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Category Divergence, Straddling, and Currency: Open Innovation and the Legitimation of Illegitimate Categories

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Citation

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ABSTRACT   The organizational literature is increasingly interested in the origins and consequences of category emergence. We examine the effects of being affiliated with categories initially considered illegitimate ('divergence'), and of organizational attempts to blur the boundaries between categories ('straddling'), on capital market reactions to firm announcements. We develop arguments for how these effects likely vary with increasing legitimation ('currency') of the category. We apply event study methodology to the complete population of firms' announcements of open source activities, an open innovation model for software development that is novel and defies the extant dominant logic of software production and valorization. Over a ten-year period, we find negative effects of divergence, positive effects of straddling, and that the magnitude of both these effects diminishes with increasing category currency. The implications for theories of organization and open innovation in the context of category emergence are discussed.

Keywords: category emergence, open innovation, open source software, organizational legitimacy, valuation

INTRODUCTION

Categories provide firms with a 'conceptual system' (Rosa et al., 1999, p. 64) to 'organize information, generate shared meaning, affect valuation, and facilitate exchange in market settings' (Khaire and Wadhwani, 2010, p. 1282). Category systems encourage producers to display similar behaviour or appearance as comparable rivals so as to remain easy to compare and evaluate (Khaire and Wadhwani, 2010; Navis and Glynn, 2010; Rosa et al., 1999). In contrast, firms choosing to be different are punished with an illegitimacy discount – their actions are valued more negatively simply because they do not conform to existing categories (Hannan et al., 2007; Zuckerman, 1999). Yet, this view of categorization as resulting from comparisons with largely static prototypes creates a challenge in

explaining how innovation can ever be legitimate. Accordingly, in his seminal work on the negative consequences of unclear categorical membership on firm evaluations, Zuckerman (1999) already questioned whether innovative behaviour that breaks out of established categorical paradigms, while risking punishment by audiences in the present, may not turn out to be the superior competitive choice in the long run.

To address this dilemma, a recent surge of academic work has documented how organizations can facilitate the creation of new categories over time that bestow legitimacy on actions that are novel or were previously looked down upon (Kaplan, 2011). For example, Rao et al. (2003) describe how nouvelle cuisine emerged as a legitimate category because it was founded by high-status defectors from an established category. King et al. (2011) show how the novel organizational form of charter school legitimately emerged following legislation enabling its creation and proliferation (see Jensen (2010) for a similar argument about pornography in Denmark). Finally, Navis and Glynn (2011) and Smith (2011) argue that being consistently different in itself may represent a legitimate identity, allowing firms to experiment with new organizational configurations and innovation. In short, these examples reveal that categories rarely emerge from a void; rather, new categorical boundaries and elements of the novel category often receive some legitimation from the outset based on inherent interlinkages to other elements of a larger category system. Because they will make membership in the novel category seem proper and desirable, such interlinkages lead to an incipient positive evaluation of the legitimacy or 'currency' (Kennedy et al., 2010) of a category in the eyes of a specific audience. This is because even though the actual meaning of the category may yet be unclear, valence – the degree of appeal that category membership has in the eyes of a specific audience (Kennedy et al., 2010) – derived from said linkages may provide some initial legitimation to the category from the viewpoint of a certain audience.

We build on these recent advances by asking: What if the core logic underlying a novel category ran counter to the existing schema and no substantive positive interlinkages were yet in place? Specifically, we study *how innovation in categories perceived as illegitimate is evaluated and how and why this evaluation changes over time*. First, we theorize the effects of perceived membership in the new category on audience evaluation. Second, we look at the members of the new category to analyse whether they may be able to differently relate to existing elements of the larger category schema to arrive at alternative evaluations. And finally, as suggested recently (Durand and Paolella, 2013; Kennedy et al., 2010), we study whether audiences update their categorization, resulting in increasing levels of category currency.

Empirically, we examine the emergence of commercial engagement in open source software (OSS) as an exemplar of open innovation. Generally, the mechanisms by which firms access knowledge beyond their boundaries to create value, sometimes by ceding control of product development pathways and its own intellectual property rights, are referred to as 'open business models' (Chesbrough, 2006). In the case of OSS, while supported by a significant social movement (see also Kuilman and Li, 2009; Rao et al., 2003), the logic at its heart clashed with prevailing ways of doing business in the software industry: rather than selling per-piece licences of the software in a format that could only be read by machines, not only would all OSS customers receive the human-readable source code of the software, they would also be allowed to modify it and pass it on free

of charge, without consulting the original authors, effectively eliminating revenues from software sales. The forsaking of the prevalent appropriation mechanism of secrecy and the lack of known valorization methods leads us to argue that the capital market, a crucial audience for software firms, considered OSS a clear infringement of established ways of profiting from software development, creating the empirical setting needed to study our research question. Also, since benefitting from engagement in commercial OSS development is dependent on successfully establishing collaborations with external actors, it is likely that companies will publicly announce such efforts, and simultaneously attempt to legitimize them to their audience (see Martens et al., 2007) by laying out the mechanisms through which the company intends to benefit from OSS: the open business model.

To examine the ten-year period from the inception of the OSS, we conducted an event study analysis of the complete population of firms announcing their intent to provide an OSS product which they could have sold as proprietary software. We collected press releases of publicly-listed firms, assessed their perceived category membership at that time, and scrutinized them for the exact way in which they intended to monetize OSS. Thus, following a long tradition of studies on categories (e.g. Hsu, 2006; Negro et al., 2010; Pontikes, 2008), we look at how individual actions by organizations are perceived by relevant audiences, and how this perception affects evaluation.

In doing so, we make three contributions to the literature on organization and innovation. First, we highlight the initial negative effect of membership in true 'low currency' categories. However, we also show relative differences in evaluations between members of this category based on how well a chosen business model aligns to extant logics of valorizing software (Karthikeyan and Wezel, 2010; Kennedy et al., 2010). Second, in line with the causal-model view of categories, we find that, over time, audiences change their evaluation scheme, impacting both the overall category currency as well as earlier differences in evaluation of different models. Finally, the study addresses a significant gap in the literature on the value created by 'openness'. Whereas studies speculate using anecdotal evidence on the benefits of openness (e.g. Chesbrough, 2003; von Hippel and von Krogh, 2003), this is the first systematic study to proffer evidence that open business models influence firm value.

THEORY AND HYPOTHESES

Legitimacy is defined as the 'generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions' (Suchman, 1995, p. 574). Firms achieve legitimacy on the capital market by conforming to widely accepted categories (Hannan et al., 2007; Zuckerman, 1999), with categorization having two related, yet distinct effects (e.g. Khaire and Wadhwani, 2010; Navis and Glynn, 2010). First, categories establish social and symbolic boundaries demarcating stable collective identities for firms or products. These highlight differences and similarities between categories and between category members and non-members, easing audiences' ability to process and interpret related information (e.g. Khaire and Wadhwani, 2010). Second, category meanings shape expectations about members. Categories allow producers and audiences to develop a

common understanding of how firms or products within a category should look or act, allowing for their comparison and relative evaluation (e.g. Lounsbury and Rao, 2004). In short, audiences, such as consumers, critics, and the capital market, are hypothesized to compare firms' actions with taken-for-granted prototypical representations of legitimate, category-conforming behaviour (Durand and Paolella, 2013; Kennedy et al., 2010), punishing divergent behaviour inside one category as well as simultaneous membership in multiple categories (Hsu, 2006).

In light of the boundary-spanning nature often inherent in innovative activity, recent studies have taken a critical perspective on earlier work for its focus on static, taken-for-granted categories resulting from prototype-based comparisons (e.g. Durand and Paolella, 2013; Kennedy et al., 2010; Schneiberg and Beck, 2010; Wry et al., 2011). Most importantly, when innovative activity defies the logics behind extant categories – as is the case for corporate engagement in OSS – no suitable categories or frame of reference can possibly exist to which such behaviour can be compared (Navis and Glynn, 2010). Consequently, legitimacy in the eyes of audiences should always be negative, implying innovative firms would always be punished in the present, even though innovation will often result in longer-term superior performance (Zuckerman, 1999).

To scrutinize this dilemma, researchers have started to examine the socio-cognitive processes and performance consequences of category emergence – the legitimation of novel categories. First, this literature shows that categorization does not need to be based on the comparisons of prototypes (Durand and Paolella, 2013), and strict adherence to prototypes is not always necessary for positive audience reactions. Rather, some categories show an inherent 'leniency' or 'fuzziness' (Hannan, 2010; Pontikes, 2008), resulting in lower punishments for deviance or multiple memberships. Accordingly, circumstances exist under which organizations may posit membership claims to multiple categories, with positive evaluations being attributable to the fact that, in essence, such category-straddling bridges a gap between two separate legitimate categories, where membership in each should be desirable by companies (Hannan et al., 2007). Nevertheless, singular membership in either category is still considered a superior strategy, as increasing numbers of category-straddling organizations blur the distinctiveness of each individual category and confuse relevant audiences, causing lower evaluations (Kovács and Hannan, 2010; Negro et al., 2010).

