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COCREATION OF VALUE IN A PLATFORM ECOSYSTEM: THE CASE OF ENTERPRISE SOFTWARE[1]

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It has been argued that platform technology owners cocreate business value with other firms in their platform ecosystems by encouraging complementary invention and exploiting indirect network effects. In this study, we examine whether participation in an ecosystem partnership improves the business performance of small independent software vendors (ISVs) in the enterprise software industry and how appropriability mechanisms influence the benefits of partnership. By analyzing the partnering activities and performance indicators of a sample of 1,210 small ISVs over the period 1996–2004, we find that joining a major platform owner's platform ecosystem is associated with an increase in sales and a greater likelihood of issuing an initial public offering (IPO). In addition, we show that these impacts are greater when ISVs have greater intellectual property rights or stronger downstream capabilities. This research highlights the value of interoperability between software products, and stresses that value cocreation and appropriation are not mutually exclusive strategies in inter-firm collaboration.

Keywords: Platform ecosystem, partnership, business value, sales, IPO, intellectual property rights, downstream capabilities

Introduction

Platform-based technologies such as personal computers, mobile computing systems, and video game consoles are becoming increasingly important in the information economy (Evans et al. 2006). As noted by Boudreau (2007), such platforms are defined as the set of components used in common across a product family whose functionality can be extended by applications. To meet the needs of heterogeneous users and to exploit indirect network effects, platform owners often seek to encourage complementary third-party innovation from resources located outside the firm, ranging from customers, research companies, and business partners to universities (Linder et al. 2003). This approach of complementary innovation has given rise to the model of a platform ecosystem, the network of innovation to produce complements that make a platform more valuable (Gawer and Cusumano 2002). A burgeoning body of research has started to theorize about how such ecosystems are formed and their implications for platform owners, complementary providers, and users (Adom-

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avicius et al. 2007, 2008; Eisenmann et al. 2009; Gawer and Henderson 2007; Lee and Mendelson 2008; Mantena et al. 2007; Parker and Van Alstyne 2008; West 2003).

To encourage complementary innovation, owners of IT hardware and software platforms such as Microsoft, IBM, and SAP often have partnership programs for members of their platform ecosystems. Members of these partnership programs cocreate value with the platform owner by developing applications and solutions to be used on the platform. Such partnerships have also drawn interest as examples of co-opetition[2] (Hamel et al. 1989) that inevitably involve competition and conflict of interest. However, despite increasing interest among practitioners and researchers in ecosystems, there has been little work in understanding the value of these partnership programs, and under what conditions they are most valuable to their participants. This is a significant gap in understanding. For researchers, this means that there is little systematic measurement of the extent to which partnership programs facilitate the cocreation of value. For example, recent theoretical work on how platform owners can encourage the development of ecosystems (Eisenmann et al. 2009; Parker and Van Alstyne 2008; West 2003) would benefit from empirical evidence on the value of these programs. For practitioners, platform owners and their complementors currently have no systematic means to determine how much to invest in them. In addition, efforts of start-up software vendors to use ecosystem participation as a growth strategy will have meaning only if vendors know who is most likely to benefit from such relationships.

In this paper we take one step toward addressing this gap in prior research. To do this, we develop a set of hypotheses building upon a rich literature on the commercialization of new technologies and markets for technology (e.g., Arora et al. 2001; Gans et al. 2002; Gans and Stern 2003). Following on one stream of the literature on standards competition (Brynjolfsson and Kemerer 1996; Katz and Shapiro 1994; Kauffman et al. 2000; Matutes and Regibeau 1988; Tassey 2000), we argue that independent software vendors (ISVs) will join a platform ecosystem to signal compatibility with the platform. This signal will increase the expected net benefits to platform adopters of adopting the ISV's software and lower the ISV's cost of selling to the platform installed base. Partnership leads to a cocreation of value that should, on average, be associated with an increase in the performance of the ISV.

[2]Co-opetition is a term used to describe collaboration between competitors. It was coined by Raymond Noorda, the founder of the networking software company Novell, to characterize Novell's business strategy. For details, see Nalebuff and Brandenburger (1997).

While ISVs that join a platform ecosystem cocreate value with the platform owner, they also face classic issues of value appropriation in IT innovation networks. In particular, one potential risk is that competitors including the platform owner may replicate the technology of the ISV and begin to offer a competing product. Specifically, the risk of platform owner entry into the ISV's market is likely to increase with partnership due to knowledge transfer between the ISV and the platform owner that occurs as a result of partnering. Prior research from other settings has noted that these risks of knowledge transfer can be mitigated if intellectual property rights (IPRs) like patents and copyrights are available (Arora and Ceccagnoli 2006; Gans and Stern 2003; Oxley 1999), and that appropriability risks will also be affected by the ownership and strength of specialized downstream capabilities (Arora and Ceccagnoli 2006; Ceccagnoli and Rothaermel 2008; Gans and Stern 2003; Rothaermel and Hill 2005; Teece 1986). Building on this prior work, we develop hypotheses that explore the relationship between the returns to partnership and appropriability mechanisms like IPRs and downstream capabilities.

In short, we seek answers to the following set of questions for ISVs:

(1) Is participation in a platform ecosystem, on average, associated with an increase in performance?

(2) How is this improvement in performance affected by an ISV's ownership of IPRs and specialized downstream capabilities?

We investigate these issues in the context of the enterprise software industry. Specifically, using a unique data set on the partnering activities of 1,210 ISVs over the period 1996–2004, we evaluate the effects of joining the SAP ecosystem on an ISV's performance. We examine two critical performance measures for ISVs: sales and the likelihood of obtaining an initial public offering (IPO). We analyze the former because it is strongly correlated with the profitability and overall financial performance of the firm, due to the high fixed cost/low marginal cost structure of software firms. We analyze the latter because it is both a measure of the future sales prospect for the firm and a common measure of small firm performance (Cockburn and MacGarvie 2009; Shane and Stuart 2002). We present robust empirical evidence showing that the decision to partner is, on average, associated with both an increase in sales and a greater likelihood of an IPO. To enhance identification of causal effects we adopt a variety of approaches, including the use of fixed effects panel data models with instrumental variables. Our instruments are based on an ISV's personal connections to SAP in the years

prior to partnering, obtained from LinkedIn, and the propensity of similar ISVs to partner with SAP.

We next investigate how appropriability strategies, such as ownership of intellectual property rights (IPRs) and downstream complementary capabilities by the ISV, moderate the effects of partnership on ISV performance. In particular, we find that the impact of partnership on sales is higher for an ISV that is better protected by IPRs or that has stronger downstream capabilities, and find a similar pattern of results when we study the impact of partnership on the likelihood of an IPO.

A key feature of our setting is that ISVs have the option to choose between joining a platform and selling platform-independent, stand-alone applications. Partnership cocreates value by signaling software compatibility to platform users. In that sense, while our setting shares many commonalities with important platforms such as Cisco's Internetwork Operating System, it does differ from many platform settings in which ISVs are required to join one platform or another (e.g., video game platforms like Microsoft's Xbox or Sony's Playstation).

Our study contributes to the extant literature on several fronts. First, although prior research on alliance relationships has examined their impact on firm performance (Bae and Gargiulo 2004; Baum and Oliver 1991; Goerzen and Beamish 2005; Mitchell and Singh 1996; Zaheer and Bell 2005), the focus in much of that literature has been on the value of alliances as a mechanism to facilitate learning and access to specialized resources (Porter and Fuller 1986). Our analysis and theory differs from this extant literature in significant ways: in our setting, partnerships are valuable primarily as a way of signaling compatibility with the platform rather than as a mechanism of sharing critical information that will improve the innovative productivity of the partnering organizations (Colombo et al. 2006; Khanna et al. 1998; Mowery et al. 1996). In that way, our study shares similarities with Chellappa and Saraf (2010), who also argue that compatibility signaling is a primary benefit of partnership in enterprise software. However, while Chellappa and Saraf are primarily interested in how a firm's position in the social network of large enterprise software firms influences firm performance, we examine the impact of ecosystem partnership on an ISV's performance.

Second, with the exception of Lavie (2007), few authors have simultaneously studied value cocreation and value appropriation in alliance relationships. We contribute to prior alliance literature by applying theory on innovation commercialization to interfirm alliance studies. While Lavie emphasizes the role of bilateral and multilateral competition on value appropriation in alliance relationships, we examine how the benefits of participation in a platform ecosystem vary according to different appropriation strategies. Specifically, our findings imply that appropriability, in particular intellectual property protection, is a critical determinant of the returns to ISVs from the cocreation of value in the software industry, and that successful and sustainable ecosystems will be found in environments where appropriability mechanisms are strong. In such environments, strong ISV participation in the ecosystem will engender a rich supply of innovative solutions to meet heterogeneous customer needs, igniting a virtuous cycle of indirect network effects that will in turn lead to further value cocreation.

More broadly, while a growing body of literature has examined how platform owners can encourage third-party complementors to stimulate indirect network effects, the current literature on platform technology focuses primarily on the management issues and strategies from the perspective of the platform owners (Eisenmann et al. 2009; Gawer and Cusumano 2002). There is at present little work that takes the perspective of the platform participants. In this way, our research builds upon Huang et al. (2009) who study the decisions of ISVs to participate in a partnership program.

The rest of the article is organized as follows. In the next section we present an overview of literature in related research areas and propose hypotheses regarding value cocreation and appropriation in a platform ecosystem. We then describe the research setting, data, and methods used in the empirical investigation. We present the results, as well as a set of robustness checks, in the following section. We conclude the paper by discussing the implications of our findings.

Relevant Literature and Hypotheses

In this section, we propose hypotheses regarding value creation and appropriation in platform ecosystems. Our hypotheses are grounded in the literature on innovation commercialization, appropriability, and markets for technology (e.g., Arora et al. 2001; Gans et al. 2002; Gans and Stern 2003). This line of work suggests that the decision of start-ups to partner with established firms in order to commercialize their innovations is critically conditioned by ownership of IPRs and downstream complementary capabilities. We apply and extend these ideas to analyze the impact of an ISV's decision to join a platform ecosystem on its financial performance. Later, in the "Conclusions" section, we discuss the generalizability of our findings to other platform environments.

