone firm value) exceeds the costs of setting up a new firm.

The model of Klepper and Thompson (2006b) accounts for an impressive number of empirical findings on spin-offs. However, strategic disagreement alone appears insufficient as

a conceptual foundation of the spin-off process. Employee learning also has a role in the Klepper and Thompson (2006b) model. Firm members communicate their knowledge to each other, even though in forming expectations about the firm's value, each weighs their own knowledge more heavily than that of their peers. Through communication with other firm members, employees thus benefit from working in a high-quality firm. At the same time, the model is driven by the variance in information quality or assessment ability among individuals. Spin-offs perform well because of the superior quality of their founders and/or the information these possess. This superiority is exogenous to the model. Spin-off founders are born as superior evaluators of information, or they have access to superior information sources, but they do not acquire this superiority as a consequence of working at a superior firm.

It moreover seems useful to consider the causes of strategic disagreement. In particular, both opportunity discovery and adverse events at the parent firms may give rise to conflicts. The discovery of opportunities that are then rejected by the firm's management is a well-established cause of conflicts that have resulted in spin-off formation (cf., e.g., Garvin, 1983; Christensen 1993; Agarwal et al., 2004, as well as the evidence presented in Klepper and Thompson, 2006b). Disagreements may also result from events such as firm exit, withdrawal from specific market segments, or relocation decisions. Distinguishing these deeper causes of disagreements leading to spin-offs helps to predict spin-off performance as well as the determinants of spin-off rates.

At the same time unexploited opportunities do not necessarily result in strategic disagreements. There may well be consensus among all firm members that a viable opportunity does exist but is not suitable for exploitation by the existing firm. In this situation, spin-off activities are sometimes actively supported by the parent firm's management. In the case of adverse developments, the existing firm's management and the prospective founders may likewise agree that spin-off entrepreneurship is an option to create employment and possibly secure some of the existing firm's capabilities. Consequently, the creation of spin-offs is not necessarily caused by a conflict.

Development of spin-off capabilities

Spin-off founders possess various kinds of knowledge acquired in their prior employment that they try to bring to the spin-off. Since these kinds of knowledge differ in both nature and substance, differences are to be expected in how easily they can be transferred to the spin-off.

Technology / markets and customer needs: Knowledge about technologies or markets is often at the root of spin-off formation triggered by the discovery of new opportunities. In these cases, opportunity-related knowledge will naturally be the focus of the founders' efforts of communication and knowledge transfer, because it is a defining element of the new firm's strategy. In contrast, reproducing other elements of the parent firm's knowledge of technologies and markets appears more problematic, as this knowledge tends to be distributed among many employees and will often not have been readily observable for the spin-off founders during their tenure at the parent firm.

Organizational processes: Participation in routinized firm behavior is largely based on habituated skills. It is plausible to expect that spin-off founders naturally resort to internalized behavior also in the new organizational setting of the spin-off. However, since routines operate through interaction with other firm members, individuals cannot simply transfer internalized routines to another organization. Rather, they have to recreate the underlying interaction patterns to fit the new context, which will frequently modify the working of the routine. Transfer of internalized routines is facilitated when founder teams come from the same parent firm, or when first-round employees are hired from the founder's parent firm. In these cases, multiple elements of the previous interaction patterns are brought to the new organization, attenuating the need to "fill in" missing complementary elements.

Template-based transfer of organizational knowledge involves the deliberate imitation of the parent's organizational processes by spin-off founders. Again, except for processes they aim to modify relative to the parent firm, resorting to template imitation appears a straightforward default solution in setting up the new organization. This is further facilitated if the parent firm has started initiatives of knowledge articulation and codification to safeguard the consistency and continuity of its organizational processes (Kogut and Zander, 1992; Zollo and Winter, 2000).

Personal skills: Spin-off firms usually begin as small entities, having at most a few employees in addition to the founder team. Under these conditions, the personal skills brought by the spin-off founder or the entrepreneurial team are of particular importance. In managing the fledgling spin-off, these individuals have a "holistic picture" (Agarwal et al., 2004, p. 506) of the venture. They also provide natural role models for newly hired employees. Accordingly, one determinant of the spin-off's performance is the founders' ability to communicate the business model and strategy to the employees and thus coordinate the firm members'

activities (Witt, 1998). This ability seems particularly important to those elements of the spin-off's strategy that depart from the parent firm's practices and possibly also challenge established industry practices.

