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**PUTTING A VALUE ON OPENNESS: THE EFFECT OF PRODUCT SOURCE CODE
RELEASES ON THE MARKET VALUE OF FIRMS**

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Abstract:

Using the example of open source software, this study examines the effect of opening up the innovation process on the market value of firms. In a sample of 30 software companies in the time span from 1 January 1999 to 30 April 2007, I find that market valuation is strongly influenced by the business model firms choose for their open innovation efforts. The non-existence of an explicit revenue model is punished by the capital market while firms whose efforts include an explicit revenue model achieve a premium on their stock price, confirming the potential for value-creation of open innovation efforts.

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Keywords: openness; open innovation; business model; open source software; event study

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INTRODUCTION

Does openness pay off? Over the last years, researchers have put a lot of effort in explaining the benefits of openness in general, and open source and open innovation processes in particular. Examples include papers on the impact of the open source software (OSS) phenomenon on the innovation process within and outside firms, the economic effects of open source strategies of commercial firms, and the effects of openness on the innovative performance of firms (e.g., Dahlander, 2005; Laursen *et al.*, 2006; Stewart *et al.*, 2006; von Hippel *et al.*, 2003; West, 2003; West *et al.*, 2006a). In many cases, patterns of releasing proprietary software as OSS were found to be consistent with profit maximization, and that increased corporate openness might lead to a stronger innovative performance.

Still, current research on both open innovation and open source software does not yet answer the question whether open innovation activities in general and releasing product source code in particular encompass an effect on the value of firms—and, more specifically, a *positive* effect. Releasing proprietary software source code is an illustrative example of firms practicing openness in its most extreme form, that is, giving away the “blue prints” of the product, and, consequently, ideally suited to study the effects of openness on the market value of firms.

After identifying a set of business models firms may choose to generate and appropriate value from releasing proprietary software as OSS—namely business transformation, cost or risk reduction, dual licensing, and the sale of complementary goods or service—I analyze how the capital market reacts to firms announcing a release of proprietary software as OSS regarding the different business models. I maintain that the choice of business model affects the abnormal

returns that firms may generate. In particular, investors punish firms engaging in OSS without a revenue model.

The event study method is an appropriate technique to measure market reaction to specific events. It is widely used in research to measure the impact of managerial decisions (McWilliams *et al.*, 1997). Nevertheless, to the knowledge of the author, no event study measuring the effect of OSS or open innovation efforts on the value of firms has been conducted up till now apart from one event study in the slightly related field of open vs. proprietary Extensible Markup Language (XML) standardization where Aggarwal *et al.* (2006) discovered that capital markets react negatively on open XML standardizations in the years 1999 to 2003.

The rest of this paper is organized as follows. I will first review the literature on advantages and disadvantages of OSS for firms as well as business models they might choose when releasing their proprietary software and deduce the hypotheses for the event study. Next, data and methods are introduced, and, thereafter, the results of the event study are presented. Finally, the implications of the findings and limitations of the study are discussed and recommendations for future research are given.

THEORY AND HYPOTHESES DEVELOPMENT

Openness as a Profit-maximizing Strategy

Extending the definition of openness in the sense of open innovation by Chesbrough (2003), openness with respect to the innovation process shall be defined as a firm not only looking for external actors or ideas to provide input for the innovation process, but also allowing for interactive co-development of the innovation with the outside environment, including both individuals and other firms. By doing this, the firm voluntarily forsakes the opportunity to

appropriate the rents of the innovation through secrecy or patenting which seemingly eliminates the possibility of a recoupment of the investments in the innovation process.

Allen (1983) was the first to describe a scenario where voluntary spillovers are consistent with a profit-maximizing strategy. He labeled this *collective invention* and defined collective invention as a process under which technical information is freely exchanged between firms and individuals and for which no explicit allocation of R&D resources had happened upfront, the invention in fact rather being a by-product of day-to-day business.¹ By studying the English iron furnace industry during 1850-1875, Allen identified three reasons why individuals and firms chose to disclose their inventions in iron furnaces rather than to keep them secret—patenting them would not have been possible—, which can be summarized as reputational gains, an inability to keep the innovation secret due to high cost, and an increase in value of other firm-specific complementary assets. By freely revealing their invention, that is, voluntarily giving up all intellectual property rights to it and making it a public rather than a private good (Harhoff *et al.*, 2003), the inventor might also enlarge the total market for the resulting innovation (Varian *et al.*, 1999).

Building on Allen's model of collective invention, von Hippel and von Krogh (2006) describe three conditions under which free revealing in the sense of the private-collective model of innovation (von Hippel *et al.*, 2003) is likely to take place as part of a larger R&D strategy. First, this is the case when others have knowledge close to that contained in the innovation so that, in fact, the decision of free revealing lies with that individual or firm who has the least to lose from it—even if all others want to keep the information secret (Allen, 1983; Harhoff *et al.*,

¹ In the case of OSS, however, this definition is only valid for innovations generated by users as there are firms that deliberately dedicate a significant amount of resources to OSS *as part of their R&D strategy*, which is also what this paper is focusing on.

2003; von Hippel, 2005). With OSS, more often than not, problem-solving information resides with more than just one person (Lakhani *et al.*, 2003).

Second, assuming that the innovator indeed is the only one to have the necessary information for the innovation *and* there are no available substitutes for this information, there might still be reasons to choose free revealing over other means of intellectual property protection. Benkler (2002) argues that co-development—or, as he labels it, commons-based peer production—will take place when peering is more efficient than markets and hierarchies and, in addition, the implementation costs of a property system are higher than the opportunity costs. In the case of patenting, individual innovators and small and medium-sized firms in particular may consider this impractical as they would have to bear relatively large costs and wait two years or more for the necessary approval (Harhoff *et al.*, 2003; von Hippel *et al.*, 2006).²

Finally, there are situations in which incentives for free revealing are positive, that is, the benefits of free revealing are larger than the costs, and the choice of free revealing is superior to both secrecy and patenting. While some of the advantages such a strategy might have already been touched on above, the next section has been reserved for a detailed discussion of this, using the example of OSS.