Table 1. Terminology	
ERP	Enterprise Resource Planning
ISV	Independent Software Vendor, or a company that makes or sells software products that run on one or more computer hardware or operating system platforms
IPR	Intellectual Property Right
IPO	Initial Public Offering
IOS	Cisco's Internetwork Operating System
ICC	SAP's Integration and Certification Center
USPTO	United States Patent and Trademark Office
Platform Ecosystem	The network of innovation to produce complements that make a platform more valuable (Gawer and Cusumano 2002)

Appropriating the Returns from Innovation

Technology entrepreneurs such as small enterprise software vendors often face a critical challenge when attempting to translate their innovation into a steady stream of economic returns. When start-ups commercialize their innovations, they often face a choice between (1) embedding the innovation into a product and competing with incumbent firms or (2) earning returns through cooperation with incumbents (Gans and Stern 2003). A key determinant of this choice is the ownership of costly-to-build downstream complementary capabilities (such as manufacturing, marketing, and distribution) that are essential to a firm's value chain and required for successfully launching a product or service (Teece 1986). These complementary capabilities are often a choke point for innovation commercialization; they cannot be easily contracted for through the market on competitive terms and are therefore rare and difficult to imitate (Teece 1986). Their ownership may constitute a barrier to entry and provide a sustainable competitive advantage (Barney 1991; Rothaermel and Hill 2005; Teece 1992). Indeed, large scale empirical studies suggest that ownership of downstream capabilities required to commercialize an innovation is one of the most effective means of securing returns from innovation across a wide range of industries (Cohen et al. 2000).

While the ownership of downstream complementary assets is typically conducive to an appropriation strategy through vertical integration into the product market, securing returns from innovation by commercialization through the market for technology depends critically on the possession and strength of IPRs (Arora et al. 2001; Gans and Stern 2003; Oxley 1999).[3] For example, Gambardella and Giarratana (2006) find a positive relationship between the effectiveness of patent protection and technology licensing in the security software industry, while the ownership of downstream complementary capabilities increases the likelihood that firms will launch new products. Recent research has also extended this literature to examine the role of markets for technology in affecting the survival of entrepreneurial firms in the security software industry (Arora and Nandkumar 2008).

In what follows, we develop a set of hypotheses based on some of the key ideas outlined above.

Participation in the Ecosystem and Sales

In technology industries where network effects are important and a dominant standard has yet to be established, small technology firms may initiate an alliance or join a platform ecosystem to achieve technology compatibility with a platform. The literature on standards competition suggests that technology compatibility is often a prerequisite for gaining access to the installed base of the platform owner (Brynjolfsson and Kemerer 1996; Katz and Shapiro 1994; Kauffman et al. 2000; Matutes and Regibeau 1988; Tassey 2000).

Since the key objective of partnerships in this industry is to achieve compatibility between innovative software solutions of ISVs and the platform, cooperation is a way to access a key complementary asset, certification of software compatibility, that increases a start-up's ability to appropriate the returns from its innovation (Arora et al. 2001; Gans et al. 2002; Gans and Stern 2003; Teece 1986). This kind of alliance, therefore, *cocreates value* by avoiding investments in hard-to-duplicate complementary assets (e.g., investments needed to integrate complementary products with the platform and gain a reputation for quality and reliability). They also increase the *value captured* by the complementors, by allowing the ISV to achieve a more reliable integration with the platform, as well as to reach the installed base faster and more cost effectively.

[3]Research in the markets for technology literature examines transactions for the use, diffusion, and creation of technology. These include transactions involving knowledge that may or may not be protected by intellectual property and may or may not be embodied in a product. For a recent overview of the markets for technology literature see Arora and Gambardella (2010).

Indeed, since platform owners are usually established incumbents with a large installed base, partnership exposes an ISV to a greater potential market that is not served or is underserved by the platform owner. Successful exploitation of the platform owner's installed base is, therefore, expected to boost the sales of a partnering ISV. In addition, in order to become a certified complementary solution provider to a platform, an ISV may have to conform to a series of quality specifications in product design and pass a rigorous certification process conducted by the platform owner. As a result, obtaining certification from an industry leader may be perceived by potential users as a quality signal (Rao and Ruekert 1994), which may enhance the willingness-to-pay of the ISV's potential customers, and in turn have a positive impact on sales, on average. Indeed, prior research has shown that obtaining quality certification such as ISO 9001 enhances software companies' revenue and is associated with higher price per unit of output (Arora and Asundi 1999).

Therefore, we propose

Hypothesis 1: *ISV's participation in an enterprise software platform ecosystem is associated with an increase in sales, on average.*

A few words are in order about the statement of our hypothesis. As we discuss later , while platform participation may be associated with an increase in sales on average, the relationship between participation and sales may vary significantly with ISV characteristics (in particular, ISV appropriation strategies) and the market conditions under which the ISV operates. In other words, there may exist considerable heterogeneity in value cocreation—and for the ISV, value appropriation—across partnerships. Further, ISVs may choose to partner while facing incomplete knowledge about the future values of these variables that will moderate the effects of partnership. We discuss these variables in detail in the subsection after next.

Participation in the Ecosystem and IPO

For young ISVs, a crucial dimension of long-term performance is the speed at which the company issues an initial sale of securities in the financial market (Hsu 2006; Stuart et al. 1999). An initial public offering (IPO) is a critical milestone that marks the transition of a privately held venture into a publicly owned company. From the perspective of a new venture, selling securities to the public is a less expensive way to raise working capital that is required for future growth and expansion, and it presents an opportunity for the equity holders to exchange their stakes in the company for cash.

However, the IPO market is a context in which investors need to assess the quality of relatively new companies with a short track-record and about which investors will have limited information (Pollock and Rindova 2003). We argue that given the significant uncertainty surrounding a new venture's viability and future profit-generating capabilities, an ISV's decision to join a platform ecosystem will be an effective way of mitigating uncertainties in the eyes of third party investors. First, the market's evaluation of the firm is based on its expected future cash flow (Kaplan and Ruback 1995), which will be correlated with its current market penetration and sales. Since joining the platform ecosystem facilitates a faster and more effective penetration of the platform's installed base by the ISV, as argued above, such partnerships should be interpreted favorably by the financial markets and boost investors' confidence in the future profitability of the new venture, resulting in a higher likelihood of IPO.

Second, institutional theory (DiMaggio and Powell 1983) suggests that organizations are under the pressure of institutional environments to conform to prevailing social norms and demonstrate legitimacy. Third parties such as investors will be more willing to engage in exchange relationships with firms that have proven social legitimacy (Sine et al. 2007). To the extent that small ventures have a limited history of demonstrating their conformance to prevailing rules, practices, and social norms, partnering with large, well-established companies can significantly increase their visibility, reputation, image, and prestige. Indeed, studies have examined how endorsements from venture capitalists (Gulati and Higgins 2003; Shane and Stuart 2002), investment banks (Gulati and Higgins 2003; Stuart et al. 1999), alliance partners (Stuart et al. 1999) and media coverage (Pollock and Rindova 2003) can affect impression formation and impart legitimacy to entrepreneurial ventures, and can increase the likelihood of raising capital through an IPO. Therefore, we propose

Hypothesis 2: *An ISV's participation in an enterprise software platform ecosystem is associated with an increase in the likelihood of issuing an IPO, on average.*

Participation in the Platform Ecosystem and Appropriation Strategies

As is widely noted in the markets for technology literature, cooperative strategies like ecosystem partnerships often occur in the shadow of competition (Arora and Ceccagnoli 2006; Arora et al. 2001; Gans et al. 2002; Gans and Stern 2003). The literature has highlighted the *paradox of disclosure* that occurs when start-ups explore potential licensing strategies with established firms: when trading in ideas, a potential

buyer's willingness to pay depends on their knowledge of the idea; however, disclosure of the idea will result in the potential buyer not needing to pay for it (Gans and Stern 2003).

Similar appropriability risks arise for ISVs that consider joining a platform ecosystem. Although joining a platform ecosystem may improve an ISV's sales and likelihood of IPO *on average*, there may be considerable risks associated with such relationships that may lead to variance in the returns to partnership. One particular risk is that the platform owner may replicate the technology of the ISV and begin to offer a competing product, a risk that is likely to increase with partnership. Interfirm collaborative relationships often lead to unintended knowledge transfer (Khanna et al. 1998; Mowery et al. 1996). Knowledge that is not protected by any appropriation mechanism can, therefore, be profitably used by collaborators (Bresser 1988; Heiman and Nickerson 2004). As noted above, the potential risk that platform owners may enter a complementor's product space has been acknowledged by theoretical and case study work on software platforms (Gawer and Cusumano 2002; Gawer and Henderson 2007; Iansiti and Levien 2004), but has not been empirically tested.

The partnership between an ISV and a software platform owner is likely to facilitate such knowledge spillovers. Software certification may require the ISV to disclose proprietary knowledge, the codification of business processes, or its best practices that the platform owner could imitate. In this way, the costs of entry for the platform owner into the ISV's product market are reduced.

Prior research has noted that the disclosure problem can be ameliorated if IPRs are available (Arora and Ceccagnoli 2006; Gans and Stern 2003; Oxley 1999). Both patents and copyrights have been shown as common methods of IPR protection in the software industry (Bessen and Hunt 2007; Graham et al. 2009). In particular, in the presence of patents and copyrights, a start-up may be able to deter imitation or exercise its IPRs and prevent entry once imitation has occurred (Gans et al. 2002). We expect that stronger IPR protection from patents and copyrights will increase the payoff to partnering by decreasing the risks of imitation. As a result, the effect of partnership on sales and the likelihood of issuing an IPO will be higher in the presence of IPR-based appropriability strategies.