3. Concepts and hypotheses

Defining opportunity and necessity spin-offs

In this section, the different kinds of triggers identified above will serve to classify spin-offs into opportunity spin-offs and necessity spin-offs. Subsequently, specific hypotheses are developed regarding how the two types of spin-offs are expected to differ.

For some time entrepreneurship researchers have made a distinction between opportunity and necessity entrepreneurship. Its origins can be traced back to the Global Entrepreneurship Monitor (GEM), a large-scale survey project aimed at identifying the extent and nature of entrepreneurial activities on a global scale. Opportunity and necessity entrepreneurship are defined in the 2001 edition of the GEM (Reynolds et al., 2002). The GEM authors characterize opportunity entrepreneurship as new firm formation to take advantage of a unique business opportunity, while necessity entrepreneurship reflects new firm formation induced by a lack of alternative employment options. Classifying respondents on the basis of self-reported motivations, the GEM project found substantial differences in the prevalence and drivers of the two kinds of entrepreneurship. For example, while national rates of opportunity entrepreneurship were related to economic growth, rates of necessity entrepreneurship varied with the extent of social welfare programs.

The distinction between opportunity and necessity entrepreneurship has also been made in more detailed studies at the national level. For Germany, Wagner (2005) found necessity entrepreneurs to be more risk averse than opportunity entrepreneurs. Defining necessity entrepreneurs as individuals who lost their job through being laid off or because of the employer's exit, Block and Wagner (2006) showed that opportunity and necessity entrepreneurs differed in their personal characteristics as well as the levels and determinants of their earnings.

Based on the conceptual model of the spin-off process discussed above, the distinction between opportunity and necessity entrepreneurship can be extended to spin-off activities. In what follows, the two kinds of spin-offs will be characterized in terms of how the triggering events underlying their formation affected the opportunity costs faced by their founders.

Similar to the approach of Block and Wagner (2006), types of spin-off entrepreneurship are derived from observable information rather than self-reported motivations. Specifically, *opportunity spin-offs* are defined as spin-offs triggered by an increase in the expected future benefits of spin-off formation caused by the new discovery of a promising entrepreneurial opportunity. In contrast, *necessity spin-offs* are defined as spin-offs triggered by a decrease in the expected future benefits of further employment at the parent firm, which is driven by events that adversely affect the parent firm and/or decrease the subjective attractiveness of further employment at that firm for the spin-off founder. Note that the distinction between opportunity and necessity spin-offs is solely based on the triggering event driving the actual decision to start the new firm. For example, this does not rule out that the founder of a necessity spin-off has identified an entrepreneurial opportunity at some point of her tenure at the parent firm –provided, however, that this discovery alone was not sufficient to induce the spin-off formation before the triggering event.

The performance of opportunity and necessity spin-offs

Hypotheses on the determinants and performance of opportunity and necessity spin-offs are formed against the background of earlier spin-off analyses. To enhance comparability, the discussion emphasizes prior results on spin-offs in the laser industry, which has been studied both in the U.S. and Germany (Klepper and Sleeper, 2005; Buenstorf, 2007a). The hypotheses will then be tested, using data for the German laser industry.

Founders of both types of spin-offs start their new firms on the basis of prior industry experience. Both spin-off groups can (and actually do) include entrants coming from the industry's top performers. Based on the theoretical considerations on employee learning and the prior evidence on spin-off performance (e.g., Sleeper, 1998; Klepper, 2002), spin-offs are expected to be among the more successful firms in an industry, with a performance comparable to diversifiers and outperforming de novo entrants whose founders come from outside the industry. As regards the relative performance of the two types, opportunity spin-offs have the additional benefit of being based on a unique, newly discovered business opportunity and also of a more controlled timing of entry. This is expected to result in a more distinctive performance of opportunity spin-offs relative to necessity spin-offs. The following results are predicted:

Hypothesis 1a (spin-off performance): Opportunity spin-offs outperform inexperienced entrants.

Hypothesis 1b (spin-off performance): Opportunity spin-offs outperform necessity spin-offs, which in turn outperform inexperienced entrants.