Advantages of Releasing Proprietary Source Code as Open Source Software

Since its inception in April 1998, the term OSS is exactly specified by the Open Source Initiative (OSI). Following their definition, OSS is software that is licensed under an OSS license approved by the OSI. OSS does not necessarily mean that the software is gratis (although this is very common). For a license to be OSI-compliant, users of the respective software have to be

² Regarding OSS, Blind, Edler, and Friedewald (2005) show that patenting is rather unpopular in the IT industry, especially with firms whose primary business is software development, but also with those firms that need software development for their products, such as the electronics or telecommunications industry. Rather, both types of firms rely on secrecy and lead-time advantages, as they think the costs (direct financial cost and opportunity cost regarding the long application procedure and its uncertain outcome) of patenting are too high and have doubts about the patentability of their inventions (Blind *et al.*, 2005).

provided access to the source code (upon request, at least), the distribution of derived work must be allowed, and no discrimination against persons, groups, or fields of endeavor is allowed (OSI, 2001).

By releasing their software under an open source license, companies can, first of all, benefit from external developers' support and the latter can make improvements and further developments to the software. As many of these developers will be making adaptations for other companies, the feedback received is often direct user input³ to better tailor existing and future products to existing markets. In such cases in particular, it is highly likely that a piece software will develop faster than if kept proprietary (Dalle *et al.*, 2003; Henkel, 2004; Lakhani *et al.*, 2003). In addition to this, by having customers make further developments to a piece of software, the company might both be able to get a gratis stream of innovations to its product and achieve higher rates of customer satisfaction. By allowing the customers to make changes and additions to the software on their own, they will be more likely to fully commit to the product, and make the improvements needed and hoped for (Goldman *et al.*, 2005; Morrison *et al.*, 2000; von Hippel, 2001). In this way, the company might also be able to receive knowledge that might have been difficult to find, transfer, or acquire otherwise, so-called "sticky information" (von Hippel, 1994, 1998). Furthermore, the community might not only help the company with the actual program, they might also engage in more mundane tasks such as user support or documentation. Again, this will reduce the amount of developer resources the company will have to spend for activities unrelated to its core business that also do not generate any revenue (Goldman *et al.*, 2005; Lakhani *et al.*, 2003; Shah, 2006).

³ "User" does not necessarily equal "end consumer," but rather stands for another firm using the OSS program to build a product or support a process (also see von Hippel, 1988). For example, in the case of Embedded Linux (see, e.g., Henkel, 2007), the "user" most likely to provide feedback to Embedded Linux developers would be a manufacturer of embedded devices (who would be a user of Embedded Linux).

Standard setting and compatibility issues also play important roles. As will be explained in the following, releasing a piece of software gives the company the opportunity to make the software the standard in a certain area if none has existed there before, to tip the standard race in favor of its piece of software, or to prevent a proprietary standard. All of this is useful to the company and actually an opportunity to increase profits: if the company defines (parts of) the standard—even if it is an open one—it is highly likely that it includes parts that are only beneficial to that one company, may it be because only the company itself knows of them or because they are already optimally realized in an existing product (Goldman *et al.*, 2005; Henkel, 2004). If one strong standard already exists, releasing a piece of software as OSS can make it part of this standard, or it will at least increase compatibility of the software to existing software and hardware offerings (Harhoff *et al.*, 2003; Hecker, 1999; Henkel, 2004; Raymond, 2001b). In any case this increased compatibility will create network effects that not only encourage distribution and adoption of the software, but also related innovations and second generation innovation built on the software (Bonaccorsi *et al.*, 2006; Farrell *et al.*, 1988; Farrell *et al.*, 1985; Harhoff *et al.*, 2003; Henkel *et al.*, 2005; Katz *et al.*, 1985, 1986; Shepard, 1987). If there is already a dominant standard or a dominant competitor in the market that the company has trouble keeping up with, building on OSS or releasing their software as OSS might be a valuable option. Apple has for example decided to build its operating system Darwin based on OSS.

Potential Downsides of Releasing Proprietary Software as OSS

Whereas the possibility of free bugfixes and new features seems promising at first glance, a company has to bear in mind that releasing software under an OSS license does not automatically attract lots of developers who will do all the work and cost nothing. On the contrary, if the code is not modular enough, people will simply not be able to grasp the nature of the software and will only be able to make minor contributions—the company will basically still

have to do all the further developments by itself (Baldwin *et al.*, 1997; Goldman *et al.*, 2005; Hissam *et al.*, 2001; MacCormack *et al.*, 2006). Thus, the source code needs to either be modular from the beginning or modified accordingly before being released. In addition to this, the source code needs to be sanitized, for example all inappropriate comments need to be removed, business logic extracted, and so on, which can bring a significant amount of start-up cost (Hecker, 1999; MacCormack *et al.*, 2006).

The most obvious risk of releasing the source code of proprietary software under an OSS license is of course a loss of intellectual property and, consequently, of competitive advantage. The idea is that the company's competitors will be able to quickly start working with many of the ideas contained in the product at little additional cost. However, a caveat is in order. Whereas spillovers to a competitor may be problematic, the firm may nevertheless profit from going OSS if the added value—lower costs of development, new features, fixed bugs, and new sources of revenue—outweighs the losses as needs to be addressed by a preceding business case (Henkel, 2004; West *et al.*, 2006a). Still, the threat of losing intellectual property hampers the release of proprietary software. As, with OSS, customers will also have direct access to the source of the company's products and are allowed to freely redistribute it, they may see less of a reason to pay for it, especially when there might be someone else from whom they could receive a gratis copy. Indeed, with OSS it will no longer be possible to demand license fees for the product, so it is likely that no direct revenue stream will come from the software any longer. Instead, the company will have to look for new, mainly indirect sources of revenues, such as the sale of complementary goods or services (Raymond, 2001b).

From a technical point of view, several dangers arise. In case the source code is incomplete or of low quality, the outcome of an OSS project could range from the public merely ignoring the OSS efforts to a serious damage of the company's technical reputation. In these

cases, none of the possible benefits of going OSS will be reaped (Goldman *et al.*, 2005; Henkel, 2004; Hissam *et al.*, 2001; MacCormack *et al.*, 2006).

If a company has managed to successfully establish an OSS project based on formerly proprietary software, the danger of forking remains:⁴ if people are unhappy with the way the company manages the OSS project they may simply take the existing code base and start their own project as is permitted by any OSS license (FSF, 2006; OSI, 2001).