Second, the literature has begun to study the emergence of novel categories in its own right. Here, empirical work has largely looked at cases in which the new category has an incipient position in a larger category system (e.g. Jensen, 2010; King et al., 2011; Navis and Glynn, 2011; Rao et al., 2003; Smith, 2011). In these instances, the space in which novel categories are created has been legitimated in some form or another, increasing the desirability of membership and likelihood of audiences displaying more favourable reactions. Indeed, some authors explicitly acknowledge that the focus of their and others' work centres on cases of positive valence, that is, of novel categories that audiences would describe as appealing from the outset (Hannan et al., 2007; Kennedy et al., 2010; Schneiberg and Beck, 2010).

In contrast, when innovation takes the form of creative destruction (Schumpeter, 1911), companies will strive to supplant existing technological solutions and the systems in which they are embedded. These new firms, at least initially, will be directly competing

against members of the old guard around which categorization schemas are built, while falling outside existing categorical boundaries so that audiences might be unsure about the meaning of these new organizations. However, even if audiences do not understand *what* the innovation is, they should be highly cognizant of the fact *that* it is substantially different (see also Wry et al., 2011). In turn, recent literature argues that rather than invoking an automatic punishment for divergence from established prototypes, audiences will implicitly or explicitly challenge their simple prototypical schemas and develop cause–effect models to explain categorical differences and membership (Durand and Paolella, 2013). This argument is relevant for three reasons. First, it implies that audiences may consider competing institutional logics at the same time (Rao et al., 2003). Second, audiences using causal models of categorization will only require an organization to display essential features of the respective category, often implicitly adding other non-observed features (Durand and Paolella, 2013; Hannan et al., 2007). Finally, audiences may update their causal models based on new information – simply stated, audiences learn, and increased levels of expertise will positively affect their evaluations, possibly leading to the institutionalization of new or modified categories (Durand and Paolella, 2013; Kovács and Hannan, 2010). Below, we derive hypotheses related to each of these three points in our empirical context.

The Negative Effect of Category Membership in Open Source

OSS represents a radically different approach to developing, distributing, and valorizing software development. Notably, this approach was historically fuelled by an identity movement, the free software movement, which tried to establish an alternative logic to developing software. This movement, however, was considered to hold an anti-business ideology, and accordingly lacked support from business (see also Moody, 2001, and our data and methods section). To overcome this problem, leading activists in the free software movement created the new label 'OSS' to invite the business world to join them in establishing OSS as a legitimate method of commercial software development.

In theoretical terms, this movement aimed at actively creating a new category through subdivision (Kennedy et al., 2010): splitting up the existent category of software development into OSS and 'closed source' software, a distinction which had previously not existed. Thus far, most software companies had tried to achieve profits by developing source code in-house, and selling per-piece licences to consumers from whom the source code would be kept secret. The advent of OSS should have made exactly those features more salient to relevant audiences (see Durand and Paolella, 2013): *better* software firms are those following the old model, because they make money from selling their closed software. In turn, the proposed OSS category should be of low currency: not only might audiences struggle to understand it due to its novelty, more importantly, membership in the category will not be considered desirable in the eyes of the audience due to the obvious disconformance with the dominant logic of software development. Notably, such clear contrast between two categories is usually felt to be beneficial to members of both categories (Hannan, 2010; Hannan et al., 2007; Negro et al., 2010). However, it should be an outright disadvantage for aspiring members of a category for which high contrast only highlights its disconformity with established models of production and valorization.

Accordingly, when an organization announces engagement in OSS, its evaluation will depend on the degree to which the audience perceives the focal firm as an actual proponent or member of the OSS category. The more a firm's identity is perceived as aligned with an illegitimate category, the higher the chance it receives a negative evaluation by an audience *even if it conforms to the expectations of that category*. That is, even if categorical boundaries are relatively clear and a firm's identity falls within these boundaries, if category valence is negative, a negative evaluation by the audience should ensue. Thus, we hypothesize:

Hypothesis 1: The more strongly an organization is identified with the OSS category, the more its stock price will decline when announcing commercial engagement in OSS.

The Positive Effect of Category Straddling

The literature is clear about the negative effects of category straddling, that is, claiming membership of, or choosing to incorporate attributes from, multiple categories (e.g. Hannan, 2010; Hannan et al., 2007; Zuckerman, 1999). Traditionally, three reasons have been suggested for this (Durand and Paolella, 2013). First, category-straddling creates less meaningful identities, which is not appreciated by audiences (Negro et al., 2010). Second, straddling organizations will lack capabilities in the categories to which they claim membership – they risk becoming a 'jack-of-all-trades, but master of none' (Hsu, 2006). Finally, category-straddling may cognitively overstrain the monitoring capacity of audiences, and difficult-to-classify organizations receive less positive evaluations (Zuckerman, 1999).

However, when an emerging category conflicts with prevailing logics, the effects of straddling may need to be reconsidered (Kennedy et al., 2010). First, members of an illegitimate category have nothing to lose; on the contrary, if they convincingly borrow language and meaning from existing legitimate categories, the net effect of category-straddling on legitimation of the new category may well be positive. Put differently, if straddling negatively affects the valence of taken-for-granted categories by decreasing contrast (Kovács and Hannan, 2010; Negro et al., 2010), we expect that the same action should positively affect low-valence categories by allowing for legitimacy spillovers (Kuilman and Li, 2009) from higher-valence categories. Second, straddling will allow actors to establish parallels, analogies, or syllogisms using extant categories, which may increase audience understanding of what the firm does as well as lend a frame of reference through which an audience may attempt to evaluate the firm (Kennedy et al., 2010; Martens et al., 2007). In particular, enriching such analogies with elements of the firm-specific context to give them new meaning may be positively received by audiences (Karthikeyan and Wezel, 2010). In the context of innovative activity, for example, press releases are actively used by organization to present them as 'the right organization for the job' (Suchman, 1995, p. 581) by pointing out past successes, strong partners, or bright futures. Companies may even speak positively about direct competitors to jointly facilitate the legitimation of the category (Kennedy, 2008; Navis and Glynn, 2010). Finally, organizations that straddle categories may do so to deceive audiences about their true

category membership. Specifically, when audiences apply causal-model logics to determine organizations' category membership, what they will be looking for are only certain core features of an organization (Durand and Paolella, 2013; Hannan et al., 2007). Knowing that, the illegitimate firm may either genuinely try to embrace as many features of a legitimate category as possible, or just symbolically claim that it does so. For example, Vergne (2012) finds that arms producers are able to dilute audience attention about their membership in this permanently illegitimate, stigmatized category by straddling multiple categories.

Taken together, we argue that even when a new category fundamentally goes against the extant category system, there will be gradients of disconformity, the specific level of which should impact audiences' evaluation. These gradients will be the result of two preconditions, or their combination. First, there may be actual variation between members of the new category, a very easy-to-uphold assumption given that novel categories will have no prototypical representation and will thus still be subject to considerable diversity and experimentation by members (Navis and Glynn, 2010; Schneiberg and Beck, 2010). Second, firms may deliberately attempt to socially justify their idiosyncratic actions to their audiences and downplay or cover-up the essential illegitimacy of some their actions to the greatest possible degree (Vergne, 2012), thus creating variation through communication rather than actions.

In the context of corporate engagement in OSS, the information most relevant to audiences with respect to the valorization of software development will be the business model the company intends to apply to the specific piece of software. Generally, business models will contain information on how the firm intends to create value for its customers, and appropriate some of this value for itself (Amit and Zott, 2001; George and Bock, 2011). Innovative business models could also be seen as valuable when they increase the firm's strategic flexibility when competing in tough product markets (Bock et al., 2012). Depending on its knowledge, resource position and goals, firms can employ different business models to create value from OSS and optimally balance their potential advantages and disadvantages. Specifically, in the press release in which the company announces its intent to engage in OSS development, it should also state how it intends to benefit from OSS so as to appease capital markets to the maximum possible degree. Reviewing the literature on commercial engagement in OSS and open innovation more generally, we identify four unique business models which companies may apply.