Appropriability will also be affected by the ownership and strength of specialized downstream capabilities (Arora and Ceccagnoli 2006; Ceccagnoli and Rothaermel 2008; Gans and Stern 2003; Rothaermel and Hill 2005; Teece 1986). These are assets necessary to manufacture, market, and distribute products (e.g., assets that lose value when redeployed to other classes of products). For example, sales forces that specialize in a particular product may have accumulated specialized skills that are not easily transferred to other products. Specialized complementary assets are difficult to imitate since they are built over long periods of time, are not easily codified, and often result from the interaction of people from different parts of a firm's organization (Teece 1992).

The effect of partnering on an ISV's returns will be higher in the presence of specialized downstream capabilities for two reasons. First, the returns to accessing the platform owner's installed base will be higher if an ISV has an established brand image or strong marketing, distribution, and service capabilities, as it is able to convert platform adopters into its own customers more effectively. For example, recently the French toy retailer Picwic selected several supply chain solutions from Manhattan Associates, a certified SAP partner, to complement its ERP system from SAP. Manhattan Associates owns a strong portfolio of trademarks and a well-recognized brand that increases the probability of being selected by customers using the SAP platform, thus increasing the business value of its participation in the SAP ecosystem. Put differently, a partnership with the platform owner and a strong brand are complementary for the ISV. The partnership signals software compatibility and a strong brand signals superior quality, and the two clearly increase their respective marginal value.

Second, an ISV with strong downstream capabilities will be able to better defend its "territory" in the presence of platform owner entry than those without such capabilities. Knowledge embedded in business practices or downstream service and consulting activities is difficult to codify and, therefore, will be more difficult for the platform owner to imitate (Barney 1991; Dierickx and Cool 1989). For example, implementation of enterprise software often requires extensive effort to configure it to meet the user's idiosyncratic needs (Hitt et al. 2002; Ko et al. 2005). Knowledge of how to conduct such configurations will typically reside in the consulting and service activities of the ISV. Such downstream knowledge and capabilities are difficult to transfer across firm boundaries (Brown and Duguid 2001; Von Hippel 1994) and may also act as a barrier to entry. In other words, transfer of codified knowledge about the ISV's product during the certification process is insufficient to compete effectively with the ISV without the complementary and tacit knowledge embedded in the latter's employees (Teece 1998).

In summary, we argue that the extent to which an ISV may benefit from joining a platform ecosystem is likely to vary according to the ISV's ownership of IPRs or downstream capabilities. In particular, we propose

Hypothesis 3a: *The marginal effect of an ISV's participation in a platform ecosystem on sales is greater when the ISV is better protected by intellectual property rights such as patents and copyrights.*

Hypothesis 3b: *The marginal effect of an ISV's participation in a platform ecosystem on sales is greater when the ISV has stronger downstream capabilities.*

Hypothesis 4a: *The marginal effect of an ISV's participation in a platform ecosystem on the likelihood of issuing an IPO is greater when the ISV is better protected by intellectual property rights such as patents and copyrights.*

Hypothesis 4b: *The marginal effect of an ISV's participation in a platform ecosystem on the likelihood of issuing an IPO is greater when the ISV has stronger downstream capabilities.*

Figure 1 schematically represents the research model and the hypotheses.

Methods and Measures

Research Context

Enterprise software is often considered to be the organizational operating system (Chellappa and Saraf 2010; Cotteleer and Bendoly 2006), consolidating the diverse information needs of an enterprise's departments into a single, integrated software that operates on a shared database. In this study we are interested in the partnership between an enterprise software platform owner and the ISVs that develop complementary applications that are integrated with the owner's platform. As noted above, we adopt the definition of Boudreau (2007) and define a platform as the components used in common across a product family whose functionality can be extended by applications and is subject to network effects. ISV applications extend the functionality of the platform and cocreate value for customers who adopt the platform. SAP AG, the business software company, is chosen as the focal enterprise software platform owner for several reasons. First, SAP's enterprise computing platform is economically significant. Partnerships are core to SAP's platform strategy and its network of software solution providers, value-added resellers, distributors, and technology and service partners (numbering over 7,000 as of 2009) is among the industry's largest (SAP 2009). Second, many core features of SAP's platform are common to other settings where platform owners cocreate value with their partners. For example, partnership with SAP signals compatibility with SAP's platform (Chellappa and Saraf 2010), enabling ISVs to more easily sell to SAP's installed base. Similar motivations are behind the decisions of network equipment vendors to join platforms such as Cisco's Internetwork Operating System platform for computer networking (Gawer and Cusumano 2002). Further, platform participants in other industries face similar appropriability risks, as platform owners have entered complementary markets for efficiency gains or strategic advantage (Casadesus-Masanell and Yoffie 2007; Eisenmann et al. 2011; Gawer and Cusumano 2002; Gawer and Henderson 2007). Further details on SAP's platform ecosystem program, as well as the major tradeoffs that an ISV faces when joining the platform, are presented in the Appendix.

Data

We test our theoretical predictions using a longitudinal data set of 1,210 small ISVs over the period of 1996 - 2004. We collect information on both ISVs' decisions to join SAP's platform ecosystem and information on their business performance. The sampling period starts from 1996 as we find no partnership activities between SAP and small ISVs before then (more details will be provided later in the section on variable definitions).

Our primary data source is the CorpTech database, a subscription-based database that has detailed information on over 100,000 public and private firms, including information on sales, employees, product offerings, source of funding, and company executives.[4] It is well known that studies related to firm performance solely based on public firms may suffer from severe sample selection bias issues (Cockburn and MacGarvie 2006; Shan 1990), and will be particularly problematic for our study given our focus on small firms.

To construct a representative sample of ISVs that could potentially form partnerships with SAP, we first identify within CorpTech the set of firms operating in the United States that list computer software as their primary industry. To further identify firms in the enterprise software industry we examine the product portfolios of current SAP software

[4]These data have been used frequently to study firm behavior in technology industries. For examples of recent studies using the CorpTech database to study the software industry, see Lerner and Zhu (2007) and Cockburn and MacGarvie (2009).

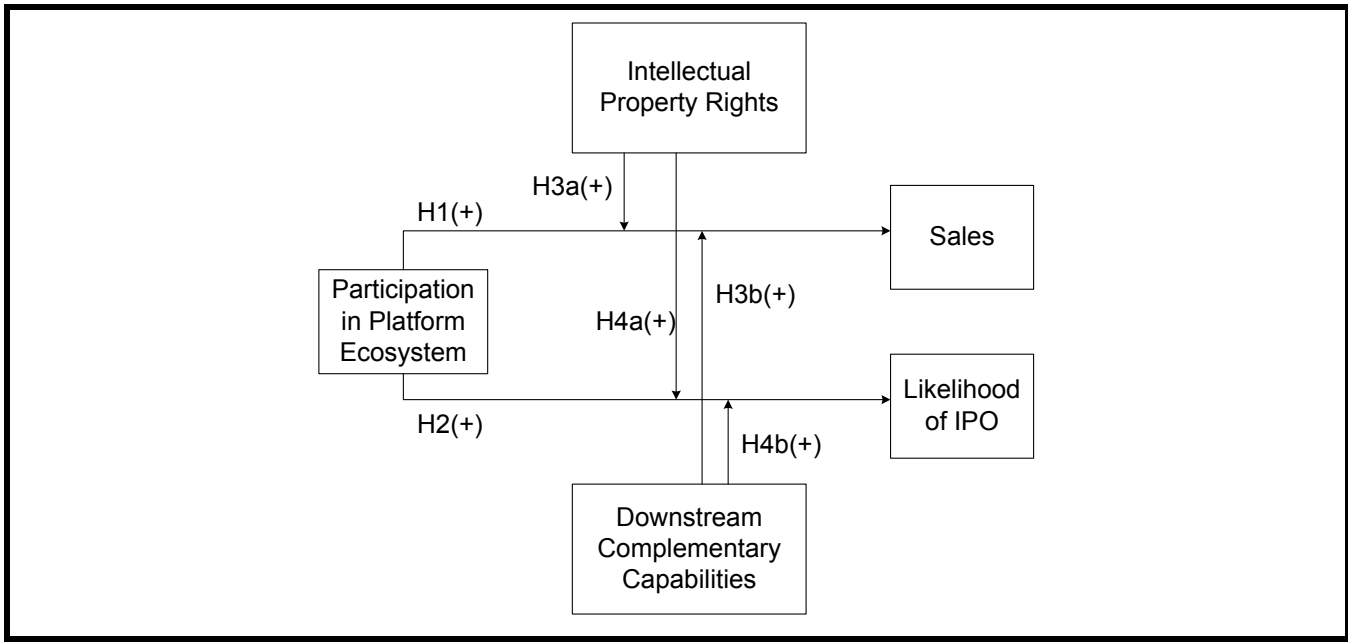


Figure 1. Research Framework

partners, and then find all software firms in CorpTech that produce similar products. The first step involves retrieving a complete list of SAP's current software partners. SAP publishes the directory of all of its certified partners as well as their solution offerings on its Internet portal,[5] and a search using the terms "*Country: United States*" and "*Partner Category: Independent Software Vendor*" yields a list of 411 software firms that are current SAP partners. Comparing this list with software firms within CorpTech generates 206 matching records.

We use these matching records to identify the set of potential partners. One of the key advantages of the CorpTech database is that it records the product portfolio of each company and assigns each product to a three-digit product class.[6] We retrieve the distinct two-digit product classification codes of the 206 current SAP software partners, and find that SOF-MA (manufacturing software, 61 firms, or 29.6 percent) and SOF-WD (warehousing/distribution software, 44 firms, or 21.4 percent) are the most frequent software product codes in the product portfolios of the matched partnering firms. To verify that the unmatched partners are not systematically different from those matched to CorpTech, we collect information on the unmatched ISVs and find that manufacturing software and warehouse/distribution software are also the two most frequently produced by the unmatched ISVs.[7] We subsequently define our sample as firms that have produced SOF-MA or SOF-WD products during the sample period.[8] The final query retrieves 2,175 ISVs from the CorpTech database.