Open Source Software-based Business Models for Proprietary Software Firms

“How do I make money on software if I can't sell my code?

*You can sell your code. Red Hat does it all the time. What you can't do is stop someone else from selling your code as well. That just says that you need to add extra value to your code, by offering service, or printed documentation, or a convenient medium, or a certification mark testifying to its quality.”*⁵

Despite the advantages presented above, at first glance, it may still seem hardly if at all possible to directly earn money with OSS. One even has to reveal the source code of one's product to the customer which seemingly dries up all revenue streams possibly coming from this piece of software. Still, there are ways to make money with OSS, may they be indirect ones in most cases, and it is possible to build up a business around OSS.

Using the least common denominator found in the literature, I define a business model as the way in which the firm creates and delivers value for the customer and how the firm appropriates the rents from the business.⁶ The revenue model, that is, the way in which the company generates revenues with its business, consequently, is an important part of a business model (Amit *et al.*, 2001; Chesbrough *et al.*, 2002; Zott *et al.*, 2008).

⁴ “A *fork* is a *competing project* based on a version of the pre-existing project's source code. All OSS/FS projects can be ‘forked’; the ability to create a fork is fundamental to the definition of OSS/FS.” (Wheeler, 2007, formatting copied from original source)

⁵ This quote was taken from the OSI's “Frequently Asked Questions” (FAQ) page to be found at <http://www.opensource.org/advocacy/faq.php>, retrieved March 10, 2006.

⁶ West and Gallagher (2006b) show that OSS and open innovation are synonymous in case OSS efforts follow a business model to appropriate value for the firm.

From the existing literature on OSS and the advantages of OSS specified before, four different but non-exclusive business models can be deduced: business transformation, cost or risk reduction, dual licensing, and the sale of complementary goods or assets. Indeed, oftentimes, a combination of several of these models seems more promising than choosing a single one.

In Table 1, I have briefly summarized these business models and given examples of firms having used them in the past. It becomes obvious that the four business models not only differ with respect to the goals that firms may reach when applying them, but also with respect to time horizon (short-term vs. long-term focus) and appropriability (financial gain that is clearly attributable to OSS efforts).

Insert Table 1 about here

When thinking about investors valuating these four business models differently, it is important to understand that releasing proprietary software as OSS using the strategies of cost and risk reduction, dual licensing, and sale of complementary goods and services can be expressed as an easy-to-understand business model, and a revenue model in particular, whereas the business transformation approach shows little to no clear short-term benefits, and the hard-to-quantify long-term benefits might be ignored by the capital market (Dos Santos *et al.*, 1993; Oh *et al.*, 2006). On average, I thus expect that firms announcing a release of proprietary software as OSS using the business transformation model will see this more negatively evaluated than firms choosing one of the three other strategies.

H1: Firms following the business transformation strategy will be evaluated less positively by investors than those firms releasing proprietary software as OSS using another business model.

METHOD AND DATA

Event Study Methodology

Event studies have been widely used in both management (McWilliams *et al.*, 1997) and IS literature (see, e.g., Dehning *et al.*, 2002; Dehning *et al.*, 2003; Dos Santos *et al.*, 1993; Im *et al.*, 2001; Oh *et al.*, 2006) but are new to the field of openness in general and OSS in particular. The research design used in this paper is mainly based on the papers by Campbell, Lo, and MacKinlay (1997), MacKinlay (1997), McWilliams and Siegel (1997), and McWilliams and McWilliams (2000).

In an event study, the stock market reactions on the public disclosure of specific information affecting a firm are investigated. According to the efficient market hypothesis (Fama *et al.*, 1969), the semi-strong form of which is underlying an event study, the market reacts to the announcement of new information. Basically all publicly available information goes into the stock price of firms. An event is anything that results in new relevant information which may have an impact on the future cash flows of a firm (McWilliams and Siegel 1997). Thus, when software or technology companies announce the release of source code to the public the information of releasing code can be expected to be included in the stock price shortly after the announcement (Dann *et al.*, 1977; Mitchell *et al.*, 1989).

An event study works with the daily returns of stocks in a time series. There are two time windows in this time series (see Figure 1). The estimation window W_1 is the time slot prior to the event where the typical return of the stock is calculated. The event window W_2 has an anticipation component prior to the event and a market reaction component after the event.

Insert Figure 1 about here

Data Collection

Event definition and selection. In this paper, I define an event as follows.

An event is the announcement of the release of proprietary source code—that could have been sold (or has been) as a product—under an OSI compliant license either to an existing public open source project or by setting up a new public OSS project.

Using Lexis Nexis, I searched the PR-Newswire, Business Wire, and Market Wire database using the search term “open source AND (contribute OR release OR reveal) AND code” from January 1999 to April 2007. After checking whether the company that released code was listed on the AMEX, NYSE, or NASDAQ and whether the event fit to the event definition, 111 events by 58 distinctive firms were identified.

Estimation window, event window, and check for confounding events. After creating a sample of events the time windows had to be specified. The length of the windows was strongly orientated on the window length found in the related literature (Brown *et al.*, 1985; Campbell *et al.*, 1997; MacKinlay, 1997; McWilliams *et al.*, 1997). The estimation window was defined as 125 trading days and the event window as two days including the event day and the day prior to the event. The inclusion of the day prior to the event was to take anticipation effects into account. I then checked for confounding events within this period of time. A confounding event was defined as an announcement within the event window that might have overshadowed the effect of the actual event on the stock price of the company. Confounding events were for example the announcement of new products, information about pending lawsuits, or the release of quarterly or annual reports.

The check for confounding events eliminated 69 of the 111 events. A possible reason for the mass of confounding events may be that many software companies tend to publish information on new products, strategic partnerships, etc. in bundles on conferences and other

mass events.⁷ In addition, four more events had to be removed from the sample; three events because the IPO of the respective firms had only happened recently, so that the available stock price data would not have sufficed for the 125-day estimation window, one event was removed because the respective firm was considered for delisting at the time of the event. A list of all remaining 38 events by 30 firms with no confounding events is given in Table 2. More detailed event descriptions can be found in Table A. 1 in the appendix.