The determinants of opportunity and necessity spin-offs

As was detailed in the previous section, prior analyses of the spin-off process in the laser and other industries have found higher spin-off rates at times of firm-specific events such as exit or management changes. If the conceptual distinction between opportunity and necessity spin-offs is valid, then adverse effects such as parent firm exit should strongly predict the rates of necessity spin-offs, but not the rates of opportunity spin-offs. This conjecture can be tested by identifying the years of firm exit from the industry and the rates of spin-off entrepreneurship in these years.

Hypothesis 2 (adverse events at parent firm): Adverse events lowering the expected future benefits from continued employment at a firm only increase the firm's rate of necessity spin-offs. Opportunity spin-offs are unaffected.

In both the U.S. and German laser industries, annual spin-off rates were higher in firms that survived longer in the industry. This suggests that employees in better performing (and hence more long-lived) firms had a better chance to acquire knowledge, enabling them to start firms. A positive relationship between firm performance and spin-off rates is expected for both types of spin-offs, because all spin-off founders are expected to benefit from the better learning environments in superior firms. It is conceivable that the relationship with parent firm longevity is weaker for necessity spin-offs, which in part are triggered by events reflecting problems in the parent firm.

Hypothesis 3a (industry longevity of parent firm): More long-lived firms spawn spin-offs of either type at a higher rate.

Hypothesis 3b: The effect of longevity is stronger for opportunity spin-offs than for necessity spin-offs.

Earlier studies of spin-off rates in the laser industry found firm longevity in specific markets (defined by laser types) to be a better predictor of spin-offs entering this market than firm longevity in the aggregate industry. This suggests that, at least in part, employee learning is related to knowledge about specific technologies and markets / customer needs. As these

kinds of knowledge are beneficial for potential founders of both types of spin-offs, market longevity in specific markets should be reflected by higher annual rates of both types of spin-offs (in the respective markets). At the same time, knowledge about technologies and markets is essential for the identification of new entrepreneurial opportunities on which opportunity spin-offs are based. The effect of specific (rather than general) knowledge is therefore expected to be stronger for opportunity spin-offs than for necessity spin-offs.

Hypothesis 3c (market longevity of parent firm): Longevity in specific markets favors the emergence of opportunity spin-offs more strongly than that of necessity spin-offs.

Hypothesis 3d: The effect of market longevity is stronger for opportunity spin-offs than for necessity spin-offs.

For each firm, longevity is measured by its *total* years of survival in the industry. This number is known only *ex post*; it is constant over the firm's entire lifetime irrespective of the time of spin-off formation. Alternatively, a firm's *current* industry and market experience can be used as a proxy to study experience effects on spin-off emergence. Current experience is identified by counting the number of years that the firm had been active in the industry or the specific market when the respective spin-off was organized. Thus, the experience indicator varies over the lifetime of the firm. It is smaller for spin-offs spawned early in the firm's lifetime and higher for spin-offs spawned at a later stage.

Prior studies have consistently found that annual spin-off rates are highest at intermediate firm ages (Klepper, 2002; Klepper and Sleeper, 2005; Buenstorf, 2007a). Finding that spin-off rates depend positively on the firm's accumulated experience (at younger ages) can be interpreted as further evidence for the importance of employee learning, which would be expected to benefit the formation of both types of spin-offs. The more knowledge the parent firm has built up over time, the more there is for potential spin-off founders in the firm to draw upon. At the same time, founders of necessity spin-offs have less influence on the timing of spin-off formation. In particular, "premature" formation of necessity spin-offs may show up in a weaker effect of parent firm experience on spin-off formation.

Hypothesis 4a (experience of parent firm): The accumulated industry and market experience of a firm enhances its spin-off rates, at least at young ages.

Hypothesis 4b: The effect of experience is stronger for opportunity spin-offs than for necessity spin-offs.

4. Empirical analysis

Setting: The German laser industry, 1960-2003

The empirical context of this study is the German laser industry, an industry characterized by the absence of two key features that are generally found in the evolution of industries (Buenstorf, 2007a). To date, no shakeout in the number of active firms has been observed in this industry, but there has been sustained entry into the industry over 40 years of evolution. Furthermore, no first-mover advantages in favor of early entrants are observable in this industry. There are no significant differences in the average longevity of firms entering in different cohorts. Both findings can be attributed to the prominent role of heterogeneous and changing (sub)markets in the laser industry. Historically, incumbent experience in specific laser markets has not operated as a barrier to entry, which applies also to laser markets outside Germany (Klepper and Thompson, 2006a).