Their definitions and descriptions, given in Table I, allow us to juxtapose the four types of open business models with traditional 'closed' business models (Chesbrough, 2003), emphasizing the protection of innovative outputs through intellectual property rights or secrecy to achieve monopoly rents. We find that three of the open business model types – cost or risk reduction, dual licensing, and the sales of complementary goods or services – explicitly encourage a hybrid business model design (Bonaccorsi et al., 2006) that incorporates the joint deployment of open as well as traditional, closed elements. Thus, companies choosing either of these hybrid models should find themselves aligned more closely with extant closed models of software development on a cognitive dimension. This is most prominently the case for dual licensing and cost or risk reduction that have direct analogues in technology commercialization and efficiency-driven models of product development, such as outsourcing. Similarly, firms

Table I. Categorization of open source business models

Business model	Potential goals	Examples
Dual licensing	Company offers different licences of the product to different customer groups, for example a free version to individuals and a commercial version under a company-friendly licence to firms. Precondition: firms owns 100% of copyright	MySQL offers its database for free to individual developers and offers companies the possibility to purchase commercial licences that allow for easy integration even into proprietary software products (Hecker, 1999)
Sale of complementary goods or services	Complementary services such as consulting, implementation, training, and subscription-based models, as enterprise customers that choose OSS are in most cases also looking for services around the offer (most easily applicable model)	Most entirely OSS-based firms run this business model. OSS also allows start-ups to overcome entry barriers and liabilities of newness and smallness and they are typically faced with (Gruber and Henkel, 2006)
	Complementary hardware, devices. In case of releasing OSS related to a certain hardware product, the software itself is usually not a profit centre, for example drivers. As before, the firm is still earning money through hardware sales, OSS should lower development cost over time	Creative is providing support to the OSS developers trying to make Creative hardware work with Linux (Hecker, 1999).
	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)	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 and Molin, 2003).
Business transformation	Preventing a competitor from establishing or keeping a dominant standard ('preventing a choke hold')	Netscape releases source code of Navigator to prevent Microsoft from locking up HTTP and HTML (Moody, 2001, ch. 11)
	Setting a standard or tipping the standard race in favour of oneself	IBM releases Eclipse to replace Sun's or Microsoft's 'native' software development products with its own standard cross-development framework (West, 2003)
	Commoditizing a layer of the software stack that is of little or no value to the company	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)
	Advertising oneself as software-developing company on the job market	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 cool stuff' (Henkel, 2004)
Cost or risk reduction	OSS is cheaper than doing proprietary software development for components that provide basic functionality and little to no sales value, yet are highly critical	IBM replaces its own web server development with Apache (Hecker, 1999)
	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 time spent by developers 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	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 (Henkel, 2004)

Additional references are available from the authors upon request.

focusing on the sale of complementary goods or services may invoke traditional logics of 'razor-and-blade' business models. Consequently, companies choosing one of these three models may borrow on extant closed business model language, draw successful parallels and analogies, and may hope to activate within their audience existing evaluation schemes of the legitimate closed source software category.

In contrast, the business transformation model (see Table I) differs radically from traditional business models. The benefits of this model are completely contingent upon the new logic of being open. Accordingly, it cannot be deployed in a hybrid form to mask its deviation from established definitions of software business, which should decrease the valence of this subset of the category. Furthermore, investors and stakeholders will lack understanding of the business transformation model, so that its meaning should be more unclear than any of the hybrid models. In particular, the business transformation model will seem long-term and speculative, and thus more uncertain than the hybrid models, further highlighting its non-conformance with established business model categories. Taken together, we would thus predict variance in the audience's reaction to different embodiments of the new category 'open source business model' depending on whether firms are following a hybrid business model that can build on and borrow from extant legitimate elements of the larger category system, or not:

Hypothesis 2: The higher the cognitive divergence of the business model the company chooses to engage in OSS, the more its stock price will decline when announcing commercial engagement in OSS relative to companies that have chosen business models in closer cognitive proximity to existing legitimate categories.

The Moderating Effects of Category Emergence

However, the evaluation of audiences need not be static over time – and even producers in categories associated with strong social stigma may finds ways of manipulating existing categorization schemes to attain higher levels of legitimacy (Jensen, 2010). In particular, if a newly proposed category is strongly supported by a social movement – as is the case in our empirical context (Moody, 2001) – an increase in both the shared meaning as well as the perceived valence of the category should ensue. For example, Weber et al. (2008) highlight how the dynamics of social movements may lead to the creation of new market niches by constructing an alternative logic which then emerges into novel, official categories.

More generally, Lounsbury and Rao (2004) describe how new categories are created to reduce uncertainty in the market following the introduction of products that do not fit existing categories. In turn, novel categories are legitimized by achieving consensus among audience members about what features and behaviours of a potential member should be considered appropriate and desirable (see, e.g. Cattani et al., 2008; Navis and Glynn, 2010). After such a profile is established, it is used by observers to judge the legitimacy of firms and their actions, and may be updated continuously in this process. For example, Khaire and Wadhwani (2010) show how new categories are formed and shaped by discourses fostered by agents in existing markets, resulting in more consistent as well as more positive valuations of its members. In short, received theory proposes the

emergence of new categories as a reaction to a repeated mismatch of the existing categorization scheme and reality (e.g. Kaplan, 2011; Pontikes, 2008). While such a mismatch may cause the negative reactions by audiences described above *in the present*, at the same time, it should trigger a learning and updating process, resulting in a revised categorization scheme *in the future* (Durand and Paolella, 2013).

The outcome of this updating process may be either the redefinition of the boundaries of the old category to include the newly observed behaviour, or the subdivision of the old category with the divergent behaviour attaining legitimate category status in its own right (Kennedy et al., 2010). Either case would imply a convergence in the meaning of a new category, with valence also increasing. In turn, once the new category achieves taken-for-granted status, it too can act as a frame of reference to legitimate previously illegitimate action and possibly even a target of isomorphic behaviour (Suchman, 1995).

Consequently, the emergence of a new category should have important effects on perceived category membership in OSS in general, as well as on the choice of the specific business model to enact it. As to the former, once category currency increases, membership should no longer lead to automatic devaluation (Kennedy et al., 2010). Rather, we would expect a concomitant reduction in the punishment that firms receive for announcing their intent to join it. Regarding the latter, the relative difference in valuation of open business models should disappear, too. A new category that legitimizes OSS will apply to all open business models, irrespective of their (dis)similarity to traditional business models. Importantly, though effort- and time-intensive, open-source strategies aimed largely at standard-setting and influencing technological trajectories can create value in varied settings ranging from the built environment, to synthetic biology, to agriculture (Alexy and Reitzig, 2011). Thus, a perpetual devaluation of the business transformation model by default should be less likely than a change in its relative evaluation versus the hybrid models. Rather, as argued before, audiences' learning and updating processes initiated by repeated exposure to firms reaping the benefits of this business model will initiate the emergence and reordering of prevailing causal models that audiences use for categorization (Smith, 2011). This revised order, in turn, will provide a frame of reference that will equally legitimize those forms of OSS engagement previously considered divergent and the hybrid business models. Taken together, we thus hypothesize:

Hypothesis 3a: With increasing levels of legitimation of the OSS category, the negative effect of perceived category membership on stock price will diminish.

Hypothesis 3b: With increasing levels of legitimation of the OSS category, the relative difference in evaluation of OSS business models based on their cognitive proximity to existing categories will decrease.

DATA AND METHOD

The Open Source Phenomenon

We analysed the effects of firm engagement in OSS on their market value from its official inception in 1998 until 2008. As indicated above, the term 'open source software' was

originally created to describe a certain type of software that had previously been most often, but not consistently, described as 'free software'. This change of term was instigated by some of the leading individuals in the field, both to more clearly delineate this type of software from others erroneously conceived as similar in the public mind, such as freeware or shareware, and to counter the commercial world's fears of the term 'free' (Moody, 2001). Indeed, we find that over our ten-year period, a considerable number of firms previously considered 'closed' join the open source movement as *de alio* entrants to reap possible technological benefits of being open, and also to try influencing the direction of the social movement in a way that its outputs become more beneficial to the focal firm (Alexy et al., 2012; Durand and Jourdan, forthcoming).

For the participating actors, there is general agreement about what is encompassed by the term open source from the outset (see Wry et al., 2011). Specifically, since its inception in April 1998 (Moody, 2001), the term OSS is specified by the Open Source Initiative (OSI). Following their definition, OSS is software that is licensed under a licence approved by the OSI. Here, 'open' does not necessarily mean that the software is gratis, although this is very common. For a licence to be OSI-compliant, users of the respective software need to have 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 endeavour is allowed. Contrary to machine code, which is derived from source code through compilation, source code is readable by humans. Any person that has the required programming skills and a compiler, which may also be obtained for free, can thus generate their own version of the program from the source code and even adapt the program to their needs by modifying the source code accordingly.

Over time, both the use of the term OSS in the commercial press as well as its diffusion and its strategic use by 'traditional' firms have increased substantially (Fosfuri et al., 2008). In addition, we observe a considerable increase in the number of new entrants in the OSS space (Bonaccorsi et al., 2006; Dahlander, 2007), as well as industry analysts focusing explicitly on OSS (e.g. Driver and Weiss, 2005). These developments are supported by a growing social movement behind open source (Moody, 2001), increasing media attention (e.g. *Economist*, 2003), as well as a growing interest in open business models in general (e.g. Chesbrough, 2006; Chesbrough and Appleyard, 2007). For example, IBM announced its support for OSS in 1999, analyst houses Gartner and Forrester published their first dedicated reports on open source about 2001, and RedMonk, the first analyst firm explicitly focusing on open source, was founded in 2002. Taken together, these developments allow us to conclude that, since the inception of OSS in 1998, a new category of 'open business models' has emerged and gradually congealed through the interaction of internal and external factors (see also Navis and Glynn, 2010), suitable to study the potentially changing effects of firms' OSS engagement and its impact on firms' market value.