Insert Table 2 about here

Calculation of abnormal returns. Abnormal returns are returns achieved by one stock that are significantly higher or lower than the returns of the market. To calculate them, first the expected return for each event i on day t is approximated and then the difference between the real returns of the market and the expected returns R_{it} leads to abnormal returns. The return of the market is estimated using the market model.⁸ The model shown in equation 1 includes α_i as intercept, β_i is the slope parameter and ε_i is the error term which is expected to be zero in case of no event-specific influence. The variable R_{mt} is the return on a comparable market on day t (McWilliams *et al.*, 1997).

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

Equation 1: Calculation of expected returns

From the market model the abnormal return AR_{it} of event i is calculated. Equation 2 shows that AR_{it} is the difference between the real day-to-day return R_{it} calculated from actual

⁷ An example of such a conference is the JavaOne conference organized by Sun Microsystems Inc. (SUN, 2007).

⁸ MacKinlay (1997) gives a detailed description of the market model. Binder (1998) shows that it has advantages compared to the capital asset pricing model, the mean adjusted returns model, and the market adjusted returns model. According to both Strong (1992) and Park (2004) the market model is the most popular model used in event studies.

stock prices and the expected return $a_i + b_i R_{mt}$ based on the market model prediction from equation 1 (MacKinlay, 1997). The parameters a_i and b_i are calculated with an ordinary least squares (OLS) regression of R_{it} on R_{mt} over the estimation window. As is done in most IT-related event studies, I used the NASDAQ Composite Index as comparable market index.⁹ The time series data of the NASDAQ Composite Index and the securities were taken from Thompson Financial Datastream. It has to be noted that the time series data from Thompson Financial Datastream excludes all weekends but not the official holidays and other non-trading days (e.g. the days after September 11, 2001). These days were excluded manually from the dataset.

$$AR_{it} = R_{it} - (a_i + b_i R_{mt})$$

Equation 2: Calculation of abnormal returns

To get evidence of the impact that a specific event has on the stock price the abnormal returns in the event window are aggregated. They can be aggregated over time and across several events (MacKinlay, 1997). In case the aggregation through time is carried out the abnormal returns AR_{it} for a single security are aggregated across the event window. In equation 3, CAR_i is the cumulated abnormal return for a specific security and T_2 the first and T_4 the last day of the event window.¹⁰ This variable also was the dependent variable in the multivariate analysis.

$$CAR_i = \sum_{t=T_2}^{T_4} AR_{it}$$

Equation 3: Calculation of cumulative abnormal returns for a security

⁹ Similar analyses were also conducted using the S&P 500 as comparable market index only to arrive at similar results.

¹⁰ As I am only using a two-day event window in this study, T_3 and T_4 were in fact the same day (see also Figure 1). For the sake of consistency, I will refer to the end of the event window as T_4 .

Independent variable for multivariate analysis. The business model was coded based on the categories introduced before. In the press releases, I looked for information on which of the above business models the firm was primarily intending to follow. This was coded as a dummy variable with respect to whether the business transformation model had been chosen or not. In order to ensure reliability of this variable, multiple coders completed such a categorization independently of one another. Differences were resolved in discussions afterwards, and the final categorization was unanimously accepted.

Control variables for multivariate analysis. Henkel (2006) found that small firms tend to release more code since they lack development resources and benefit from external development support. In addition, I included the firm's R&D-to-sales and sales-per-employee ratio to account for research intensity of the firm and employee productivity. Sales per employee were transformed to sales per 1,000 employees to ease interpretability of the results. In order to measure the effect of time, also with regards to potential investor sentiment (De Long *et al.*, 1990; Lee *et al.*, 1991; Shleifer *et al.*, 1997) due to the rise and fall of the NASDAQ in the course of the dot.com bubble and its burst, I calculated the number of days that had passed since the press conference on April 8, 1998 (Tiemann, 2006) in which "open source" was coined and the day of the event. For ease of interpretation, I divided this figure by 365.25 to arrive at the number of years. Descriptive statistics on both dependent and control variables can be found in Table 3, correlations are given in Table 4.

Insert Table 3 and Table 4 about here

RESULTS

In a univariate analysis, the event sample is first split in two parts based on whether the firms chose the business transformation model or not. As is depicted in Table 5, firms following the business transformation model are evaluated significantly more negatively than their peers following a different business model ($p\text{-value}_{\text{one-sided}} = 0.02$). The evaluation of -1.6% is also significantly different from zero ($p\text{-value}_{\text{one-sided}} = 0.07$), as is the positive evaluation of +1.6% for the other business models ($p\text{-value}_{\text{one-sided}} = 0.04$). Firms using one of the business models cost or risk reduction, dual licensing, or sales of complementary goods or services specifically achieved abnormal returns of 1.7% on the event day, which is also significantly different from zero on a 5% level using the Corrado test (Corrado, 1989), whereas firms employing the business transformation model achieve negative returns on both days.

In the multivariate analysis, I take a look at factors influencing the CAR for the individual events. Conducting a regression analysis with CAR_i as dependent variable using the independent and control variables introduced before, I arrive at a model with an R^2 of 44% (see Table 6). Regarding H1, the use of the business model “business transformation” is compared with the other three, that is, I included a dummy variable measuring whether the business model “business transformation” was chosen (value = 1) or not (value = 0) in the regression, thereby making the selection of any of the other three business models the reference group. The business model business transformation is indeed found to be valued more negatively on a 5% level of significance ($p\text{-value}_{\text{one-sided}} = 0.03$). As both a univariate and a multivariate analysis show this effect, H1 is, consequently, fully confirmed.

Insert Table 5 and Table 6 about here

To control for possible autocorrelation effects between events, that is, events originating from the same firm biasing the outcomes of the study, in two additional regression, I reduced the sample to include only one event by one firm ($N = 30$) by using either only the first or only the last event by the respective firms. In both analyses, the effect of the choice of business model remains significant (using first event only: $p\text{-value}_{\text{one-sided}} = 0.07$; using last event only: $p\text{-value}_{\text{one-sided}} < 0.01$). Similar checks were conducted for events having happened shortly after one another only to find identical results. Moreover, two regressions were conducted in which the five events with the highest (lowest) CAR_i were dropped from the sample ($N = 33$; bottom-five dropped: $p\text{-value}_{\text{one-sided}} = 0.03$; top-five dropped: $p\text{-value}_{\text{one-sided}} = 0.09$), further confirming the validity of the reported results.