We further exclude established incumbents and restrict our sample to start-up ISVs. Consistent with prior literature (Petersen and Rajan 1994; Puranam et al. 2006) that has focused on small, entrepreneurial businesses, we restrict our sample to firms with less than $500 million in sales and 1,000

[5]http://www.sap.com/ecosystem/customers/directories/searchpartner.epx.

[6]CorpTech uses a proprietary, three-digit product classification system. For example, a product coded as "AUT-AT-DA" means factory automation – automatic test equipment – analog/digital component.

[7]Specifically, we collected information on unmatched ISVs from Company Insight Center (CIC), a database launched by Business Week and Capital IQ. A short business profile is obtained from CIC for each of the remaining ISVs, which is complemented by a description of their business and products that we collect from the ISVs' websites. Then we manually examine the product portfolio of these ISVs by reading their business profiles and product descriptions.

[8]As an additional check, we manually go through the business description field in the CorpTech data for each company, and visit the website of each firm (if the company no longer exists, we visit the archival website from www.archive.org instead) to confirm that the ISVs product enterprise software applications, and delete those that do not fit the profile.

employees, and those established after 1980.[9] We exclude established incumbents because our research focuses on small ISV behavior and because the partnering incentives and payoffs of large firms are likely to be quite different from those of small firms. For example, to the extent that large firms sponsor platforms of their own, partnership may increase the value of a large firm's own platform. Also the appropriability risks that large firms face after partnering may be quite different than those of small firms due to the their strong IPRs and/or downstream capabilities. Our final sample consists of 1,210 ISVs with 6578 observations over the period 1996–2004. The typical ISV in our final sample is, on average, about 12 years old, with 56 employees, and sales of $7 million.

It should be noted that in our setting, ISVs produce software products that can be sold both as a stand-alone product and as platform-compliant software. Once the product is developed, the cost of making it compatible with a platform (technical cost, to be specific) is considerably lower than the product development cost. As a result, ISVs rarely make products that are dedicated to one specific platform from the beginning; in most cases, a stand-alone product is first developed, then is made compatible with the platforms of incumbents. In addition, many ISVs certify their product for multiple platforms to gain access to as many customers as possible. As an additional check, we examined the history of SAP partners in our sample to check whether their certified products were new, exclusive add-ons for only one platform. If this is true, it may suggest alternative explanations for the proposed hypotheses, especially H1. We found that all of our partners fell into one of three cases: (1) the partner had already produced multiple versions of the software prior to partnering with SAP; (2) the partner had already used trademarks related to the product in commerce at least two years prior to partnering (and so were not new); or (3) the product had been certified by multiple other enterprise software platforms such as Oracle, Siebel, J.D. Edwards, Infor, PeopleSoft, etc. We further note that ISVs in our sample had been around for several years prior to partnering; the average age of the ISVs in the year prior to patenting is 9.4, with the youngest being 1 in the year prior to partnering (that is, 2 in the year when a partnership was formed) and oldest being 23, and the average sales of these firms at one year prior to partnering is $20.7 million, with the lowest being $.33 million.

[9]Our results are robust to an alternative sample that uses $100 million in sales and 500 employees as cutoffs.

Dependent Variables

Sales. Sales data for each company-year are retrieved directly from the CorpTech database, and are measured in millions of U.S. dollars. We take the log form of the sales variable (that is, log (1 + x) to avoid taking log of zeroes) as the dependent variable in the regressions because this variable is highly skewed to the right. When the distribution of dependent variable is skewed, models using a logged transformation of the dependent variable often satisfy the classical linear model assumptions more closely than models using the level of the dependent variable (Verbeek 2008; Wooldridge 2008).

IPO. We search the Securities Data Company (SDC) platinum database to retrieve the list of ISVs in our sample that issued an initial public offering in the U.S. market during the sample period. We also obtain the date of IPO. The variable is set to 1 if an IPO is issued for a firm during a year, 0 otherwise.

Independent Variables

Partnership. The independent variable of interest is whether an ISV is an SAP-certified software solution provider in a particular year. As our study is longitudinal in nature, using the list of partnering ISVs retrieved from SAP's web portal as the key independent variable is problematic for several reasons. First, the list of partnering ISVs reflects only the current snapshot but fails to capture historical partnering events. Second, the enterprise software industry experiences considerable entry and exit during the sampling period; many partnering firms are eventually acquired by or merged with other companies. Third, information about the exact partnering date is missing from SAP's web portal, which makes determination of the year of partnership formation difficult.

As an alternative to overcome the aforementioned difficulties, we identify the partnership formation events through press releases. To test the viability of this approach, we examined the existing partner list retrieved from the SAP web portal to see whether a matching press release could be found in the LexisNexis database for each firm. For a random sample (60 firms) of the 411 existing SAP partners, we are able to find a matching news release for over 98 percent of the firms, which confirms the validity of using press releases to determine the formation of partnerships. We subsequently apply the same algorithm to our sample universe and retrieve 148 alliance events between sample ISVs and SAP. It is notable that there has been no such alliance activity prior to 1996. We further exclude pure joint development, marketing, or distribution alliances and alliances after 2004 from the list. In addition,

for ISVs that have multiple SAP alliance press releases (due to certification for multiple products, new versions of the same product, or different interface certifications), we use the first instance of such events to indicate the time that the ISV joins SAP's platform ecosystem.

The *partnership* variable is set to 1 in the first year that a partnership is formed and remains 1 for the rest of the years, and is 0 otherwise. We treat partnering with SAP as an absorbing state, as there are no obvious reasons for a partnering ISV to make its certified product incompatible with SAP's platform. In order to verify that partnering with SAP is indeed an absorbing state, we collect information on the ISVs' status after the partnering events. We find that partnering ISVs fall into the following three categories:

(1) Thirty-one percent of the ISVs remain partners with SAP with certified products as of April 2010.

(2) Forty-six percent of the ISVs were acquired or merged with other companies since they partnered with SAP. By reading the press releases of these merger and acquisition events, we find that the certified product existed at the acquisition/merger event in all cases, and note that such firms are dropped from our sample subsequently.

(3) Twenty-three percent of the ISVs are no longer listed on SAP's website as certified partners as of April 2010, but their most recent SAP certification occurs after 2004, the end of our sample period.

To summarize, these efforts reassure us that partnering is an absorbing state for all of the ISVs during our sample period (1996–2004).

Patents. We measure the patent stock of ISVs by using the USPTO CASSIS patent BIB database. Although diversified software vendors may have patented innovations in related areas (e.g., manufacturing control or data acquisition equipment), we are primarily interested in their software patents. We follow Hall and MacGarvie (2006) by defining the universe of software patents as the intersection of two sets of criteria: the patents in the software-related United States Patent and Trademark Office (USPTO) technology classes defined by Graham and Mowery (2005), and those that are found in the results of Boolean queries that searches for key words in the text of issued patents (as defined by Bessen and Hunt 2007).[10] For a survey of different ways to identify software-related inventive activities, see Arora et al. (2008). We also weight the resulting stock of software patents using each patent's forward citations, to account for the heterogeneity in the value of an innovation protected by the patent (Hall et al. 2001).[11]

Copyrights. The cumulative number of registered software copyrights for each firm-year is obtained from the U.S. Copyright Office.[12] To indicate copyright type, the U.S. Copyright Office assigns a prefix to each copyright it issues. As we are interested in software copyrights, we retrieve only those copyrights that are described as "computer file" within the TX (monograph including books, maps, and software) class.

Downstream capabilities. Following prior literature, we use the stock of software trademarks registered in the United States as a proxy of the ISV's effort to build brand, reputation, and distribution channels (Gao and Hitt 2004). According to the USPTO definition, a trademark (or a service mark) is

> a word, phrase, symbol or design, or combination of words, phrases, symbols or designs, that identifies and distinguishes the source of the goods [or services] of one party from those of others.

While trademarks may not directly protect a firm against the imitation of its products by its rivals per se, they enhance a firm's appropriability by legally protecting its investments in marketing and other intangibles such as brand and reputation (Fosfuri et al. 2008). It is important to note that trademarks not only protect the brand and logo of a firm's products, but also the broader marketing and promotional investments. For example, "The Best-Run Businesses Run SAP" is a registered trademark of SAP AG, as the slogan "Global Access to Local Knowledge" is of Microsoft. We follow prior research where trademarks have been used as a proxy for the stock of marketing-specific downstream assets and a firm's brand capital (Fosfuri et al. 2008; Gambardella and Giarratana 2006). Brand capital represents a hard to imitate capability since it is not easily contracted for through the market on

[10]As a robustness check, we also use the union of the two software patent sets and derive alternative measures, and find that all of the empirical results are robust to this alternative measure.

[11]Use of patent data is becoming increasingly common in IS research. For one example, see Kleis et al. (2009).

[12]A copyright protects the original expression of an idea fixed in a medium and does not need to be registered to be obtained. However, registration of a copyright in the U.S. Copyright Office provides evidence of validity of the claim and enables the rights holder to file an infringement suit in court and to file for statutory damages as well as recover attorney's fees if claims are litigated (http://www.copyright.gov/circs/circ01.pdf).

competitive terms and is hard to be redeployed to alternative uses and alternative users (Williamson 1991). The data have been obtained from the USPTO CASSIS Trademarks BIB database. We use only software trademarks that are active for the firm-year.

While a firm's stock of trademarks is a good measure of its marketing and distribution capabilities as well as other intangibles such as brand and reputation, we acknowledge that the downstream capabilities of an ISV may encompass other equally important dimensions that may not be entirely captured by the firm's stock of trademarks, such as its consulting and other professional service capabilities. As a robustness check of our measure of downstream capabilities, we construct a variable that measures the extent of software services that are offered by an ISV. The CorpTech database provides information on our sample firms' portfolio of software service offerings, which are classified into categories such as software consulting services, business intelligence services, custom software programming services, and artificial intelligence R&D services.[13] From this information we derive the variable *anyService*, which indicates that the ISV offers services to its clients (about 22 percent of the sample has *anyService* equal to 1). These offerings of services and support will, in many cases, be required by potential buyers to purchase the software. Thus, it is an alternative measure of downstream capabilities.