Data Collection and Event Study Methodology

Event studies using daily stock market returns are widely used in management literature as an appropriate technique to measure the financial impact of innovation and changes in corporate policy (e.g. Fosfuri and Giarratana, 2009; McWilliams and Siegel, 1997).

Contrary to accounting-based measures, stock market returns are reportedly more objective and less subject to manipulation by managers (McWilliams and Siegel, 1997). We follow the research design advocated by scholars in financial economics and management (e.g. MacKinlay, 1997; McWilliams and Siegel, 1997). Below, we describe the steps that need to be completed by the researcher to conduct any event study: (1) definition of what exactly is considered an event; (2) collecting data on all events; (3) controlling for confounding events; and (4) selection of estimation parameters to calculate abnormal returns.

In an event study, stock market reactions to the public disclosure of information affecting a firm are investigated. 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).[1] Thus, when firms announce that they intend to engage in OSS, the evaluation of this decision by investors can be expected to be included in the stock price shortly after the announcement. Following our theorizing, we define an event as follows:

> An event is the announcement of commercial engagement in OSS development, exemplified by the release of proprietary source code – that could have been or has been sold as a closed-source product – under an OSI-compliant licence.

Second, we identified all events between April 1998 and August 2008. Using Lexis Nexis and Factiva, we searched the PR-Newswire, Business Wire, and Market Wire databases for firms listed on the AMEX, NYSE, or NASDAQ that made press announcements matching our event definition in this period of time. Starting from over 14,000 press releases, we ended up with 236 distinct events by 94 firms that represent the complete population of firms engaging in OSS commercially since its inception until August 2008.[2]

Third, to make a causal attribution between events and changes in stock price, we searched, in an extended time window including the event window (see below) and one day before and after, for any other significant pieces of news in the above sources. The presence of such confounding effects (e.g. the announcement of new products, information about pending lawsuits, or the release of quarterly or annual reports) implies that the respective observation has to be removed from the sample (e.g. MacKinlay, 1997; McWilliams and Siegel, 1997). We identified 77 events by 52 firms that had not been subject to any apparent confounding effects. A possible reason for the mass of confounding events may be that many software companies tend to publish information on new products and strategic partnerships in bundles during conferences and other media events. Whereas a sample size of 77 is more than acceptable for this type of study (e.g. McWilliams and Siegel, 1997; Oh et al., 2006), we can control for potential selection-bias issues this introduces by estimating a probit model predicting the likelihood of entering our sample, and including the resulting inverse Mills ratio into our regression model.

Finally, to be able to calculate cumulative abnormal returns, we needed to define the parameters based on which they would be compiled. Event studies specify an expected market return based on its relative performance to an index, and the period of time over which this is done is called the estimation window. Daily stock returns are calculated using the closing price of both the stock and the index, and the resulting time series of

returns are linked via a regression equation. The resulting regression coefficients and the actual returns achieved by the market index are used to calculate daily anticipated stock returns during the event window – the period of time in which the event is theorized to impact the stock returns. Then, for each day in the event window, the difference between anticipated stock returns and actually achieved stock returns is calculated, and their sum equals cumulative abnormal returns. In this process, the researcher has to make a decision about the length of both time windows, the time lag between them, and the model used to predict the anticipated stock price.

Building on a long-standing tradition of event studies in the IT industries, we employ a 125-workday-long estimation window and an event window that includes the day of the event and, to control for anticipation effects, the day before the event (e.g. Oh et al., 2006). Armitage (1995) shows how this length of estimation window is easily sufficient to attain consistent estimators. The two time windows are separated by a 5-workday-long lag. To estimate the returns of the market, we use the market model (see MacKinlay, 1997 for details). 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 Armitage (1995), Park (2004), and others, the market model is the most popular model used in event studies. Finally, the NASDAQ Composite Index is used as comparable market index. The time series data of the NASDAQ and all securities were taken from Thompson Financial Datastream and corrected for official holidays and other non-trading days (e.g. the days after September 11, 2001).

Measures

Dependent variable. Cumulative abnormal returns (CAR) are the key dependent variable used in event studies. As described above, CAR is defined as the difference of the returns achieved by a stock during the event window minus the return expected based on its past performance, as compared to the returns of the market over the estimation window.

Independent variables. Following our hypotheses, we have three core independent variables, all created at the specific point in time of the event: the firm's perceived category membership in OSS; the business model announced in the event; and the degree of legitimation of the OSS category.

For perceived category membership, we build on extant work determining it through co-mentions (Karthikeyan and Wezel, 2010; Kennedy, 2008). Specifically, even though technical benefits from OSS result from engagement with other organizations and members of the public, firms may try to hide this exposure from the capital market, which should be feasible given that it is a completely separate audience. Oppositely, other firms, in their attempt to legitimate the category, will readily name the focal firm as another valiant actor in this space, which audiences will interpret as these firms belonging to the same category (Navis and Glynn, 2010). Accordingly, for each firm, we collect all press releases published by other firms which (1) mention the focal firm, and (2) are related to OSS. The resulting variable *perceived category membership* is determined by the

count of all such press releases in the year preceding the focal event. To ease interpretability of our regression coefficients, we further divide this variable by 100.

Regarding the business model, we were only interested in whether a company chose one of the hybrid business models or not. Provided with the list of open business models given in Table I, at least two out of a pool of five coders independently coded each of the firms' press releases announcing the OSS activities, looking for information on which of the above business models the firm was primarily intending to follow, using all four possible open business model classifications. Thus, the list in Table I is interpreted as a set of archetypes, and coders reading the press releases made their coding decision based on their assessment of which archetype a given release most closely resembled. Selected codings, including excerpts from the corresponding press releases, are given in the Appendix. We then transformed this coding into one single dummy variable capturing whether the clearly non-conformant business model 'business transformation' or any of the three hybrid business models was chosen (1: business transformation; 0: hybrid model). This coding showed very high inter-rater reliability (average share of agreement 86%, average kappa 0.70). To check our coding processes (Miles and Huberman, 1994), differences in codings were resolved in discussions afterwards. In the few cases where neither coder converged, the event was escalated to a third coder who was used as a tie breaker. The resulting dummy variable *divergent business model* in the regression thus measures the effect of choosing the business transformation model relative to choosing a hybrid business model.

Finally, we created several variables to approximate the emergence of a new category of 'open business models' in line with a variety of studies that share our focal interest in legitimacy as jointly constructed by agents and audience (e.g. Hannan et al., 2007; Kennedy, 2008). Specifically, we experimented with: (1) days passed since the inception of OSS; (2) the number of media mentions of OSS; (3) a simple count of preceding events in our sample; (4) density, measured by the number of unique firms in our sample that had announced their engagement; and (5) an index built from the standardized values of variables (1)–(4), which displayed a Cronbach's alpha of 0.995. Notably, the four baseline variables correlate higher than 0.97, suggesting that, in our case, they are almost interchangeable measures of category emergence. Since *density* has gathered most attention in extant literature on categorization and has also been proposed to operationalize category valence (Kennedy et al., 2010), we chose it to measure category emergence and legitimation. We further divide this variable by ten to ease interpretability of coefficients. Finally, to arrive at the interaction effects we hypothesize in Hypothesis 3, we multiply density with the two other independent variables.

Control variables. We use a series of variables to control for non-spuriousness of our effects. Descriptive statistics on these controls, and on all other variables as well as correlations, can be found in Table II.