DISCUSSION AND IMPLICATIONS

Discussion of Results

In this study, I have shown that openness has a positive impact on the market value of firms provided that an adequate business model has been chosen. I find that firms focusing on the business transformation model see a significantly worse investor reaction than those firms following one of the other three business models. I maintain that the reason behind this negative market reaction is that the business models cost or risk reduction, dual licensing, and sale of complementary goods or services are usually introduced together with a clear revenue model, which enables the company to appropriate value from its OSS engagement, and that the capital market values this more highly than the usually uncertain long-term benefits of the business transformation model. The correlation table also hints in the direction that R&D-intensive firms tend to rather use the business transformation model, whereas firms with lower R&D-to-sales ratio rather choose the sale of complementary goods or services. This could again be an

indication for the more long-term nature of the business transformation model as opposed to the other three. Should the business transformation model, however, turn out to have positive effects over the long run as argued before, this could be an indication of myopic investor behavior. An example for this could be IBM's release of Eclipse that was evaluated negatively by the capital market at the time of the announcement ($CAR_{Event\ 17} = -1.36\%$) yet is widely considered a success for IBM nowadays. With respect to another control variable in the regression, namely productivity as measured by sales per 1,000 employees, this variable is found to be significant ($p < 0.01$) and to carry a positive sign. Seemingly, the capital market thinks that these firms are more likely to succeed at their OSS efforts because they are generally more productive and sales-oriented, indicating that they have already had considerable business success in the past.

Indications for Investor Myopia

Again considering the idea that the business model business transformation has long-term positive effects, I controlled for an improvement of the market valuation of firms choosing this business model over time, with the underlying assumption that the market will come to understand the rationale behind and the positive effects of the initial decision, and consequently react more positively to similar future decisions. For this, an interaction term between the business model business transformation and time was included in the regression (see Table 7). Indeed, while all other factors keep or improve their level of significance, the interaction term is positive and significant ($p_{one-sided} = 0.05$), indicating that the market, over time, has come to better appreciate this business model, too. Another possible explanation might be that the business transformation model has evolved since the inception of OSS: firms have come to understand that the business transformation model as originally chosen was not sustainable—or

at least not accordingly valued by the capital market—and both the model in itself as well as the processes needed to realize it were consequently improved and refined over time.¹¹

Insert Table 7 about here

Conclusion, Limitations, and Suggestions for Future Research

The findings show that value may well be created by firms deciding to open their knowledge in the form of OSS—under the condition that they have a business model for this that includes a clearly communicated revenue model. Firms announcing such initiatives are awarded an average premium on the stock price of 1.6% by the capital market, whereas firms that fail to include a revenue model into their announcement see a 1.6% decrease in their stock price.

Looking at the two days of the event window separately, for firms using the business transformation model, those receive negative returns on each day ($\overline{AR}_{t=-1} = -0.9\%$, $\overline{AR}_{t=0} = -0.7\%$), whereas firms choosing any of the other business models achieve significantly positive returns on the event day ($\overline{AR}_{t=-1} = -0.1\%$, $\overline{AR}_{t=0} = 1.7\%$). Whereas these univariate observations might be biased because of potential investor sentiment during the rise and fall of the dot.com bubble, multivariate analysis confirms the validity of the findings, showing that firms choosing one of the business models cost or risk reduction, dual licensing, or sale of complementary goods or services achieved premiums on their stock price, in particular when compared to firms choosing the business transformation model to engage in OSS.

Yet, the valuation of the latter revenue model has improved over time, either because the capital market has come to understand the potential long-term valuation of this business model,

¹¹ For example, there is a possibility that, of the four models comprising the business transformation category, some might create more value than others or might be easier to put into action, and that these models became more relevant to the business transformation category as a whole only over time. Due to restrictions in sample size, I could not control for such an effect.

or because firms have refined the business transformation model and the processes needed to put it into action. As is also illustrated in Figure 2 (based on the regression coefficients from Table 7), whereas firms choosing the business transformation model have only been able to achieve positive abnormal returns when announcing a release of proprietary software as OSS since early 2006, firms choosing any of the other three business models cost or risk reduction, dual licensing, or sale of complementary goods or assets have almost constantly been able to achieve positive CAR, and only slightly negative CAR from mid 2002 to late 2004.

Insert Figure 2 about here

I think that these findings also contribute to the research on business models in general as they highlight that the capital market is able to distinguish between differences in the choice of business model and the consequences on value appropriation by the firm. Business models that include a clearly articulated and comprehensible—to the capital market, that is—revenue model indicating short-term appropriability of generated value are viewed more positively by investors than business models emphasizing more uncertain long-term effects—at least until the uncertainty has been reduced, that is. This line of research might be extended by further analyzing the differences between the other three revenue models—dual licensing, cost or risk reduction, and the sale of complementary goods and services, or other business models—where I would for example expect mere “outsourcing” deals falling in the cost or risk reduction category to be valued less positively by the capital market than more innovative IT investments especially inherent in the sale of complementary goods and services category (Dehning et al., 2003; Dos Santos et al., 1993).

Like any other event study this paper faces some limitations. One limitation may be the rather small sample size. Limiting the event window to one day so that the confounding check eliminates fewer events might seem as a solution to this problem, however, as I expect rather strong anticipation effects on the day preceding the event, this does not seem to be a wise choice. Rather, one might think about expanding the search terms and applying those to more and different data sources as the ones used in the study, or recomposing the study in a couple of years: since the number of qualified events has been steadily increasing over the past view years, redoing the study in a few years time should produce a much larger sample size. In such a study, learning effects of firms over time might be analyzed, too, that is, such studies could look at whether the success or failure in previous efforts to release source code under an OSS license has an impact on the market valuation of similar future announcement.

Moreover, event studies only take into account events for public companies. Thus, privately held companies are not in the sample. In this study in particular, a lot of events from private companies were excluded. Future research efforts—applying methods different to the one used in this paper—might look at venture capital or corporate venture capital investments in such firms, OSS-based firm acquisitions by publicly-traded companies, or, potentially, at the IPO performance of OSS-based firms, since I expect all of these actions to rise in number in the future.