Control Variables

We control for a number of firm characteristics that could potentially influence operational performance. In particular, we control for an ISV's basic R&D capabilities by including its yearly stock of *publications* in academic journals or conferences in both the sales and IPO regressions. We obtain this variable from the ISI Web of Knowledge database, by searching for the ISV's name as organization and (article or proceedings paper) as document type. We weight the number of publications by the number of forward citations obtained by each article to account for heterogeneity in their importance.

Software firms' funding sources are likely to impact their operations. Therefore, we control for the effect of firms' sources of funding. We create three dummy variables, *cinvest*, *pinvest*, and *vinvest* following the CorpTech database classification of funding sources into corporate investment, private investment, or venture capital investment.

We also control for firm *age* in both performance equations based on the year in which an ISV was established, as well as its quadratic term, to account for nonlinear effects. As is typically done for IPO regression equations, we control for firm size by incorporating the number of *employees*, which is obtained directly from the CorpTech database. Due to the high correlation (greater than 0.9) between *sales* and *employees*, we exclude *sales* in the IPO equation to avoid multicollinearity (Hsu 2006). The variable *employees* is not included in the sales equation due to endogeneity concerns. To control for performance differences between public and privately held companies, we instead add an ownership indicator variable in the sales equation.

Investments in product and process innovations are driven in part by expectations about the potential size of the market and its growth potential (Acemoglu and Linn 2004; Cohen 1995; Schmookler 1966). In other words, ecosystem partnership may be associated with unobserved industry-level features such as expected industry growth that may influence a firm's success. To control for these industry-level features, we obtain the target industries that each ISV serves from the CorpTech database and classify them into 40 categories (such as banking, chemical, oil and gas). Next, we calculate the industry growth rate by averaging the sales growth rates of all the ISVs that serve the industry. We then map the industry growth to individual ISVs and derive the variable *industryGrowth* as a control. Table 2 presents the summary statistics of all of our variables, as well as the correlation among them.[14]

Methods

Main effect of partnering. Cross-sectional analysis of the effect of partnering on an ISV's performance is likely to suffer from unobserved firm heterogeneity, which may be correlated with partnering decisions, resulting in inconsistent estimates. We choose panel data methods with fixed effects as a starting point for the empirical analysis. Specifically, for firm sales we estimate the following equation:

[13]The complete list of service categories is as follows: artificial intelligence (AI) services, AI software programming, AI R&D services, other R&D services not elsewhere classified, software consulting services, custom software programming services, applications software services, systems software services, other custom programming services, and other software services.

[14]Notice that the correlations need to be interpreted with caution due to the panel structure of the data. For example, the correlation coefficient between partner and IPO is 0.06. If the data are collapsed at the firm level, the correlation increases to 0.24, which reflects variation *between* firms. Similarly, the correlation between trademarks and IPO is 0.005 overall, but jumps to 0.11 in the between sample. It is difficult to describe the correlation between variables *within* firms.

Table 2. Summary Statistics and Correlation Matrix

	Variable	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	$Sales_{i,t}$	7.539	16.219	0.000	206.400	1.000													
2	$IPO_{i,t+1}$	0.004	0.064	0.000	1.000	0.035	1.000												
3	$Partner_{i,t}$	0.017	0.129	0.000	1.000	0.295	0.063	1.000											
4	$Copyright_{i,t}$	1.988	12.841	0.000	498.000	0.253	0.029	0.044	1.000										
5	$Patent_{i,t}$	0.145	0.722	0.000	13.000	0.303	0.038	0.129	0.016	1.000									
6	$Trademark_{i,t}$	0.835	2.011	0.000	23.000	0.377	0.005	0.154	0.282	0.338	1.000								
7	$Age_{i,t}$	12.566	5.830	0.000	24.000	-0.052	-0.059	-0.058	0.069	-0.114	0.004	1.000							
8	$Publication_{i,t}$	0.600	5.259	0.000	137.000	0.044	-0.005	0.003	0.001	-0.005	0.030	0.045	1.000						
9	Corporate $invest_{i,t}$	0.046	0.210	0.000	1.000	0.102	0.010	0.101	-0.019	0.031	0.062	-0.118	-0.016	1.000					
10	Private $invest_{i,t}$	0.501	0.500	0.000	1.000	-0.087	-0.029	-0.039	-0.007	-0.048	-0.053	-0.144	-0.017	-0.068	1.000				
11	VC $invest_{i,t}$	0.122	0.327	0.000	1.000	0.176	0.108	0.171	-0.008	0.155	0.106	-0.339	0.039	0.071	-0.073	1.000			
12	$Employee_{i,t}$	56.248	104.904	1.000	997.000	0.901	0.071	0.283	0.240	0.286	0.385	-0.075	0.049	0.108	-0.100	0.199	1.000		
13	Industry $growth_{i,t}$	1.261	0.342	0.873	6.322	0.007	0.006	0.012	-0.001	-0.012	-0.023	-0.051	0.013	-0.019	-0.015	-0.019	0.011	1.000	
14	$Public_{i,t}$	0.061	0.239	0.000	1.000	0.447	-0.017	0.230	0.059	0.248	0.243	-0.058	0.072	0.075	-0.040	0.157	0.477	0.013	1.000

Notes: Number of firms: 1,210. Number of observations: 6,578.

$$\begin{aligned} Log(sales_{it}) &= \alpha + \beta_1 partner_{it} + \beta_2 patent_{it} + \beta_3 copyright_{it} \\ &+ \beta_4 trademark_{it} + \beta_5 age_{it} + \beta_6 age_{it}^2 + \beta_7 public_{it} \\ &+ \beta_8 cinvest_{it} + \beta_9 pinvest_{it} + \beta_{10} vinest_{it} \\ &+ \beta_{11} publication_{it} + \beta_{12} industryGrowth_{it} + year_t \\ &+ c_i + u_{it} \end{aligned}$$

where $year_t$ is a set of year dummies, and c_i denotes firm fixed effects. The variables patent, copyright, trademark, and publication are entered in log form (that is, log (1+x) to avoid taking log of zeroes) because their distributions are highly skewed.

Following prior studies (Forman et al. 2009; Gowrisankaran and Stavins 2004; Tucker 2008) with binary dependent variables, we estimate the IPO regression using a linear probability model with firm fixed effects, due to the known difficulty of controlling for time-invariant unobserved heterogeneity using panel data probit or logit models.[15] In particular, we estimate:

$$\begin{aligned} 1(IPO_{it+1} = 1) &= \alpha + \beta_1 partner_{it} + \beta_2 patent_{it} + \beta_3 copyright_{it} \\ &+ \beta_4 trademark_{it} + \beta_5 age_{it} + \beta_6 age_{it}^2 + \beta_7 cinvest_{it} \\ &+ \beta_8 pinvest_{it} + \beta_9 vinest_{it} + \beta_{10} publication_{it} \\ &+ \beta_{11} industryGrowth_{it} + \beta_{12} employee_{it} + year_{t+1} \\ &+ c_i + u_{it+1} \end{aligned}$$

where $1(IPO_{it+1} = 1)$ represents a binary variable indicating whether an IPO has been issued in year t+1. Note that only private firms are included in the IPO regression. The observations after a firm goes public are dropped from the sample as the firm is no longer exposed to the hazard of issuing an IPO. We lag all of the independent variables by one year to further mitigate for potential endogeneity of the right-hand-side variables. Number of employees is entered into the regression equation in log form.

Moderating effects of appropriation mechanisms. In order to evaluate Hypotheses 3 and 4, we add interactions between an ISV's partnering status and its IPR and downstream capabilities. To enable a more intuitive interpretation of our regression results, we create discrete measures of IPR and downstream capabilities. In particular, the variables *highCopyright* and *highTrademark* are set to 1 if an ISV's cumulative number of copyrights and trademarks is in the top quartile of the distribution.[16] Because less than 15 percent of the observations have patents, the variable *highPatent* is set to 1 if an ISV has at least one patent during the year, 0 otherwise.

To summarize, we estimate the following two equations to test if the effects of partnering on an ISV's sales and likelihood of issuing an IPO are moderated by appropriation mechanisms:

[15]For a full discussion of these issues, see Wooldridge (2002). Unconditional fixed effects provide inconsistent estimates using probit or logit models because of the well-known incidental parameters problem. Further, conditional fixed effects models drop panels where there is no variation in the dependent variable; in our setting, this would include any ISV that does not eventually issue an IPO.

[16]As a robustness check, we test the models using an alternative threshhold, the 50th percentile, to define the variables *highPatent*, *highCopyright*, and *highTrademark*. We conduct further robustness checks using continuous values for patents, copyrights, and trademarks. All of our findings reported in the main text are robust to these alternative specifications.

$$
\begin{aligned}
Log(sales_{it}) = {} & \alpha + \beta_1 partner_{it} + \beta_2 highPatent_{it} \\
& + \beta_3 highCopyright_{it} + \beta_4 highTrademark_{it} \\
& + \beta_5 age_{it} + \beta_6 age_{it}^2 + \beta_7 public_{it} + \beta_8 cinvest_{it} \\
& + \beta_9 pinvest_{it} + \beta_{10} vinest_{it} + \beta_{11} publication_{it} \\
& + \beta_{12} industryGrowth_{it} + \beta_{13} partner_{it} \\
& \times highPatent_{it} + \beta_{14} partner_{it} \times highCopyright_{it} \\
& + \beta_{15} partner_{it} \times highTrademark_{it} + year_t + c_i + u_{it}
\end{aligned}
$$

$$
\begin{aligned}
1(IPO_{it+1} = 1) = {} & \alpha + \beta_1 partner_{it} + \beta_2 highPatent_{it} \\
& + \beta_3 highCopyright_{it} + \beta_4 highTrademark_{it} \\
& + \beta_5 age_{it} + \beta_6 age_{it}^2 + \beta_7 cinvest_{it} + \beta_8 pinvest_{it} \\
& + \beta_9 vinest_{it} + \beta_{19} publication_{it} \\
& + \beta_{11} industryGrowth_{it} + \beta_{12} employee_{it} \\
& + \beta_{13} partner_{it} \times highPatent_{it} + \beta_{14} partner_{it} \\
& \times highCopyright_{it} + \beta_{15} partner_{it} \\
& \times highTrademark_{it} + year_{t+1} + c_i + u_{it+1}
\end{aligned}
$$

Results

Effect of Joining Platform Ecosystem on Sales

The results of fixed effects models that use *log(sales)* as the dependent variable are presented in Table 3. Variables are entered into the regressions sequentially. In column 1, we present the baseline model in which only the variables partnering status, IPRs, and downstream capabilities are included. In column 2, we add the other control variables. In column 3, we include year dummies.