Since we use *density* to construct our interaction terms, it is also included as control. Further, in line with the literature using this measure, we run models with and without *density-squared*, with no effects on our variables of interest. In addition, we try to measure a firm's self-proclaimed gradient of membership (Hannan et al., 2007), focus, and interest in the OSS space by calculating the *share of press releases of the focal firm over the past year*

Table II. Descriptive statistics and correlation table (n = 77)

	(1) CAR	(2) Category membership	(3) Category membership * density	(4) Choice of divergent model	(5) Choice of divergent model * density	(6) Firm size	(7) Media legitimation	(8) % awards of press releases	(9) R&D-to-sales ration	(10) Market volatility	(11) Density	(12) (Density)²	(13) % OSS of past press releases	(14) Repeated choice of divergent business model	(15) Inverse Mills ratio
(1)	1														
(2)	-0.208	1													
(3)	-0.115	0.897	1												
(4)	-0.271	0.084	0.058	1											
(5)	-0.198	0.089	0.134	0.9	1										
(6)	-0.048	0.554	0.598	0.141	0.163	1									
(7)	-0.165	0.74	0.723	0.003	-0.021	0.649	1								
(8)	0.117	-0.134	-0.113	0.029	-0.001	-0.186	-0.197	1							
(9)	0.027	-0.091	-0.082	0.156	0.1	-0.243	-0.094	0.14	1						
(10)	-0.07	0.023	-0.148	0.028	-0.142	-0.113	0.054	-0.136	-0.069	1					
(11)	-0.192	0.149	0.354	0.068	0.278	0.322	0.062	-0.007	-0.039	-0.519	1				
(12)	-0.111	0.146	0.373	0.023	0.24	0.303	0.065	-0.021	-0.066	-0.547	0.975	1			
(13)	-0.137	0.245	0.068	0.053	0.053	-0.239	-0.101	0.26	0.018	0.05	0.028	0.02	1		
(14)	-0.103	0.273	0.313	0.403	0.451	0.316	0.106	0.007	-0.046	-0.044	0.128	0.144	0.037	1	
(15)	0.002	0.499	0.576	-0.099	-0.042	0.719	0.628	-0.134	-0.287	-0.134	0.274	0.284	-0.19	0.172	1
Mean	0.00	0.76	4.37	0.34	1.83	8.02	1.49	0.03	0.35	2.65	5.17	33.04	0.10	0.43	0.96
SD	0.06	1.19	7.76		2.86	2.10	2.38	0.05	1.32	3.64	2.53	25.44	0.25	1.50	0.32
Min	-0.14	0.00	0.00	0	0.00	4.38	0.00	0.00	0.02	0.08	0.20	0.04	0.00	0.00	0.07
Max	0.20	5.01	43.59	1	8.60	12.70	14.95	0.36	11.71	13.82	8.80	77.44	1.00	11.00	2.13

that speak *about open source software*. *Firm size* (as measured by the number of employees) may be a driver of firms' commercial OSS engagement (Henkel, 2006). Moreover, firm size has also been shown to exhibit a positive effect on legitimacy and firms' ability to introduce new categories (Greenwood and Suddaby, 2006). Finally, larger firms may automatically be attributed with a lower degree of membership in the new category (Hannan, 2010) and thus consistently receive lower devaluations. As this variable is highly skewed, we employ its natural logarithm for regression analysis. We also control for *media legitimation* resulting from the firm being reported on in the public press. We used a measure brought forward by Pollock et al. (2008) in employing the cumulative amount of media reports in key US newspapers and magazines in the year preceding the event, and divide it by 100 to ease interpretability of coefficients. Moreover, absorptive capacity – the firm's ability to acquire, assimilate, transform, and exploit knowledge towards value creation purposes (Cohen and Levinthal, 1990; Zahra and George, 2002) – is likely to become a critical capability to benefit from external engagement. Following Cohen and Levinthal's (1990) original definition, we approximate absorptive capacity using the *R&D-to-sales ratio*, taking the latest reported financial figures at the time of the event. Similarly, the *share of press releases* over the last 12 months *that announces awards* that the firm has won may convey legitimacy to the firm's OSS endeavours. Awards would positively contribute to the firm's reputation, representing a proxy of the firm's general level of competence or skill (Rao, 1994). In addition, we capture the effect of *repeatedly choosing the divergent model*. We do so for two reasons. First, we want to exclude firm-level learning effects (e.g. Adler and Clark, 1991). Learning would positively impact the firm's ability to integrate knowledge, thus suggesting a positive effect on market valuation. However, second, from a legitimacy perspective, a negative effect is much more likely: firms that repeatedly choose to violate the norms, beliefs, and values of their constituents should lose legitimacy or become (or remain) illegitimate (Suchman, 1995). Finally, to control for market irregularities, we include a measure of *market volatility*, which we calculate as inter-day variance of the NASDAQ in the 30 days preceding the event window; we further divide this variable by 10,000 to arrive at meaningful coefficient values. Also, we introduce *time dummies* to filter out time-variant, legitimacy-related effects caused, for example, by investor sentiment (e.g. Shiller, 2005) in the course of the dot.com bubble.

RESULTS

Before we turn to the multivariate analysis of our hypotheses, we take a closer look at our dependent variable. In particular, we want to see whether or not engagement in OSS produces significantly positive or negative returns. To do so, we apply the non-parametric rank test introduced by Corrado (1989), which has been reviewed as the most powerful test to attain significance of cumulative abnormal returns (Campbell and Wasley, 1993). In short, its test statistic is the ratio of the mean deviation of the event day ranks to the estimated standard deviation of the mean abnormal rank over all events (Campbell and Wasley, 1993; Corrado, 1989). For the sample of all 77 events, it can be observed that CAR is not significantly different from zero, which comes as no surprise given that we perform a cross-sectional analysis having hypothesized changing effects over time. However, when we split the sample of events by the different business models,

Table III. Results of regression analysis (generalized linear model, n = 77)

Independent variables	Baseline Only controls	Model (1) Main effects	Model (2) Results	Model (3) Results with IMR
Firm size	0.013** (0.005)	0.016** (0.005)	0.017** (0.004)	0.018** (0.005)
Media legitimation	−0.010** (0.003)	−0.008* (0.004)	−0.009** (0.003)	−0.009** (0.003)
% awards of past press releases	0.191† (0.122)	0.158† (0.114)	0.152† (0.111)	0.150† (0.112)
R&D-to-sales ratio	0.005† (0.004)	0.009* (0.004)	0.009* (0.004)	0.008* (0.004)
Market volatility	0.001 (0.004)	0.002 (0.004)	0.002 (0.004)	0.002 (0.004)
Density	−0.094* (0.042)	−0.089** (0.036)	−0.086** (0.033)	−0.089** (0.033)
(Density)^2	0.009* (0.004)	0.008* (0.004)	0.007* (0.004)	0.007* (0.004)
% OSS of past press releases	−0.006 (0.024)	0.022 (0.023)	0.034† (0.021)	0.035* (0.021)
Repeated choice of divergent model	−0.009** (0.002)	−0.004** (0.002)	−0.006** (0.002)	−0.006** (0.002)
Category membership		−0.009† (0.005)	−0.028** (0.012)	−0.028** (0.012)
Category membership * density			0.004* (0.002)	0.004* (0.002)
Choice of divergent model		−0.035** (0.012)	−0.070** (0.024)	−0.071** (0.023)
Choice of divergent model * density			0.007* (0.003)	0.007* (0.003)
Inverse Mills ratio				−0.010 (0.030)
Time dummies	Yes**	Yes**	Yes**	Yes**
Constant	0.103* (0.045)	0.085* (0.043)	0.081* (0.042)	0.086* (0.045)
Model fit	127.1	130.9	133.8	133.9
Change in model fit	n.a.	3.8 (p = 0.003)**	2.9 (p = 0.012)*	0.1 (p = 0.39)

Notes: † p < 0.10, * p < 0.05, ** p < 0.01 (all tests are one-tailed).

Robust standard errors clustered by firm are shown in parentheses; there are 52 different firms in the sample.

Dependent variable: cumulative abnormal returns using NASDAQ composite as index.

Model fit is measured by log-pseudolikelihood, its significance by corresponding *F*-tests.

Inverse Mills ratio results from a probit using the following variables to predict the absence of a confounding effect: sales in million USD (negative, significant), sales-per-employee (negative, significant), sales growth over past year (positive, significant), PPE (property, plants, and equipment)-to-sales ratio (negative, insignificant).

these tests suggest that there are differences between the groups in their respective difference from zero even in such a pooled analysis (Table V). Also, t-tests comparing the different groups of business models also lend initial support for Hypothesis 2, arguing for different evaluations of the business models depending on how closely they cognitively resemble the traditional 'closed source' model.

We now turn to the multivariate regression analysis, for which we employ a generalized linear model (see Table III). The baseline model only contains control variables. Model 1 introduces our main effects. Interaction effects are included in Model 2, with model fit significantly increasing. Finally, in Model 3, we include the inverse Mills ratio resulting from a probit regression predicting the presence of confounding events. Because the term is insignificant and has no discernible impact on model fit, we choose Model 2 as our preferred specification. Here, all our variables of interest are significant at the 5% level, lending strong support to our hypotheses.