This study has shown that firms that choose to open up their innovation process to include outside actors, despite giving away much of their intellectual property, are valued positively by the market if they choose an appropriate business model for this strategy. Furthermore, this study has emphasized the need for a view on the capital market in research on openness in general and on OSS in particular. The theme of openness has long become relevant for business world—this study has shown that there is well reason to believe that this relevance

will further increase in the future. Managers thinking about releasing some of their intellectual property into the open thus need not fear a negative reaction of the capital market—that is, if they have carefully selected a business that allows them to both create *and* appropriate value with their efforts. While it is obvious that openness is not the right choice for every firm in the every industry, for many firms, thus, the interesting question will no longer be *whether* to actively open up, but rather *how*, that is, the processes firms need to follow and implement when transforming from a closed to an open innovation regime.

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FIGURES & TABLES

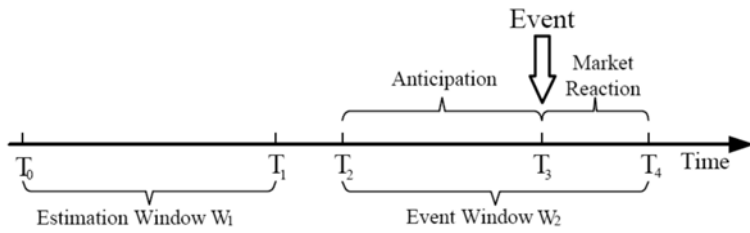


Figure 1: Time windows in event studies (based on MacKinlay (1997))

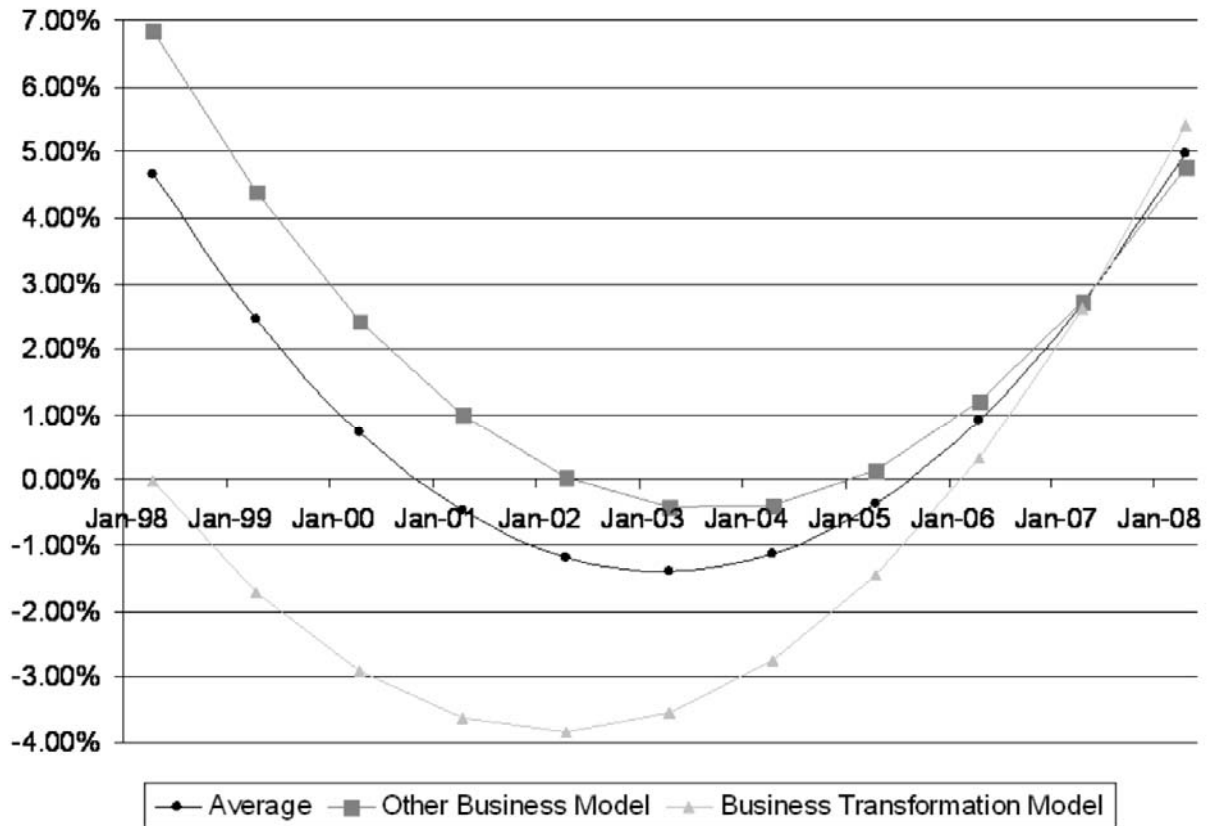


Figure 2: Market valuation of the business models over time

Table 1: Business models in OSS

Business Model	Potential goals	Examples	Revenue source
<i>Business transformation</i>	<ul style="list-style-type: none"> - preventing a competitor from establishing or keeping a dominant standard (“preventing a choke hold”) - setting a standard or tipping the standard race in favor of oneself - commoditizing a layer of the software stack that is of little to no value to the company - advertising oneself as software-developing company on the job market 	<ul style="list-style-type: none"> - Netscape releases source code of Navigator to prevent Microsoft from locking up HTTP and HTML (Raymond, 2001b) - IBM releases Eclipse to replace Sun’s or Microsoft’s “native” software development products with its own standard cross-development framework (Koenig, 2004) - IBM’s support of Linux provided a common set of APIs across IBM’s entire product line, it changed the area of competition so that IBM was able to show its traditional strengths in services, availability, and reliability (West, 2003) - Dresdner Kleinwort Wasserstein releases openadaptor in January 2001 because, in late 2000, “it was very difficult to employ competent developers, because everybody was interested in joining start-ups and getting their share options.” Making openadaptor an OSS project “acted as a kind of advert [...] we are a bank but we do really 	<p>No direct source of income.</p> <p>Benefits will only become visible in the long run and may not be clearly attributable to the OSS release.</p>