Examining the results from the full model (column 3), we find support for Hypothesis 1, suggesting that joining a platform ecosystem is associated with greater sales. The variable *partner* is significant at the 5 percent level in all of the models. On average, ISVs enjoy a 26 percent ($e^{23} - 1$) increase in sales after they become SAP certified. Interestingly, we also find that ISVs' annual sales are strongly correlated with their appropriability mechanisms, as the coefficients of patent, copyright, and trademark are positive and highly significant.[17]

[17]Note that we present two sets of R-squared values in all of our tables. First, we present "within" R-squares that do not include the explanatory power of the fixed effects on the explained sum of squares, and are computed based on the fraction of variance explained within firms. These within R-square values are lower than our R-squared with fixed effects, which are based on the total (within and between) sum of squares and incorporate the explanatory power of our fixed effects. Note that in our IPO regressions, our dependent variable is binary, not continuous, and regressions with binary dependent variables typically have lower R-squared values than continuous variables. For further examples, see Forman et al. (2009).

Effect of Joining Platform Ecosystem on IPO

Hypothesis 2 suggests that joining a platform ecosystem is associated with a greater likelihood of issuing an IPO. The hypothesis is supported by the results in Table 4. As we did for the sales models, we present the baseline model in column 1, the one with the full set of control variables in column 2, and include year dummies in column 3. The variable *partner* is significant at the 5 percent or 10 percent level in all of the models. Using the results of the full model in column 3, we find that joining SAP's platform ecosystem is associated with a 5.9 percentage point increase in the likelihood of obtaining an IPO, supporting Hypothesis 2.

Robustness Checks

We test a number of alternative models and use different variable definitions to demonstrate the robustness of our findings. The results are presented in columns 4–7 in Table 3 (sales results) and Table 4 (IPO results).

First, in the benchmark models we use forward-citation-weighted patents and publications as independent variables. In column 4 of Tables 3 and 4, we present a similar specification using a fixed effects model and raw counts of patent stocks and scientific publications that are unweighted by forward citations. Second, although fixed effects models are robust to time-invariant unobserved heterogeneity, they are more susceptible to attenuation bias arising from measurement error (Griliches and Hausman 1986). In column 5 of Tables 3 and 4, we present the results from a random effects model. We observe that the estimates of the marginal effects of partnering are very similar to that of the fixed effects model.

It is possible that there exist time-varying omitted variables that affect both the ISV's decision to join SAP's platform ecosystem and its performance, which are not fully accounted for in our fixed effects models. For example, it is possible that ISVs with superior performance choose to join SAP's platform ecosystem. We address these endogeneity concerns in several ways. First, as a falsification test, we verify that the measured positive impacts of partnering on ISV performances do not occur before the partnering year (Agrawal and Goldfarb 2008). If we expect firms with better financial status will join SAP's ecosystem, it is likely that we will observe an increase in sales or the likelihood of an IPO in the years preceding their partnership with SAP. To investigate this possibility, we add as additional controls two dummy variables that are equal to one in the two years prior to the first

Table 3. Effect of Partnering on Sales

Variables	(1) Baseline model	(2) With firm level controls	(3) With year dummies	(4) Unweighted patent and publication	(5) Random effects	(6) Years before partner	(7) Instrumental variables
Partner	0.484***	0.254**	0.231**	0.230**	0.232**	0.298***	1.995**
	(0.115)	(0.105)	(0.105)	(0.102)	(0.096)	(0.115)	(0.822)
Patent	0.179***	0.121***	0.111***	0.443***	0.097***	0.110***	0.100***
	(0.032)	(0.026)	(0.027)	(0.091)	(0.022)	(0.027)	(0.029)
Copyright	0.233***	0.167***	0.156***	0.128***	0.173***	0.156***	0.136***
	(0.034)	(0.031)	(0.031)	(0.031)	(0.022)	(0.031)	(0.032)
Trademark	0.204***	0.102***	0.085***	0.080***	0.136***	0.084***	0.057**
	(0.025)	(0.024)	(0.024)	(0.023)	(0.021)	(0.023)	(0.028)
Age		0.079***	0.037***	0.035***	0.032***	0.036***	0.037***
		(0.009)	(0.011)	(0.011)	(0.008)	(0.011)	(0.011)
Age^2		-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Publication		0.062	0.048	0.062	0.014	0.049	0.089
		(0.065)	(0.065)	(0.060)	(0.044)	(0.065)	(0.068)
Cinvest		0.339***	0.327***	0.321***	0.301***	0.328***	0.347***
		(0.119)	(0.117)	(0.118)	(0.082)	(0.117)	(0.125)
Pinvest		0.040	0.027	0.024	-0.058*	0.028	0.036
		(0.045)	(0.045)	(0.044)	(0.033)	(0.045)	(0.048)
Vinvest		0.172**	0.171**	0.166*	0.290***	0.168**	0.033
		(0.085)	(0.085)	(0.086)	(0.059)	(0.086)	(0.108)
IndustryGrowth		0.048***	0.055***	0.054***	0.059***	0.055***	0.057***
		(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
Public		0.715***	0.704***	0.626***	0.791***	0.705***	0.426**
		(0.136)	(0.136)	(0.137)	(0.105)	(0.136)	(0.217)
One year before partnering						0.070	
						(0.102)	
Two years before partnering						0.122	
						(0.123)	
Year dummies	No	No	Yes	Yes	Yes	Yes	Yes
Constant	1.232***	0.476***	0.848***	0.868***	0.941***	0.850***	
	(0.019)	(0.071)	(0.090)	(0.090)	(0.067)	(0.090)	
Observations	6578	6578	6578	6578	6578	6578	6578
Number of firms	1210	1210	1210	1210	1210	1210	1210
R-squared (within)	0.103	0.183	0.192	0.197	.	0.193	0.069
R-squared (with fixed effects)	0.906	0.914	0.915	0.915		0.915	

Notes: Fixed effects panel data models (except for column 5). Robust standard errors, clustered by firm, in parentheses. R-squared (within) centers the dependent and independent variables before R-squared computation; R-squared (with fixed effects) includes fixed effects in R-squared computation.
***p < 0.01; **p < 0.05; *p < 0.1.

Table 4. Effect of Partnering on IPO

Variables	(1) Baseline model	(2) With firm level controls	(3) With year dummies	(4) Unweighted patent and publication	(5) Random effects	(6) Years before partner	(7) Instrumental variables
Partner	0.066**	0.060*	0.059*	0.059*	0.058*	0.063*	0.242*
	(0.033)	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)	(0.132)
Patent	0.004	0.005	0.004	0.018	0.006	0.004	0.002
	(0.004)	(0.004)	(0.004)	(0.016)	(0.004)	(0.004)	(0.005)
Copyright	0.019**	0.016**	0.016*	0.015*	0.014**	0.016**	0.014*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.006)	(0.008)	(0.008)
Trademark	0.002	-0.000	-0.000	-0.000	-0.001	-0.000	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Age		0.000	-0.001	-0.001	0.000	-0.001	-0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age^2		-0.000	-0.000	-0.000	0.000	-0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Publication		-0.006*	-0.006*	-0.010**	-0.005	-0.005*	-0.002
		(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)
Employee		0.004***	0.004**	0.004**	0.006***	0.004**	0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Cinvest		0.043	0.044	0.044	0.028	0.044	0.041
		(0.028)	(0.028)	(0.028)	(0.021)	(0.028)	(0.028)
Pinvest		0.004	0.004	0.004	-0.002	0.004	0.006
		(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Vinvest		0.027	0.028	0.029	0.035**	0.028	0.014
		(0.021)	(0.021)	(0.021)	(0.015)	(0.021)	(0.018)
IndustryGrowth		0.002	-0.001	-0.001	-0.001	-0.001	-0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
One year before partnering						-0.009	
						(0.030)	
Two years before partnering						0.032	
						(0.050)	
Year dummies	No	No	Yes	Yes	Yes	Yes	Yes
Constant	-0.005	-0.025***	-0.003	-0.002	-0.021*	-0.003	
	(0.003)	(0.009)	(0.022)	(0.022)	(0.011)	(0.022)	
Observations	6266[1]	6266[1]	6266[1]	6266[1]	6266[1]	6266[1]	6266[1]
Number of firms	1175[1]	1175[1]	1175[1]	1175[1]	1175[1]	1175[1]	1175[1]
R-squared (within)	0.020	0.032	0.037	0.038	.	0.040	0.041
R-squared (with fixed effects)	0.654	0.662	0.664	0.664		0.665	

Notes: Fixed effects panel data models (except for column 5). Robust standard errors, clustered by firm, in parentheses. R-squared (within) centers the dependent and independent variables before R-squared computation; R-squared (with fixed effects) includes fixed effects in R-squared computation.

***p < 0.01; **p < 0.05; *p < 0.1.

[1]Only private companies are included. Post IPO observations are dropped.

partnering event. We present the results in column 6 of Tables 3 and 4. The results show no significant preexisting trend on sales or the likelihood of an IPO for partnering ISVs. The effect only takes place *after* partnering with SAP.