Yet, since we hypothesize both an interaction effect and one of its constituent terms, interpretation of coefficients is ideally supported by the use of graphs. This is because for
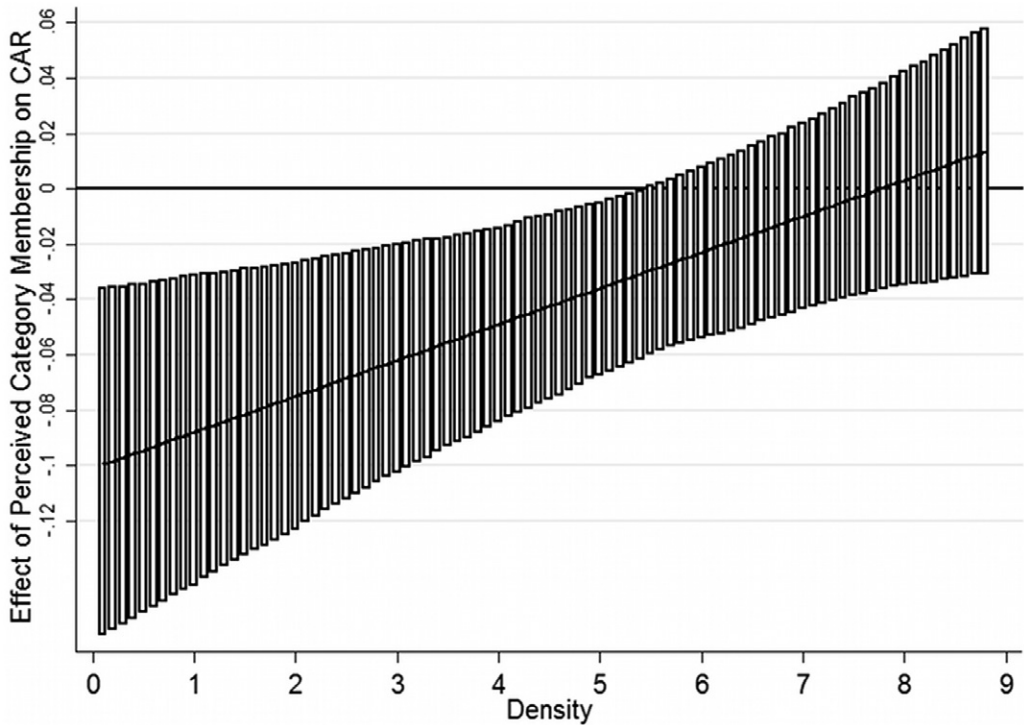
Figure 1. Change in effect of perceived category membership with increasing density. Bars represent confidence intervals (5% level, one-tailed) for simulations at respective levels of density. All variables but density and perceived category membership are set to their mean, and then we compare low levels to high levels of perceived category membership (5%ile vs. 95%ile)

Note: Since the respective STATA code currently does not support the application of Zelner's procedure to a GLM regression, the results of the simulation analysis are built on a simple OLS regression instead.

the constituent term, the coefficient given does not represent the true marginal effect of the respective variable, but an effect conditional on the value of the variable it is interacted with – in our case, density. Using the approach suggested by Zelner (2009), we can further accommodate our constituent terms appearing multiple times in the regression. The result of this analysis, shown in Figures 1 and 2, provides further encouragement. We clearly see that, for low levels of density, perceived membership in the category as well as the choice of the divergent model are discounted significantly. With increasing category currency, captured by higher values of density, both discounts decrease.

Sensitivity Analysis

To corroborate our results, we conducted several additional analyses. First, we replaced the NASDAQ Composite Index with the S&P 500 as comparable market index. Next, although our sample size is easily within the acceptable range for this type of study (e.g. Oh et al., 2006), we controlled for bias caused by extreme outliers by removing those events with the three highest and three lowest cumulative abnormal returns from the
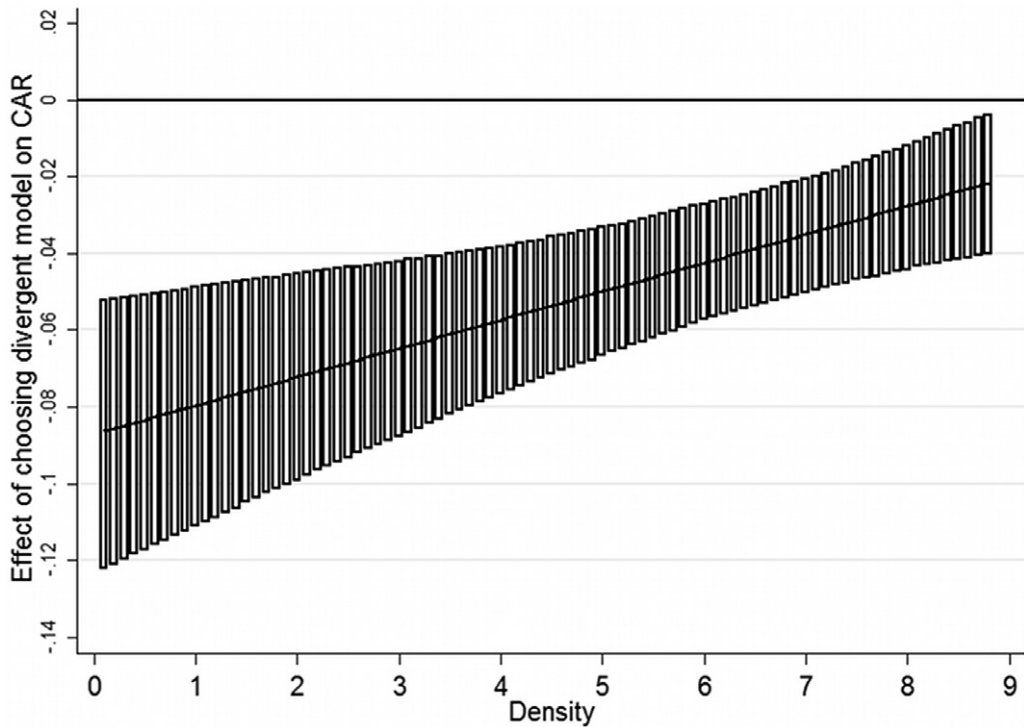
Figure 2. Change in effects of category divergence with increasing density. Bars represent confidence intervals (5% level, one-tailed) for simulations at respective levels of density. All variables but density and the divergent business model dummy are set to their mean, and then we compare the effects of choosing the divergent business model vs. not doing so

Note: Since the respective STATA code currently does not support the application of Zelner's procedure to a GLM regression, the results of the simulation analysis are built on a simple OLS regression instead.

sample. Finally, regarding the estimation method, we also estimated our regression using standard OLS, using robust standard errors instead of clustered ones, and using firm-fixed-effects OLS and GLS approaches. For all these tests, our results remained qualitatively unchanged, with all variables keeping their sign and only minor changes in the levels of significance.

Concerning potential multicollinearity issues, we use several precautions. Importantly, we chose not to standardize or mean-centre our variables. Accordingly, those variables included in interaction terms display high correlations and variance inflation factors, but neither of these points needs to imply multicollinearity (Echambadi et al., 2006).[3] To rule out this issue, we look at changing values in t-statistics between regression models. Also, we ran separate estimations in which we introduce each variable of interest individually. Finally, we also ran reduced regression models only containing our variables of interest, and find the results to remain qualitatively unchanged. Accordingly, we judge that multicollinearity should not be an issue.

To enhance external validity, we conducted several additional tests (see Table IV). First, in Model R1, we re-estimated our equations, removing all control variables and

Table IV. Robustness checks (generalized linear model, n = 77)

Independent variables	(R1) Fama/French	(R2) Linux	(R3) Category membership
$rmkt_t - rf_t$	0.000 (0.005)		
SMB_t	−0.017 (0.016)		
HML_t	−0.008 (0.014)		
Firm size		0.015** (0.004)	0.020** (0.005)
Media legitimation		−0.004† (0.003)	−0.010** (0.003)
% awards of past press releases		−0.287* (0.167)	0.203* (0.106)
R&D-to-sales ratio		0.006* (0.003)	0.009** (0.004)
Market volatility		−0.001 (0.003)	0.003 (0.004)
Density	−0.010** (0.003)	−0.095* (0.043)	−0.077* (0.034)
$(Density)^2$		0.007† (0.004)	0.006† (0.004)
% OSS of past press releases		−0.030† (0.023)	0.003 (0.020)
Repeated choice of divergent model			−0.006** (0.002)
Perceived category membership	−0.034** (0.010)	−0.051** (0.014)	−0.014** (0.006)
Perceived category membership ∗ density	0.005** (0.002)	0.005** (0.002)	0.002* (0.001)
Choice of divergent model	−0.088** (0.029)	−0.054† (0.040)	−0.088** (0.024)
Choice of divergent model ∗ density	0.011** (0.004)	0.064** (0.018)	0.010** (0.003)
Time dummies	No	Yes**	Yes**
Constant	0.070** (0.022)	0.108* (0.050)	0.065† (0.042)
Model fit	120.1**	133.7**	134.3**

Notes: † p < 0.10, * p < 0.05, ** p < 0.01 (all tests are one-tailed).
Calculation methods and tests performed are as described for Table III. Regarding the variables: In Model (1) $rmkt_t$ is the return on all firms in NYSE, AMEX, and NASDAQ at time t; rf_t the risk-free rate of return; SMB_t is Fama and French's (1992) index of small versus big capitalization and HML_t their index of high versus low book/price ratio from a set of book-to-market reference portfolios they construct. In Model (2), choice of divergent model means that the core business model of the company depends entirely on the Linux operating system (N′ = 7), such as RedHat's selling of Linux variants and related services. In Model (3), we replace our standard perceived category membership variable with the total count of press releases by the focal firm in the preceding 12 months.