For the period 1960 to 2003, a total of 143 German producers of laser sources have been identified using buyers' guides and other trade publications. Similar to the U.S. laser industry, spin-offs have been prominent among the entrants into the industry (Klepper and Sleeper, 2005; Buenstorf, 2007a). For the present study, all 48 spin-off entrants into the German laser industry have been classified into opportunity and necessity spin-offs.³ The categorization is based on information provided by the firms themselves about their founding context and/or coverage in the trade press discussing the firms' origins and strategy.

Firms were categorized as necessity spin-offs whenever there was substantial evidence that the impetus for their organization was based on events at the parent firm (13 cases in total). In four cases, the spin-off was started after the parent firm had gone bankrupt. In a fifth case, bankruptcy was eventually avoided by partial acquisition, but spin-off formation had already been initiated, and the spin-off took over some of the parent firm's previous activities. Seven spin-offs were started by employees because the parent firm abandoned the laser industry or a specific laser market, in part due to post-acquisition strategic refocusing. Finally, one spin-off was started by a leading R&D employee of a successful West German laser

³ This number compares to 79 spin-offs in the U.S. laser industry. Cf. Buenstorf (2007) for a detailed discussion of data sources and coding decisions.

producer when it was acquired and relocated to Eastern Germany following Germany's reunification.

In contrast, 28 entrants are classified as spin-offs based on available information about their initial strategy in terms of product innovation and targeted market segments. This information indicates that the founders had perceived new opportunities on which they based their business models, while no evidence was found suggesting the organization of these firms was primarily due to adverse developments at the parent firm. The group of opportunity spin-offs includes three cases of serial entrepreneurs reentering the industry after successfully selling an earlier laser business. Among the other opportunity spin-offs, opportunities were in some instances evaluated differently by the founder and the prior employer. In yet other cases, the founding impetus was exclusively attributable to entrepreneurial aspirations. For example, one spin-off entrepreneur suggested he had entertained plans to start a firm already while being a university student, and that he had entered into employment at the parent firm only to learn. Finally, some opportunity spin-offs were "parent spin-offs" (Helfat and Lieberman, 2002) in that they were initiated by the parent firm's management to pursue new activities in different segments of the laser industry than the ones the firm was already active in.

Overall, there was explicit information allowing for a classification of 41 of the 48 spin-offs, showing there were 28 opportunity spin-offs and 13 necessity spin-offs. In the remaining seven cases, no explicit information was available on which a classification could be based. For these firms it was checked whether adverse developments occurred at the parent firm at the time of spin-off formation. This check identified two cases in which the spin-off organization coincided with the parent firm's exit from the industry, suggesting that these two firms also were necessity-based. No such evidence was found in the remaining five cases. In total, we thus found that 33 out of the 48 spin-offs (69%) were opportunity-based versus 15 that were necessity based.⁴

Spin-off performance

In line with earlier studies on industry evolution, the spin-off's own longevity in the laser industry is adopted as a measure of spin-off performance. Hazard rate models are utilized to analyze how firm characteristics affected longevity, which ranged between one and 37 years in the data. (The average firm remained in the industry for seven years.) Hazard models allow

⁴ As a robustness check, the econometric analyses were alternatively performed classifying as opportunity spin-offs all seven firms for which no explicit information was available, i.e., with a smaller set of only 13 necessity spin-offs. This had no appreciable effect on the estimates.

for controlling differences in the type of exit. Specifically, exits through acquisition by a competitor, which is often not an indication of poor performance (but possibly the opposite), are treated as right-censored observations. Semi-parametric Cox regressions are utilized in the subsequent analysis. They are attractive because no assumptions on the time-dependence of the hazard need to be made. Adequacy of the proportionality assumptions underlying the Cox model was established using specification tests based on Schoenfeld residuals (Grambsch and Therneau, 1994).