Second, we use instrumental variables (IV) methods to address potential endogeneity concerns. In particular, we use two candidate variables that should be correlated with the partnering decision but not with financial performance. The first variable describes how many executives of an ISV have personal connections with SAP. From the CorpTech database, we retrieve the complete list of executives for every firm-year. We then look up the working experience of each executive on the business-oriented social network website, LinkedIn, to find if he/she has ever worked for SAP as an employee. We then aggregate the number of executive links to SAP at the firm-year level. The rationale for using this variable as an instrument is that an executive's past working experience at SAP is likely to establish personal connections that would increase the propensity to partner with SAP. However, it is unlikely to be correlated with unobserved firm-level factors that would increase the performance of the firm where he/she serves as an executive. The second variable describes the propensity to partner with SAP among ISVs that serve markets similar to those of the focal ISV. The CorpTech database has data on the target industries within which each company sells its products and services, which we broadly classify into 40 categories. We calculate the fraction of ISVs that partner with SAP in each industry-year, and use this to approximate the partnering propensity at the industry level. We then calculate the partnering propensity for each ISV, by weighting these data by the set of industries served by the ISV. If an ISV serves multiple industries, the industry-level propensities are averaged to derive the ISV's propensity. The logic for this variable is that it will capture cross-industry differences in the value of partnership. However, conditional on our controls for industry growth, it should be uncorrelated with factors influencing ISV performance. Following prior literature on instrumental variables under binary endogenous variables (Angrist and Pischke 2009), we use these instruments to run a probit model of the propensity of a firm-year to be an SAP partner.[18] We then use the predicted probability of partnership from this probit model and the square of this predicted probability as our instruments. Using nonlinear fitted values of instruments in this way has been shown under some cases to have efficiency properties superior to a traditional linear first stage but still able to provide consistent estimates (Angrist 2001; Newey 1990).

We present the results from the instrumental variable model in column 7 of Tables 3 and 4. Our results are robust to the use of these models.[19]

Since acquisition by another firm is often considered a successful exit strategy for small start-up firms, an alternative measure of forward-looking performance in the literature is whether the firm issues an IPO or has been acquired (Cockburn and MacGarvie 2009). We also examine how partnership influenced the likelihood of obtaining an IPO or acquisition,[20] and the results were qualitatively similar to our IPO models.[21]

Moderating Effect of Appropriability Mechanisms for Sales

Hypotheses 3a and 3b suggest that the marginal effect of joining a platform ecosystem on an ISV's sales is greater when the ISV enjoys greater IPR protection or stronger downstream capabilities. In other words, the effect of partnering on ISV sales is moderated by their appropriability mechanisms. We present the results for the moderating effects in Table 5. As usual, fixed effects panel data models are used. Column 1 presents the baseline model where only partnering status, appropriability mechanisms, and their interactions are included. In column 2, we add the control variables, while in column 3, we include year dummies. The results in column 3 suggest that ISVs that partner with SAP on average experience a 35.9 percent sales increase provided they have high patent stocks ($p < 0.01$), a 22.5 percent increase provided they have high copyright stocks ($p < 0.05$), or a 18.8 percent increase provided they have high trademark stocks ($p < 0.05$). The upper panel of Figure 2, which is based on column 3 of Table 5, visually illustrates the moderating effect of IPR and downstream capabilities on the relationship between partnership and ISV sales. Surprisingly, our results indicate that ISVs whose innovations are not protected by any

[18]That is, we run the probit model of partnership on our two instruments: social connections and industry propensity to partner.

[19]All of the instrumental variable results presented in the paper are supported by tests of instrument validity (available from the authors on request). Indeed, the p-value related to the tests of the joint null hypothesis of no effect of the instruments on partnership is always lower than 0.001. In addition, the tests of the overidentifying restrictions (Hansen J tests) always suggest that the instruments used are exogenous in all of the IV specifications presented in the paper.

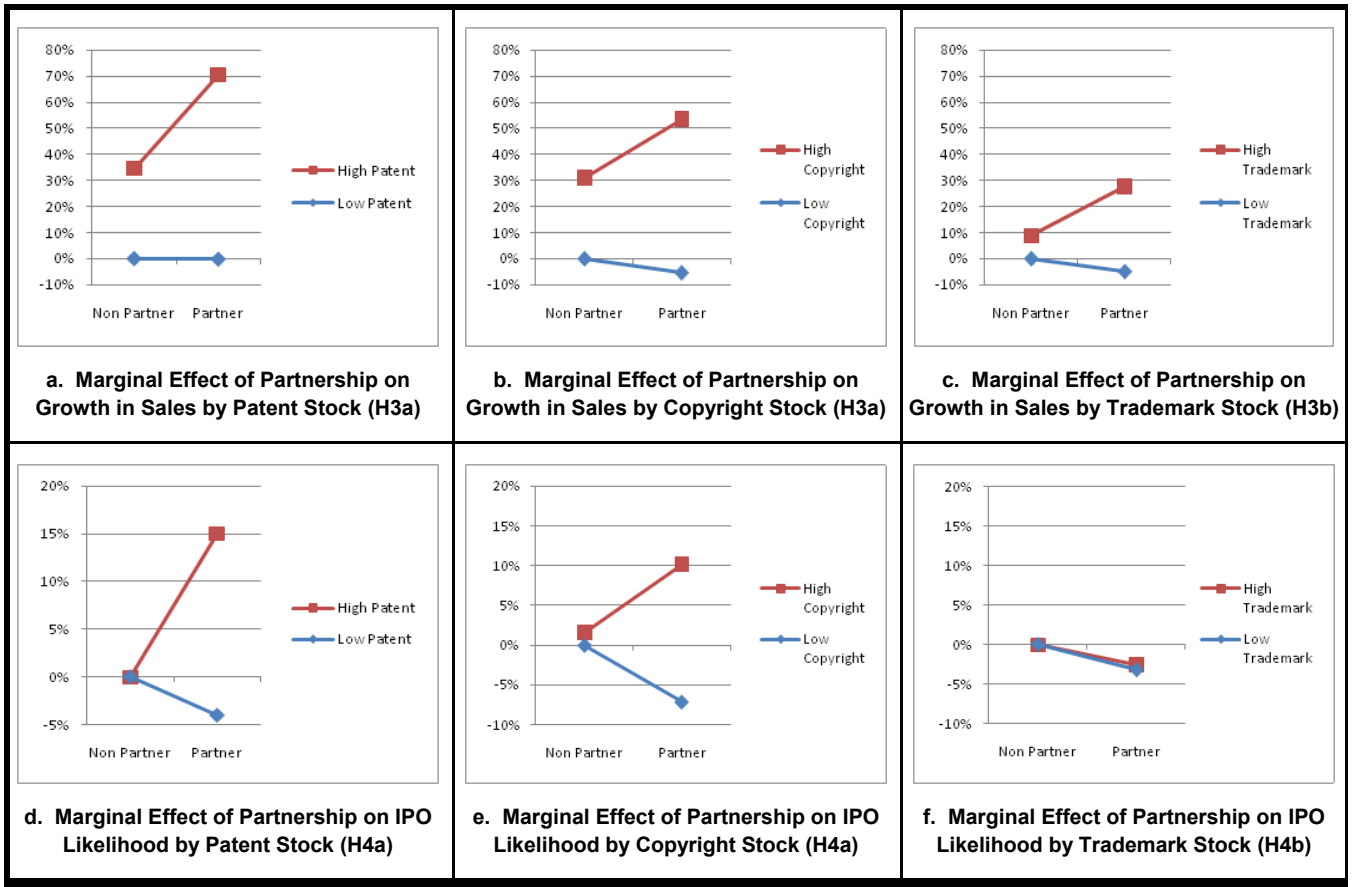
[20]We define acquisitions as majority share acquisitions, and we exclude bankrupt acquisitions and liquidation acquisitions. Data are collected from the SDC Platinum database.

[21]Due to space constraints, the results of these models are not reported, but are available on request from the authors.

Table 5. Moderating Effect of IPRs and Downstream Capabilities, Sales

Variables	(1) Baseline model	(2) With firm level controls	(3) With year dummies	(4) With service only	(5) With service and trademarks	(6) Instrumental variables
Partner	0.057	-0.084	-0.149	-0.043	-0.185	-0.543
	(0.136)	(0.129)	(0.129)	(0.107)	(0.132)	(1.398)
HighPatent	0.616***	0.383***	0.346***	0.356***	0.344***	
	(0.058)	(0.057)	(0.056)	(0.056)	(0.056)	
HighCopyright	0.456***	0.339***	0.310***	0.315***	0.310***	
	(0.045)	(0.043)	(0.043)	(0.043)	(0.043)	
HighTrademark	0.199***	0.104***	0.088***		0.089***	0.070*
	(0.021)	(0.021)	(0.021)		(0.021)	(0.031)
AnyService				0.009	0.017	
				(0.043)	(0.043)	
HighIPR						0.285***
						(0.063)
Partner × HighPatent	0.392***	0.323**	0.362**	0.466***	0.426***	
	(0.149)	(0.143)	(0.142)	(0.148)	(0.149)	
Partner × HighCopyright	0.251**	0.262**	0.278**	0.265**	0.295**	
	(0.127)	(0.121)	(0.121)	(0.121)	(0.121)	
Partner × HighTrademark	0.385***	0.214**	0.238**		0.199*	1.175
	(0.112)	(0.107)	(0.106)		(0.110)	(0.765)
Partner × AnyService				0.230*	0.161	
				(0.121)	(0.124)	
Partner × HighIPR						2.498*
						(1.323)
Age		0.081***	0.035***	0.038***	0.035***	0.029***
		(0.007)	(0.009)	(0.009)	(0.009)	(0.011)
Age^2		-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Publication		0.083*	0.066	0.064	0.062	0.120*
		(0.050)	(0.050)	(0.050)	(0.050)	(0.068)
Cinvest		0.357***	0.339***	0.354***	0.342***	0.329**
		(0.069)	(0.068)	(0.068)	(0.068)	(0.136)
Pinvest		0.049	0.035	0.042	0.036	0.059
		(0.034)	(0.034)	(0.034)	(0.034)	(0.050)
Vinvest		0.165***	0.164***	0.158***	0.159***	-0.035
		(0.051)	(0.051)	(0.051)	(0.051)	(0.125)
Public		0.749***	0.730***	0.754***	0.732***	0.484*
		(0.061)	(0.061)	(0.061)	(0.061)	(0.225)
IndustryGrowth		0.048***	0.055***	0.055***	0.056***	0.058***
		(0.013)	(0.015)	(0.015)	(0.015)	(0.018)
Year dummies	No	No	Yes	Yes	Yes	Yes
Constant	1.220***	0.430***	0.839***	0.838***	0.835***	
	(0.014)	(0.053)	(0.076)	(0.077)	(0.077)	
Observations	6578	6578	6578	6578	6578	6477
Number of firms	1210	1210	1210	1210	1210	1109
R-squared (within)	0.091	0.182	0.192	0.189	0.193	0.012
R-squared (with fixed effects)	0.904	0.913	0.915	0.914	0.915	