replacing them with the basic model proposed by Fama and French (1992) and applied in the management literature for example by Fosfuri and Giarratana (2009). Our results remain robust; the fact that these controls are insignificant is most likely explained by the fact that we use the market model rather than the capital asset pricing model to predict abnormal returns. Second, we further investigate our argument proposing that higher contrast should have strictly negative effects for members of an illegitimate category. Specifically, we tried to identify firms that may be considered either *de novo* entrants into the OSS space, or *de alio* players who have fully switched to an OSS model. Whereas the numbers are very small, a selected number of events originates from firms whose business models entirely centres around the Linux OSS operating system (N′ = 7), such as RedHat. When applying our logic of initial punishment for category divergence that ameliorates with increasing category currency, we find some support for this argument despite the small number of observations: In Model R2, we see that the dummy of being a Linux firm is negative and marginally significant, and the interaction with density is positive and highly significant. Finally, for Model R3, we created an alternative

specification of the perceived category membership variable. Theorizing that true category membership will more easily be spotted by audiences when they pay more attention to firms and have more information about them (Fiss and Zajac, 2006; Hoffman and Ocasio, 2001), we operationalize perceived category membership by the count of press releases launched by the focal firm. Again, results remain qualitatively unchanged. Overall, the combined results of the sensitivity checks thus lead us to conclude that our findings are indeed robust.

DISCUSSION AND IMPLICATIONS

We have studied the effects of corporate engagement in open source software, an open innovation practice considered illegitimate when it is first observed in the market. By showing how categorical divergence, category straddling, and varying levels of category currency impact the valuations of such engagement by a crucial audience, the capital market, we make three contributions to the literature.

Category Divergence and Changing Category Currencies

The literature on categories has only recently begun to include discussions on categories illegitimate at their origination, despite the fact that innovative activity will often take place under these conditions (Schneiberg and Beck, 2010; Zuckerman, 1999). We build on two recent advances in this stream of research showing that (1) effects of categorization not only depend on a shared meaning of a category but also the valence attributed to it (Kennedy et al., 2010), and (2) when the standard prototype-based logic of categorization is challenged, causal-model theories are more appropriate to explain categorization processes (Durand and Paolella, 2013). In combining these arguments, we provide a theoretical rationale for why membership in novel categories may be of negative value initially, but may improve over time. Specifically, in our case of firm engagement in OSS, it is the fundamentally clashing core logics of open and closed source that render OSS a category of low valence, for which meaning is largely inferred from its precise boundary: open source is *not closed source*. Extending Pontikes' (2008) insights, this also implies that novel categories, even if their specifics are as yet unclear, need not at all be lenient when they run counter to the extant category system.

   With audiences gradually legitimizing OSS, the negative effects of perceived membership in this category disappear. In turn, this legitimation process is best explained as a learning process by audiences, in which they rethink their causal modelling of category membership and its consequences based on novel information they receive (Durand and Paolella, 2013). Put differently, as proposed by Kennedy et al. (2010), we find that membership in the initially low-currency category has negative effects that gradually improve with increasing legitimation of the category, which is best understood as an increase in category valence. In addition, our findings allow us to point out two additional boundary conditions of the categorical imperative. First, in line with Vergne (2012), we show that conformance of a firm's identity to the existing category schemes is not desirable when this identity falls within an illegitimate category. Second, in line with

Kennedy et al. (2010), we show how valence associated with a specific category meaning may be updated by audiences, so that identical behaviour receives different valuations over time.

Category Straddling and Changing Category Currencies

Relatedly, our results speak to the importance of clearly demarcated category boundaries. Here, a lot of research argues for the positive effects of contrast, emphasizing that membership in one category, even if novel, should always be superior to category straddling, when straddling itself does not lead to a new, separate category (e.g. Hannan et al., 2007; Negro et al., 2010). Recent extensions in the categorization literature have refined this argument by showing that some categories are more permissive of boundary transgressions (e.g. Pontikes, 2008). Similarly, transgressions may be punished less severely when the category system itself is in flux (Ruef and Patterson, 2009), or when firms are members of stigmatized categories (Vergne, 2012). Consequently, Durand and Paolella (2013) call for future research to study conditions under which category-straddling could appeal to audiences. Answering this call, we highlight that category straddling is strictly positive when firms are members of categories carrying negative valence, but can credibly activate legitimacy spillovers from an existing category of higher valence, even in the absence of stigma. In these circumstances, category straddling allows organizations to extend the scope of behaviours that audiences would consider appropriate. Specifically, we find that capital investors perceive firm engagement in OSS as more legitimate if firms embrace business models that more strongly conform to existing cognitive models, while others are discounted. That is, members of the same category are attributed with significantly different levels of category currency because of variance in their relative cognitive proximity to existing, legitimate elements of a larger category system.

   Yet again, investors' updating of their causal-model categorization schemes exhibits a moderating effect. We find that category emergence reduces the discount that firms engaging in the business transformation model had so far received. Thus, whereas the model has remained fairly constant over time (in theory and practice), its valuation by the capital market improves dramatically based on the emergence of a new category that can serve as a cognitive frame of reference for *any* engagement in OSS. In this way, the business transformation model attains improved levels of legitimation, leading to an increase in its relative valuation to the other models, which can no longer benefit from category straddling. Furthermore, following the argument of an updated causal model, this process should have led to a general reconsideration of the value of this business model by the capital market *in hindsight* – a telling example for this can be seen in IBM's release of Eclipse, which was evaluated negatively by investors initially (CAR = −1.4%), yet is now widely considered an almost prototypical success story of OSS.

Valuing 'Openness' in Innovation

Our results also contribute to the surging debate in the innovation literature on 'open' models of innovation (e.g. Chesbrough, 2003). Despite its technical merit, to decide

Table V. Follow-up analysis: effect of business model choice (univariate analysis)

Business model	N	Mean	SD	Difference	Corrado z-statistic
Business transformation (*divergent business model*)	26	−0.019	0.041	–	0.99
Sales of complementary goods and services (*hybrid business model*)	32	0.004	0.067	0.06†	0.67
Dual licensing & cost/risk reduction (*hybrid business models*)	19	0.032	0.057	0.07†	−2.56**

Notes: † p < 0.10, * p < 0.05, ** p < 0.01 (p-values from one-tailed t-tests).
'Difference' in p-value compares the respective business model with the one in the line above. Corrado test statistic calculated for complete event window.

whether to engage in models of innovation like OSS, firms will need to consider another essential question: do investors consider such strategies valuable? Thus far, only anecdotal or case-based evidence points to a positive link between open business models and performance (e.g. Chesbrough, 2003; Jeppesen and Molin, 2003; West, 2003). Our results are the first to show clear, systematic links between open business models and firm value. Rather than going open per se, we provide evidence to suggest that engaging in this open innovation practice affects the firm's market value *conditional upon legitimacy as perceived by the capital market*. In turn, legitimacy will depend on the perceived category membership of a firm, its choice of open business model, and the emergence of a category of open business models. Specifically, we found that the selection of novel open business models that are cognitively distant from existing 'closed' models leads to significantly more negative investor reaction compared to more proximate open business models. We maintain that the reason behind this negative investor reaction is the higher legitimacy requirements for firm strategies that pursue uncertain technologies and goals in ways contradictory to extant logic, which investors cannot match to existing categories (see also Kuilman and Li, 2009). In contrast, firms choosing business models which allow borrowing from existing categories may reduce the ambiguity inherent in nascent market environment (Navis and Glynn, 2010). While not necessarily directly affecting present categorization schemes, this would at least give investors a foundation on which to build a more positive valuation (Durand and Paolella, 2013; Hannan et al., 2007). In accordance with this logic, we find that, on average, firms choosing open business models that are very similar to existing categories achieved a 3.2 per cent premium on their stock price, compared to firms choosing more distant models, who saw a 1.9 per cent drop (see Table V). Yet this negative effect improved significantly over time, indicating that even this model may have the potential to contribute positively to the market valuation of the firm.

Though we have studied OSS as a specific example, more broadly, there is a growing trend where firms increasingly resort to open innovation strategies to leverage their R&D spending and access a valuable conduit into new innovations, users, and markets. For instance, as an often cited success story, around 50 per cent of Procter & Gamble's current products are credited to its 'Connect + Develop' open innovation programme. GlaxoSmithKline's Centre for Excellence in External Drug Discovery applies open innovation principles to run a pipeline of drugs in preclinical stage, the

size of which rivals the number of similar in-house projects (Alexy et al., 2009). These examples evidence the increasing relevance of open innovation as a mechanism to strategically increase the porosity of organizational boundaries to improve the firm's odds to innovate successfully (Alexy et al., 2012). Though there is an expanding repertoire of anecdotal and contextual examples of open innovation practices, investor perceptions of such activity and their impact on firm value provide rich avenues for scholarly inquiry.