– Table 2 about here –

The limited sample size restricts the complexity of the models that can be analyzed. The initial model specification (Model 1 in Table 2) therefore only includes three dummy variables denoting three kinds of experienced entrants into the German laser industries: diversifiers (of which there were 56 including prior laser importers and distribution firms), opportunity spin-offs, and necessity spin-offs. Thus, the model serves to study whether the average longevity of these entrants was significantly different from that of other entrants into the industry, which make up the control group. These other entrants consist predominantly of new firms with academic (28 firms) and other (seven firms) backgrounds as well as four firms whose pre-entry background could not be identified.

Negative coefficient estimates are obtained for all three firm type indicators, suggesting that their hazard of exit was lower than that of firms in the control group (i.e., they remained in the industry longer). The coefficient estimates are significantly different from zero only for the diversifiers and the opportunity spin-offs. This suggests that, in line with Hypothesis 1a, opportunity spin-offs had a systematically higher longevity than firms in the control group. Even though there is a substantial difference in the coefficient estimates obtained for the two spin-off types, this difference is not statistically significant so that Hypothesis 1b, predicting that opportunity spin-offs performed better than necessity spin-offs, is rejected.

Two additional model specifications are utilized to check the robustness of the findings obtained for Model 1. In Model 2, the number of laser types currently produced by the individual firms is included to control for the scope of the firm's laser activities, using

annual observations.⁵ This variable does not improve the explanatory power of the model, while the effects of the firm type indicators are almost unaffected.

Finally, Model 3 modifies the way that exits by acquisition are dealt with. Instead of treating them as censored observations, this model interprets acquisition as another risk competing with the hazard of failure (i.e., exit by bankruptcy or voluntary withdrawal from the laser industry). The effects of entrants' backgrounds on the acquisition hazard are estimated as interaction effects, which indicate whether the effect of the respective background differed for the alternative kinds of hazards (Lunn and McNeil, 1995). Since firm age has different effects on the competing risks, a stratified competing risks Cox specification is adopted.

Compared to the earlier models, smaller effects on the hazard of failure are obtained for the diversifier and opportunity spin-off variables. Only the failure hazard of opportunity spin-offs remains significant. At the same time, the dummy variable identifying opportunity spin-offs has a positive effect on the hazard of being acquired, with the interaction term indicating that the two kinds of hazards are affected in significantly different ways. No such difference in the effect on the different hazards is found for the diversifiers, while the interaction term is not estimated for the necessity spin-offs because none of them exited by acquisition. (It would be very large, negative, and highly significant.) These results suggest that spin-offs that were started to pursue a distinctive opportunity, but not those that were started out of necessity, developed into attractive candidates for takeovers in the German laser industry.

Spin-off determinants

To estimate the influence of the hypothesized factors explaining annual rates of spin-offs out of existing German laser firms, the multinomial logit methodology is adopted. All 43 spin-offs spawned by German laser firms between 1960 and 2003 are included in the analysis. Five spin-offs had foreign parent firms. They are disregarded in the multinomial logit. For each industry year after the firm's entry into the laser industry and for each of seven laser types (defined by active medium as before), a firm can either spawn no spin-offs, one or several opportunity spin-offs, or one or several necessity spin-offs. There is no case in which both opportunity and necessity spin-offs emerged from the same firm in the same year and laser

⁵ Laser types are defined by the laser's active medium. The following laser types are distinguished: solid-state, semiconductor, dye, CO₂, helium-neon, ion, and excimer. The number of markets served by individual producers ranges between one and six, the mean is 1.58.

type. In two cases, two spin-offs of the same kind were created at a single firm in the same year. These two cases are underrepresented in the multinomial logit. In a small number of cases, spin-offs entered in more than a single laser type in their first year. In these cases, the spin-off event is taken into consideration in all relevant laser types.

– Tables 3 and 4 about here –

The initial model studies how firms' rates of spin-off formation were affected by their exit from the laser industry as well as the effect of firm longevity on spin-off rates. To study the role of exit in the spin-off process, a dummy variable is included in the specification that assumes the value one in the five-year period around the parent firm's exit year and is zero otherwise. Longevity is measured by the firm's total number of active years in the laser industry. Descriptive statistics of the explanatory variables are given in Table 3.