		cool stuff” (Henkel, 2004).	
<i>Cost or risk reduction</i>	<ul style="list-style-type: none"> - OSS is cheaper than doing proprietary software development for components that provide basic functionality and little to no sales value, yet are highly critical - Software is not related to the core business, yet further existence of the software is necessary. Releasing the software as OSS helps by reducing the developers’ amount of work on the non-business-relevant program and by securing a continuous stream of actualizations even if they have turned to other projects or left the company 	<ul style="list-style-type: none"> - IBM replaces its own web server development with Apache (Hecker, 1999; Raymond, 2001a) - Two employees at Cisco had devised a clever solution to printer selection and management in the late 1990s. Cisco had no intention of ever selling the software, so they released it into open source. By 2005, one of the two developers had already left the company (Goldman <i>et al.</i>, 2005; Henkel, 2004; Raymond, 2001b) 	Usually, no source of income, but potential for cost reduction. Short-term to mid-term.
<i>Dual licensing</i> Precondition: firms owns 100% of copyrights ¹²	<ul style="list-style-type: none"> - Company offers different licenses of the product to different customer groups, for example a free version to individuals and a commercial version under a company-friendly license to firms 	<ul style="list-style-type: none"> - MySQL offers its database for free to individual developers and offers companies the possibility to purchase commercial licenses that allow for easy integration even into proprietary software products (Goldman <i>et al.</i>, 2005; Raymond, 2001a) 	Licensing revenue. Short-term to mid-term.
<i>Sale of</i>	<ul style="list-style-type: none"> - Services such as consulting, implementation, training, and subscription-based models, as 	<ul style="list-style-type: none"> - Most entirely OSS-based firms run this business model. OSS also allows start-ups to 	Revenue stream from sale of

¹² Releasing software as open source does not mean giving away copyright. Under any OSS license, too, authors of a piece of code still have the copyrights to the parts they wrote.

<p><i>complementary goods or services</i></p>	<p>enterprise customers that choose OSS are in most cases also looking for services around the offer (most easily applicable model)</p> <ul style="list-style-type: none"> - Goods such as software, hardware, documentation, books, or gadgets. In case of releasing OSS related to a certain hardware product, the software itself is usually not a profit center, for example drivers - Adapted model: instead of giving away an entire software product, the company keeps a proprietary core containing the most important functionalities of the software. The company then releases that part of the source code that either enables or shows interaction with the proprietary core, that is, how to best make use of it. To make using the core even easier, the company might think about releasing a software development kit (SDK) 	<p>overcome entry barriers and liabilities of newness and smallness and they are typically faced with (Gruber <i>et al.</i>, 2006)</p> <ul style="list-style-type: none"> - Creative is providing support to the OSS developers trying to make Creative hardware work with Linux (Hecker, 1999; Raymond, 2001b). - Valve Inc. had developed a superior graphical engine for the game Half-Life. By revealing much of the source code of its game but keeping the engine proprietary, people were able to develop add-ons, so called mods, to Half-Life, but running these mods still required the user to own a copy of Half-Life. When the user-innovated mod Counter-Strike was introduced to the market, it immediately took off and became an enormous hit (Jeppesen <i>et al.</i>, 2003). 	<p>complementary good or services. Short-term to mid-term.</p>
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Table 2: List of all events

ID	Firm	Date	CAR_i	Main OSS business model as stated
1	3DFX INTERACTIVE	1999-03-01	0.86%	Comp. goods/services
2	APPLIX	1999-03-02	10.86%	Comp. goods/services
3	SILICON GRAPHICS	1999-04-26	4.18%	Comp. goods/services
4	VISIO	1999-07-27	5.32%	Dual licensing
5	SILICON GRAPHICS	2000-02-14	-0.57%	Comp. goods/services
6	BINDVIEW DEV	2000-02-15	-0.84%	Business transform.
7	SUN MICROSYSTEMS	2000-03-13	-3.92%	Comp. goods/services
8	INTEL	2000-06-15	-3.27%	Comp. goods/services
9	SYBASE	2000-08-22	-1.80%	Cost/risk reduction
10	CADENCE DESIGN SYS.	2000-09-11	12.39%	Comp. goods/services
11	SAP	2000-10-04	-3.79%	Comp. goods/services
12	SANCHEZ COMPUTER ASSOCS.	2000-11-06	4.97%	Comp. goods/services
13	PROGRESS SOFTWARE	2000-12-11	0.02%	Comp. goods/services
14	ADAPTEC	2001-01-30	1.05%	Comp. goods/services
15	SUN MICROSYSTEMS	2001-04-25	-8.38%	Business transform.
16	ON2 TECHS.	2001-08-07	1.08%	Business transform.
17	IBM	2001-11-05	-1.36%	Business transform.
18	OPENWAVE SYS.	2002-05-30	-3.01%	Comp. goods/services
19	ORACLE	2002-08-14	1.12%	Comp. goods/services
20	APPLE	2002-09-25	-2.25%	Business transform.
21	COMMERCE ONE	2003-04-29	-7.57%	Business transform.
22	REALNETWORKS	2003-07-07	-0.48%	Dual licensing
23	BEA SYSTEMS	2004-05-19	1.26%	Comp. goods/services
24	TIPPINGPOINT TECHS.	2004-11-01	11.50%	Comp. goods/services
25	IONA TECHNOLOGIES	2005-06-20	-1.09%	Business transform.
26	EBAY	2005-06-21	-2.51%	Comp. goods/services
27	QUOVADX	2005-07-19	-2.97%	Business transform.
28	ORACLE	2005-08-09	0.88%	Comp. goods/services
29	IBM	2005-08-09	0.61%	Comp. goods/services
30	IBM	2005-08-15	0.42%	Business transform.
31	AUTODESK	2006-03-07	-1.04%	Comp. goods/services
32	WIND RIVER SYSTEMS	2006-07-31	1.46%	Comp. goods/services
33	SUN MICROSYSTEMS	2006-08-23	3.21%	Business transform.
34	TIBCO SOFTWARE	2006-10-02	0.67%	Dual licensing
35	QUALCOMM	2006-10-11	4.92%	Cost/risk reduction
36	ADOBE SYSTEMS	2006-11-07	2.75%	Business transform.
37	SUN MICROSYSTEMS	2006-11-13	-2.09%	Business transform.
38	ADOBE SYSTEMS	2007-04-26	0.07%	Dual licensing