Limitations and Suggestions for Future Research

Akin to other event studies, this paper faces some limitations. Event studies only take into account events for public companies, not privately held ones. However, Dahlander (2007) shows that the distribution over time with respect to the number and dollar amounts of venture capital investments in OSS is similar to the number of announcements by public firms over time observed in this study. Nevertheless, 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 or OSS-based firm acquisitions by publicly-traded companies, or, potentially, at the IPO performance of open-innovation-based firms to further scrutinize the value-enhancing potential of OSS and open innovation.

   With regards to our results, it is interesting to observe that the coefficients of density and density-squared carry exactly the opposite signs they do in most other studies. Several explanations for this may exist. First, we control for time effects using year dummies, which may take away some of the variance usually explained by density. Alternatively, the density measure might in fact have captured the dot.com boom and bust. However, even when we explicitly model these into our regression, our results are stable. Accordingly, an explanation may well be that for truly novel categories of low currency, the effect of density might take this shape initially, before moving on to the known cycles of increasing legitimation leading to increasing competition. We call for future research to analyse this question. Finally, future research should consider the question of whether category emergence more generally follows the processes we find in our empirical example. Specifically, empirical work should enquire more deeply into the nature and effect of category straddling early in the life of a category to further substantiate recent work highlighting its pivotal importance (e.g. Kennedy et al., 2010; Navis and Glynn, 2010).

Implications for Practice

Our study highlights options for managerial action to influence positive perceptions of their innovative activities in general – and open innovation activities in particular – while discouraging others. First, managers can focus on activities with low legitimacy requirements, that is, choosing to engage in innovative activity or at least commercialize them through business models with cognitive proximity to existing categories. Second, where managers want to break out of these constraints, they may try to influence the perceived legitimacy of their actions through symbolic management by attempting to position the

firm as a marginal member of an illegitimate category and by drawing on analogies to legitimate categories wherever possible. Yet, when firms strive for the emergence of truly new categories, singular action by an individual firm will probably not be sufficient, but trying to participate in an existing social movement with similar goals might. Finally, the case of OSS reminds us of Zuckerman's (1999) original note of caution: when engaging in innovation, managers should always consider the possibility that investors' preference for category conformance may be myopic, and adhering to this preference by forsaking innovation may often be the sub-optimal choice in the long run.

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NOTES

[1] We would like to point out that this part of the semi-strong efficient market hypothesis which underlies event study methodology is largely uncontested; we also agree that stock prices will include all publicly available information at a point in time, and that they will change once new information becomes available. What we disagree with, however, is that both types of information, and particularly the newly incoming information, are processed in an unbiased fashion, as the semi-strong efficient market hypothesis would further argue (see also Zuckerman, 1999).

[2] The specific search term we used was '(open sourc* or opensourc* or open-source* or free software or GPL) AND (contribut* OR releas* OR reveal*)'. This resulted in around 14,000 press releases – one of the authors read abstracts of all of these, and full press releases whenever the abstract suggested that the press release may contain an event matching the above definition, simultaneously checking whether the respective company was listed on one of the three relevant indices. Two other coders randomly coded subsamples of the press releases to arrive at perfectly identical coding results.

[3] This fact is worth noting for the following reasons. Generally, neither the presence nor the absence of high correlations guarantees or eliminates the potential of multicollinearity. Indeed, the most potent indicator of multicollinearity would be the individual insignificance of two collinear variables in a regression, when each of which, on their own, would be significant. This is due to the fact that multicollinearity has a negative effect on the value of the t-statistic (Echambadi et al., 2006). All test results described in the remainder of this paragraph are available from the authors upon request.

APPENDIX

Examples of event codings and corresponding press releases

Date	Firm	Business model	Excerpts from press release (justification for business model coding in **bold italics**)
12-11-1998	Data Translation	Cost or risk reduction	Up to now Broadway has been a closed application for specific use under Windows 95/98 and Windows NT. Users have asked for its use on a wider range of platforms and for use under the Linux operating system. ***Data Translation has decided to meet all these needs by allowing extensions to its source code by any developer***.
29-02-2000	Starbase	Cost or risk reduction	Since we increasingly find our customers exploring new ways to use our technology, ***providing the source code to key parts of our client frameworks will broaden the usage and possibilities for our family of products in digital asset management***
24-02-1999	RealNetworks	Dual licensing	The Helix Community, located at http://www.helixcommunity.org, ***will offer two licence structures*** – the RealNetworks Community Source Licence (RCSL) or the RealNetworks Public Source Licence (RPSL). . . . After incorporating input from third parties, RealNetworks will [only] submit the RPSL to Open Source Initiative (OSI) for certification as an open source licence.
15-05-2003	Brunswick Company	Dual licensing	BIE is distributed as open source software under the GNU General Public Licence (GPL) . . . ***as well as exclusive-use commercial licences***.
01-03-1999	3dfx Interactive	Sale of complementary goods or services	Available at http://www.3dfx.com, the new web content is designed to help developers ***create games, interactive content and visual business applications for 3Dfx Voodoo acceleration technology***. On the 3Dfx website, developers will find Voodoo Banshee 2D specifications, 3Dfx Glide(R) libraries. . . . 3Dfx Interactive's Voodoo architecture fuelled 73 per cent of the performance/gaming ***video cards*** sold through US retail outlets. According to PC Data's same report, 3Dfx-based products dominated the retail space in Q4 1998, claiming the top five spots in the performance/gaming segment of best-selling retail ***cards***.
21-06-2005	eBay	Sale of complementary goods or services	***The World's Online Marketplace***, today introduced the eBay Community Codebase, a new online forum for open source developer collaboration. . . . The eBay Community Codebase is part of an effort to foster innovation and help developers more quickly and easily ***build applications using the eBay and PayPal Web services platforms***.

APPENDIX *Continued*

Date	Firm	Business model	Excerpts from press release (*justification for business model coding in* bold italics*)*
03-01-2000	Inprise	Business transformation (preventing a choke hold/tipping the standard's race)	Inprise/Borland Leads Linux Charge: Open-Sources Interbase ***Challenges Other Database Vendors to Follow Its Lead***. . . . Inprise is taking a leadership role in the Open-Source movement by releasing the beta version of InterBase 6 under an open-source licence. We are taking this bold step because we believe every Linux distribution needs InterBase. . . . This is an amazing opportunity for Inprise, its customers and the Open-Source community.
20-04-2000	Lucent Technologies	Business transformation (marketing; attraction of development talent)	Lucent Technologies' (NYSE: LU) Bell Labs announced today that it is releasing free Linux software that foils the most common form of computer security attack. . . . ***Modelled on Bell Labs' Unix software***, Linux has been gaining popularity for server and desktop computers over the last few years.
05-11-2001	IBM	Business transformation (establishing a standard)	**I**BM today announced it is donating $40 million of software to a new independent open-source community. The Java-based open source software, code-named Eclipse, will enable developers to use software tools from multiple suppliers together, allowing developers to integrate business processes used to create e-business applications, such as those for web services. This new open source community already involves more than 150 leading software tool suppliers working together to evolve Eclipse software, which . . . will be available free-of-charge to developers. . . . 'This is **IBM**'s most audacious open source gambit so far', says James Governor, analyst with IT advisory firm Illuminata, Inc. '***The company is driving the development of an open platform that provides many of the underlying services software developers need, bringing tight integration to the tools market.*** This is not just a framework or set of APIs; it's real code designed to do real work.'
08-11-2004	StorageTek	Business transformation (establishing a standard)	'The open source availability and standards-based design of OpenSMS was introduced to minimize adoption risk and encourage the evolution of a common code base across multiple operating systems and information lifecycle management policy drivers', said RB Hooks. '***In this way, we hope to help build a common foundation of expertise that spans computing platforms and industries to help advance information lifecycle management for open systems computing into the future.***'

APPENDIX *Continued*

Date	Firm	Business model	Excerpts from press release (*justification for business model coding in* **bold italics**)
06-03-2007	Oracle	Business transformation (marketing; establishing a standard)	With its latest contribution and project proposal, Oracle ***continues to demonstrate its commitment to the developer and open source communities***. . . . Through its participation in the OSGi Enterprise Expert Group, Oracle will also work with the group members to ***create a set of blueprints that define how OSGi applications can access standardized persistence technologies***. . . . 'Our latest contribution and added commitment to Eclipse demonstrates Oracle's continued efforts to initiate, lead, support and contribute technology, innovation and resources to the open source community', said Dennis Leung, vice president software development, Oracle. '***From our experience in leading several projects***, we know that Eclipse has an enthusiastic and vibrant following. ***We are very excited to grow our involvement*** by bringing all of TopLink to Eclipse and delivering a comprehensive persistence platform.'

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