Results of the specification are reported as Model 4 (Table 4). As regards firm exit, a strong and statistically significant increase in the likelihood of necessity spin-offs is found at the time of firm exit. As was predicted by Hypothesis 2, the rate of opportunity spin-offs does not increase significantly in this time period. The difference between the coefficient estimates for the two spin-off type dummies is significant at the .10 level. In line with Hypothesis 3a, the annual likelihood of both kinds of spin-offs is higher in more long-lived firms. The coefficient estimate for the effect of industry longevity on the rate of opportunity spin-offs is slightly larger than the corresponding estimate for necessity spin-offs. However, both estimates are similar and statistically indistinguishable, so that Hypothesis 3b predicting systematic differences is rejected.

Next, a second longevity measure is included in the model, which measures the number of years a firm survived in the specific laser market that a spin-off initially entered (Model 5 in Table 4). In line with expectations (Hypothesis 3c), this new variable is positive and significant for both types of spin-offs. Its inclusion strongly reduces the effect of the industry-level longevity measure. For the opportunity spin-offs, the coefficient estimate of the industry-wide longevity measure is cut in half, while for the necessity spin-offs it is virtually zero. Contrary to the prediction of Hypothesis 3d, the effect of the new, "narrow" longevity measure is similarly strong for both types of spin-offs. The coefficient estimates are statistically indistinguishable, with their relative size being suggestive of a potentially stronger effect on the necessity spin-offs. The effect of the dummy variable measuring spin-off activities around the time of the firm's exit year from the laser industry is hardly affected.

Model 6 (Table 4) uses a similar specification as Model 5, but replaces the two longevity measures by measures of current experience in the industry as well as its specific markets, for which linear and quadratic terms are entered to allow for nonlinear effects. The results are very similar to those obtained in Model 5. Only experience in specific markets increases the spin-off likelihood at young ages, and it does so for both types of spin-offs.⁶ This confirms Hypothesis 4a, while Hypothesis 4b, predicting a stronger effect on opportunity spin-offs, is rejected. Results for the exit-related variable correspond to Models 4 and 5 and further support Hypothesis 2.

5. Necessity spin-offs and the competitive market process

As noted above, necessity spin-offs accounted for about a third of all spin-off entries into the German laser industry. Their organization was mostly driven by parent firm failure or strategic reorientation following acquisition. Our sample includes the years of German reunification and the repercussions of the post-reunification transition underlie the formation of several necessity spin-offs in the sample.

The transition from socialism provides a striking illustration of the broader implications of the formation of necessity spin-offs. The pre-1990 East German economy was characterized by huge state-owned firms producing mostly outdated goods, and at a dismally low productivity. After German reunification, the facilities of these firms were mostly shut down or at least drastically downsized. Even though after more than 15 years, Germany's East has not yet recovered from this transition shock, individual locations there have developed in a remarkably different way. One of them is the city of Jena, which has recently been hailed as a role model for the entire German economy by both the *Economist* (February 2006 issue) and the *New York Times* (April 13, 2007).

Among the factors that make Jena special is the prevalence of necessity spin-offs. Before 1989, Jena's economy was entirely dominated by the VEB Carl Zeiss Jena, a giant optics and precision mechanics company with some 27,500 employees locally and acknowledged technological capabilities. By 1995, Zeiss had been acquired by its West German twin firm, and the number of its Jena employees had fallen to some 3,000. At the same time, some 80 firms had been spun out of the local Zeiss activities (Plattner, 1997).

⁶ The coefficient estimates imply that the effect of experience reaches a maximum at about age 15 and remains positive at least through age 24 of a firm.

Some of them were large, including the politically induced and heavily subsidized Jenoptik Group that took over some of the core businesses of the former socialist Zeiss firm. Others were smaller and more entrepreneurial, typically organized by individual engineers and scientists who exploited their job experiences and knowledge acquired at Zeiss and offered products and services directly related to their prior activities. For example, one of the necessity spin-offs in the laser industry sample is an entrepreneurial Zeiss spin-off focusing on lasers for measurement applications.

For former Zeiss employees, there was often no viable alternative to spin-off entrepreneurship. Local unemployment rates were soaring after 1990, and even out-migration to the West (in total, some 2 million East Germans have moved West since the reunification) was not an option for highly specialized employees, particularly older ones, who are strongly disadvantaged by the inflexible and highly regulated German labor market. By organizing their own firms, some of them could selectively draw on, and further develop, technological capabilities of the former socialist firm, while at the same time they were no longer restricted by its large-scale bureaucracy and the political prerogatives of state ownership.