Table 3: Descriptive statistics

	N	Median	Mean	Std. dev.	Min	Max
CAR _i	38	0.00	0.01	0.04	-0.08	0.12
Time	38	4.41	4.86	2.74	0.90	9.05
Time ²	38	19.43	30.96	27.78	0.80	81.88
ln(Total Assets)	38	14.40	14.37	2.58	8.28	18.46
ln(Total Assets) ²	38	207.26	212.91	72.38	68.49	340.74
R&D-to-sales	38	0.16	0.22	0.28	0.06	1.74
Sales per 1,000 employees	38	0.28	2.30	12.48	0.00	77.21
Business transformation	38	0.00	0.32		0	1
Cost/Risk reduction	38	0.00	0.05		0	1
Dual licensing	38	0.00	0.11		0	1
Compl. goods or services	38	1.00	0.53		0	1

Table 4: Correlation table

	CAR _i	Time	Ln (Total assets)	R&D-to-sales	Sales per 1,000 employees	Business transformation
CAR _i	1					
Time	-0.05	1				
ln (Total assets)	-0.12	0.20	1			
R&D-to-sales	-0.04	-0.07	-0.56**	1		
Sales per 1,000 employees	0.41*	0.10	0.22	0.02	1	
Business transformation	-0.34*	0.22	-0.04	0.28†	-0.11	1

† p < .10

* p < .05

** p < .01 (p-values are two-sided)

Table 5: Effect of business model choice (univariate analysis)

Business Model	Obs.	Mean	Std. Err.	Std. Dev.
Business Transformation	12	-0.016	0.010	0.035
Other	26	0.016	0.009	0.045
T-test	0.018** (p-value, one-sided)			

Table 6: Results of OLS regression on CAR using “business transformation” model as reference group

Independent Variable	Coefficient value	Robust standard error
Business model: bus. transf.	-0.025 †	(0.012)
Time	-0.030 *	(0.011)
Time ²	0.003 *	(0.001)
ln(Total assets)	-0.040	(0.027)
ln(Total assets) ²	0.001	(0.001)
R&D-to-sales	-0.029	(0.025)
Sales per 1,000 employees	0.002 **	(0.000)
Constant	0.379 †	(0.199)

Observations	38
R ²	0.438
F-statistic	77.847 **
Degrees of freedom	31

† p < .10, * p < .05, ** p < .01 (p-values are two-sided)

Table 7: Results of OLS regression on CAR including the interaction term time x “business transformation”

Independent Variable	Coefficient value	Robust standard error
Business model: bus. transf.	-0.069 *	(0.030)
Time x business transformation	0.007 †	(0.004)
Time	-0.027 *	(0.011)
Time ²	0.002 *	(0.001)
ln(Total assets)	-0.046 †	(0.025)
ln(Total assets) ²	0.001	(0.001)
R&D-to-sales	-0.024	(0.025)
Sales per 1,000 employees	0.002 **	(0.000)
Constant	0.419 *	(0.186)

Observations	38
R ²	0.469
F-statistic	129.900 **
Degrees of freedom	30

† p < .10, * p < .05, ** p < .01 (p-values are two-sided)

APPENDIX

Table A. 1: Events

ID	Event (Title of Release Announcement)
1	3Dfx Interactive Enables Cross-Platform Development Through Linux Community
2	Applix Launches Open Source Initiative With Applix SHELF; Embeddable, Graphical Programming Language Now Available for Applixware
3	SGI Contributes Key Storage Area Network Media Management Software to Open Source Community
4	Visio Announces Source Code Collaboration Initiative for IntelliCAD Technology
5	SGI Demonstrates High-Performance Itanium Processor Compilers at Intel Forum; Technology to Enhance Linux Application Performance to Be Released to Open Source Community
6	RAZOR Team Offers Free Utility to Put Zombies Back to Sleep
7	Sun Microsystems Announces Plans to Release Cross-Platform Java(TM) Development Tool Code to Open Source Community
8	Intel Software to Make Linux-Based Internet Access and Home Networking Devices Easier to Use
9	Sybase to Open Source Watcom C/C++ and Fortran Compilers
10	Cadence Offers Testbench Authoring Technology as Open Source Solution for Verification Challenges
11	SAP Drives Open-Source Database Development
12	Sanchez Offers GT.M Database as Open Source Freeware to GNU/Linux Users
13	Progress Software Announces Open Source Availability of Its Application Development Environment
14	Adaptec Embraces Open Source/Linux Community
15	Sun Unveils Project JXTA
16	On2 Technologies to Open Source VP3.2 Video Compression Technology; Full-Screen, High-Quality Video Technology Available to Software Community
17	IBM Donates \$40 Million of Software to Open Source Community
18	Openwave Contributes Open Usability Interface to Open Source Community
19	Oracle Announces New Clustered File System for Linux
20	Apple 'Open Sources' Rendezvous
21	Commerce One Releases Open Source, Royalty Free DocSOAP XML Developer Kit for Document Style SOAP
22	RealNetworks Releases Industry Standard SMIL Source Code to Helix Community
23	BEA Plans Open Source Project to Accelerate Java Adoption and Provide Universal Framework for Enterprise Java Applications
24	TippingPoint Releases Open Source Code for First Intrusion Prevention Test Tool, Tomahawk
25	IONA to Introduce Open Source Java Enterprise Service Bus
26	eBay Introduces Community Codebase for Open Source Developers
27	Rogue Wave Software Donates Programming Code for Enterprise Software Development to Open Source Community
28	Oracle's Industry Leading Cluster File System Endorsed by Linux Community
29	IBM Unveils Services and Contributes Management Console Code for Apache Software Foundation Geronimo Project
30	IBM Contributes Open Source Code to Make FireFox Browser More Accessible
31	Autodesk Announces Availability of MapGuide Open Source Web Mapping Software Through the Open Source Geospatial Foundation
32	Wind River Contributes Over 300,000 Lines of Code to the Eclipse Foundation
33	Sun Open Sources Java Mobile Edition Development Tool
34	TIBCO to Open Source Best-Rated AJAX Rich Internet Application Toolkit
35	QUALCOMM Launches Project in Collaboration With Mozilla Foundation to Develop Open Source Version of Eudora Email Program
36	Adobe and Mozilla Foundation to Open Source Flash Player Scripting Engine
37	Sun Open Sources Java Platform and Releases Source Code Under GPL License Via NetBeans and Java.net Communities
38	Adobe to Open Source Flex