Today, the Zeiss spin-offs formed after 1990 are the backbone of the local economy. Created out of necessity, they helped bring about a local economic structure characterized by a network of innovative and flexible SMEs that is distinctive among Eastern German locations (cf. Cantner and Graf, 2006). Survey results on these spin-offs indicate they were able to benefit from substantial transfers of technology- and customer-related knowledge, which is also consistent with their relatively low rates of failure and in part considerable growth rates (Habekost, 2007).

Similar to their role in the transition from socialism, necessity spin-offs also seem important in industries and countries emerging from patterns of pervasive protectionism and import substitution, including LDCs and emerging economies. In these industries and countries, inefficient incumbent firms are frequently restructured or shut down, while there are few, if any, existing firms active in sufficiently closely related markets available to employ those who lose their jobs in the restructuring process.

Finally, at a more micro level, problems of reutilizing competences within existing firms may be caused by highly specialized knowledge and skills developed in firms that were market pioneers but for some reasons failed to realize their potential. For example, a case study by Buenstorf and Fornahl (2006) traces the spin-off activities that followed the downsizing of a prominent German e-commerce software development firm in the wake of the bursting dot.com bubble. They find that at least 30 spin-offs were started by prior

employees of the firm, mostly in markets that were related (but not identical) to the parent firm's business model. The business models and activities of these spin-offs indicate that their founders brought highly specific knowledge from their prior employment. Presumably, this knowledge would have been difficult to apply in the context of existing firms, particularly at a time when firm failure and drastic downsizing was commonplace in the Internet-related software industry. In the home region of the parent firm, these spin-off activities have induced substantial cluster dynamics in e-commerce software.

6. Conclusions

This paper has focused on the drivers of spin-off formation. It has suggested that, following employee learning, spin-off formation is triggered by specific events. Two kinds of events have been highlighted: discovery of opportunities that increase the attractiveness of spin-off formation, and adverse events that decrease the attractiveness of continued employment in the parent firm. In analogy to the entrepreneurship literature, the spin-offs corresponding to the two types of events have been referred to as opportunity spin-offs and necessity spin-offs, respectively. This distinction is complementary to the focus of Klepper and Thompson (2006b) on strategic disagreement as a driver of spin-offs mostly because it allows for distinguishing causes of disagreements that may help predict spin-off characteristics and performance. Moreover, while disagreement appears to be widespread, it is not a necessary condition of spin-off formation.

The empirical analysis traced opportunity and necessity spin-offs in the German laser industry. As a result, about one-third of all spin-offs in this industry were classified as necessity spin-offs. To be sure, being based on a single industry and only a small number of observations, it would be premature to infer too much from the analysis. However, the empirical findings provide substantial support to the proposed conceptual distinction. Perhaps the most surprising finding is that necessity spin-offs are evidently based on comparable degrees of employee learning as opportunity spin-offs. Both proxies for learning opportunities in incumbent firms – firm longevity and firm experience – affected the likelihood of both kinds of spin-offs in the same way. This suggests that even though necessity spin-offs were triggered by shocks to the parent firm, they were not the result of a haphazard process of firm formation where the spin-off entered the market prematurely. Rather, it seems that founders of necessity spin-offs have the competence and skills to start new businesses but – perhaps for

personality reasons, perhaps for reasons related to the strategy of the prospective business – require some additional “push” to actually go ahead and do so.

As noted in the introduction, the prior discussion of spin-offs has mostly concentrated on what have been termed opportunity spin-offs in the present paper. Their importance in breaking up organizational inertia and bringing fresh ideas to the market has often been emphasized, and the present findings just add to the positive light in which they are normally portrayed. The central message of this paper is that necessity spin-offs also have an important role to play in the market process. They allow for the continued application of useful personal knowledge and skills acquired during prior employment in business firms, even in situations where employment in another preexisting firm would be difficult to find. Thus, necessity spin-offs may be suitable vehicles for the reutilization of individual competences, preventing the devaluation of human capital through events that typically are not the individual’s fault.

The findings on spin-off longevity in the German laser industry corroborate this point. In this industry, necessity spin-offs were not the distinctive performers that opportunity spin-offs were (on average). But they were no underachievers, either. Specifically, they did not perform worse than other non-spin-off *de novo* entrants. Finally, reservations are sometimes expressed vis-à-vis spin-offs because of allegedly negative effects they may have on their parent firms. Irrespective of whether these reservations are valid in general (cf. Klepper, 2007, for a dissenting argument), they are clearly less relevant for necessity spin-offs, which form in reaction to adverse developments at the parent firm.

Although the above findings and interpretation need to be corroborated in other industries and contexts, they call for adopting a fuller perspective on spin-offs that does not focus only on the Intels and SAPs of this world. Necessity spin-offs are a relevant type of entrepreneurial activities, with a substantial role to play in the dynamics of industries and economies.

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Table 1: Phases and determinants of the spin-off process

Phase	<i>Employee learning</i>	<i>Triggering event</i>	<i>Spin-off capabilities</i>
Consequence	<i>Spin-off potential</i>	<i>Spin-off formation</i>	<i>Spin-off performance</i>
Underlying factors	<ul style="list-style-type: none"> • Learning about technologies and markets • Learning about organizational processes • Acquisition of personal skills 	<ul style="list-style-type: none"> • Strategic disagreement • Opportunity discovery • Adverse events at parent firm 	<ul style="list-style-type: none"> • Transfer of technological and market knowledge • Transfer of organizational processes • Use of personal skills

Table 2: Longevity of spin-offs

<i>Method</i>	<i>Cox proportional hazards</i>		<i>Competing risks Cox regression (stratified)</i>
	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Diversifier	-.707** (.309)	-.699** (.310)	-.419 (.316)
Diversifier *acquisition			.089 (.655)
Opportunity spin-off	-.1.115** (.448)	-1.096** (.452)	-.926** (.449)
Opportunity spin-off*acquisition			1.797** (.780)
Necessity spin-off	-.477 (.408)	-.406 (.401)	-.461 (.409)
Number of active submarkets		-.201 (.206)	
Number of obs. (events)	143 (49)		143 (66)
Log-likelihood (p > chi ²)	-203.367 (.032)	-202.847 (.055)	-262.374 (.077)

(Note: Standard errors (adjusted for clustering by firm) in parentheses; *, **, and *** denote significance at the .10, .05, and .01 levels, respectively.)

Table 3: Descriptive statistics for the analysis of spin-off determinants

<i>Variable</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
Parent firm exit +/- 2 years	.176	.381	0	1
Parent firm survival in industry (years)	11.091	8.382	1	37
Parent firm survival in submarket (years)	3.236	5.273	1	32
Parent firm experience in industry (years)	6.434	6.209	0	36
Parent firm experience in submarket (years)	1.313	3.580	0	32

Table 4: Determinants of spin-off activities by year and product type (multinomial logit)

	<i>Model 4</i>		<i>Model 5</i>		<i>Model 6</i>	
<i>Spin-off type</i>	<i>Opportunity</i>	<i>Necessity</i>	<i>Opportunity</i>	<i>Necessity</i>	<i>Opportunity</i>	<i>Necessity</i>
Parent firm exit +/- 2 years	.634 (.485)	2.051*** (.527)	.620 (.488)	2.037*** (.533)	.269 (.527)	1.804*** (.578)
Parent firm survival in industry (years)	.068*** (.019)	.057** (.025)	.030 (.026)	.007 (.037)		
Parent firm survival in submarket (years)			.077*** (.029)	.097*** (.025)		
Parent firm experience in industry (years)					.086 (.089)	-.052 (.099)
Square of parent firm experience in industry					-.002 (.002)	.002 (.003)
Parent firm experience in submarket (years)					.370*** (.081)	.391*** (.087)
Square of parent firm experience in submarket					-.016** (.007)	-.012** (.005)
Constant	-6.921*** (.436)	-7.511*** (.621)	-6.810*** (.424)	-7.385*** (.632)	-6.974*** (.470)	-7.461*** (.438)
Number of observations	11956		11956		11956	
Log-likelihood (p > chi ²)	-408.220 (.0000)		-397.122 (.0000)		-380.157 (.0000)	

(Note: Standard errors (adjusted for clustering by firm) in parentheses; *, **, and *** denote significance at the .10, .05, and .01 levels, respectively.)