Notes: Fixed effects panel data models with robust standard errors, clustered by firm, in parentheses. R-squared (within) centers the dependent and independent variables before R-squared computation; R-squared (with fixed effects) includes fixed effects in R-squared computation.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.



a. Marginal Effect of Partnership on Growth in Sales by Patent Stock (H3a)

b. Marginal Effect of Partnership on Growth in Sales by Copyright Stock (H3a)

c. Marginal Effect of Partnership on Growth in Sales by Trademark Stock (H3b)

d. Marginal Effect of Partnership on IPO Likelihood by Patent Stock (H4a)

e. Marginal Effect of Partnership on IPO Likelihood by Copyright Stock (H4a)

f. Marginal Effect of Partnership on IPO Likelihood by Trademark Stock (H4b)

Figure 2. Moderating Effects of Patents, Copyrights, and Trademarks

Notes: 1. Marginal effects on sales are measured by percent increase. 2. Marginal effects on IPO are measured by percentage point increase.

means of appropriation do not experience any significant improvement in sales. If anything, their sales performance is poorer (though not significantly so) than if they did not partner. We interpret this as a finding that such firms are unable to appropriate the value cocreated by partnership. For example, ISVs with weak marketing, distribution, or service capabilities may be unable to convert platform adopters into ISV customers, even after compatibility with the platform has been signaled. Moreover, to the extent that trademarks reflect a superior brand or reputation, it should not be surprising that signaling compatibility with, say, poorly distributed software solutions would not be associated with an increase in sales.

We present the results with *anyService*, the alternative measure of downstream capabilities that incorporates the extent of an ISV's software service, in columns 4 and 5 of Table 5. When *anyService* is substituted for *highTrademark*, it behaves very similar to the latter variable; the interaction term of partner and *anyService* is positive and significant in column 4. However, when both *highTrademark* and *anyService* are included in the same regression (in column 5), we find that the latter variable is statistically insignificant. We take this as evidence that while both *highTrademark* and *anyService* capture downstream capabilities, *highTrademark* is more important than *anyService* in appropriating the returns from partnership. There may be several reasons for this result: trademarks may be a stronger appropriability mechanism because they are more difficult to imitate; further, in the case of a sales increase, the stock of trademarks can be scaled up at a much lower cost than services. Moreover, as suggested above, trademarks also reflect the ISV's brand and reputation. Regardless of the measure used, we find that the interactions between *partner* and *highPatent* and *highCopyright* are all positive and significant at conventional levels. In summary, the results lend support to Hypothesis 3a and 3b.

Table 6. Moderating Effect of IPRs and Downstream Capabilities, IPO

Variables	(1) Baseline model	(2) With firm level controls	(3) With year dummies	(4) With service only	(5) With service and trademarks
Partner	-0.077	-0.081	-0.083	-0.068	-0.080
	(0.071)	(0.072)	(0.071)	(0.042)	(0.071)
HighPatent	0.002	0.002	-0.000	-0.001	-0.001
	(0.008)	(0.010)	(0.009)	(0.009)	(0.009)
HighCopyright	0.016*	0.016	0.016	0.015	0.015
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
HighTrademark	0.004	0.000	-0.000		-0.000
	(0.004)	(0.004)	(0.004)		(0.004)
AnyService				0.006	0.006*
				(0.004)	(0.004)
Partner × HighPatent	0.194**	0.189*	0.190*	0.180*	0.179*
	(0.098)	(0.102)	(0.101)	(0.103)	(0.100)
Partner × HighCopyright	0.162**	0.160**	0.158**	0.160**	0.163**
	(0.068)	(0.068)	(0.067)	(0.068)	(0.069)
Partner × HighTrademark	0.005	0.005	0.007		0.016
	(0.054)	(0.054)	(0.054)		(0.053)
Partner × AnyService				-0.041	-0.045
				(0.031)	(0.028)
Age		0.001	-0.001	-0.001	-0.001
		(0.000)	(0.001)	(0.001)	(0.001)
Age^2		-0.000	-0.000	-0.000*	-0.000*
		(0.000)	(0.000)	(0.000)	(0.000)
Publication		-0.004*	-0.004*	-0.005*	-0.005*
		(0.002)	(0.002)	(0.003)	(0.003)
Employee		0.004***	0.004**	0.004**	0.004**
		(0.002)	(0.002)	(0.002)	(0.002)
Cinvest		0.041	0.041	0.041	0.041
		(0.028)	(0.028)	(0.028)	(0.028)
Pinvest		0.004	0.004	0.004	0.004
		(0.005)	(0.005)	(0.005)	(0.005)
Vinvest		0.024	0.026	0.027	0.027
		(0.021)	(0.021)	(0.021)	(0.021)
IndustryGrowth		0.002	-0.001	-0.001	-0.001
		(0.002)	(0.002)	(0.002)	(0.002)
Year dummies	No	No	Yes	Yes	Yes
Constant	-0.001	-0.026***	0.003	-0.001	-0.000
	(0.003)	(0.009)	(0.021)	(0.020)	(0.020)
Observations	6266[1]	6266[1]	6266[1]	6266[1]	6266[1]
Number of firms	1175[1]	1175[1]	1175[1]	1175[1]	1175[1]
R-squared (within)	0.038	0.053	0.058	0.060	0.060
R-squared (with fixed effects)	0.660	0.669	0.671	0.672	0.672

Notes: Fixed effects panel data models with robust standard errors, clustered by firm, in parentheses. R-squared (within) centers the dependent and independent variables before R-squared computation; R-squared (with fixed effects) includes fixed effects in R-squared computation.
***p < 0.01; **p < 0.05; * p< 0.1.
[1]Only private companies are included. Post IPO observations are dropped.

Moderating Effect of Appropriability Mechanisms for IPO

We find that the marginal effect of joining a platform ecosystem on the ISVs' likelihood of issuing an IPO is also moderated by their appropriability mechanisms. Table 6 presents the results of this model. Confirming Hypothesis 4a (column 3 of Table 6), we find that the increase in the likelihood of obtaining an IPO will be 15.1 percentage points higher provided the ISV also has high patent stocks ($p < 0.01$) and 8.7 percentage points higher provided it also has high copyright stocks ($p < 0.01$). These results are statistically significant at conventional levels. We do not find evidence that ISVs with high trademarks experience greater benefits from partnering. The moderating effects of IPRs are illustrated in the lower panel of Figure 2. In addition, we find that if the innovations of an ISV are not protected by any appropriability mechanism, there is no evidence that partnering will increase the likelihood of obtaining an IPO. This can be seen from the insignificant (and negative) coefficient of the *partner* variable.

We believe that the lack of result for the interaction of *partner* and *highTrademark* may be due to a feature of our data: the number of IPOs declines dramatically throughout our sample because of the deterioration of financial market conditions in the wake of the dot-com bust. At the same time, the fraction of firms with *highTrademark* increases from 22.0 percent (in 1996) to 38.0 percent (in 2004). Thus, it is difficult for us to separate the effects of increasing trademarks from deteriorating financial market conditions on the likelihood of an IPO. In a separate set of regressions, we interact our *partner* variable with a post-2001 dummy and find that the marginal effect of *partner* on IPO declines substantially post-2001 because of this change in external environment. Thus, we believe our coefficients for the *partner* × *highTrademark* variable are biased downward because of this change in economic and financial conditions. Another possibility is that this result may reflect differences in the effectiveness of trademarks as a short run and long run appropriability mechanism; if investors do not believe trademarks will improve appropriability in the long run, then that may also lead to an insignificant interaction between trademarks and partnership.[22] As a robustness check, we also use the alternative measure *anyService* (column 4 and column 5) but again find no evidence that this measure of downstream capabilities is complementary with partnership.

[22]We thank an anonymous reviewer for suggesting this interpretation.

Robustness Checks for Moderating Effects

While we do use firm fixed effects in all of our models in Tables 5 and 6, one potential concern is that there may exist time-varying omitted variables that may be correlated with *partner* and its interaction with *highPatent*, *highCopyright*, and *highTrademark*. If that is the case, then our estimates of these parameters may be biased. However, use of instrumental variables for the complete set of endogenous variables is difficult in our setting: this would require a set of four separate instruments, which would compound the usual problems that fixed effects remove all of the useful cross-sectional variation in the data and in the presence of measurement error give rise to attenuation bias (Angrist and Pischke 2009; Greene 2002). To reduce the number of endogenous variables that we must instrument for, we create a new variable called *highIPR* which equals to one if either *highPatent* or *highCopyright* is one. Since patents and copyrights are used as substitute forms of IPR protection in the software industry (Lerner and Zhu 2007), this variable is a combined measure of IPR protection for the ISV.

Thus, we have three endogenous variables: *partner, partner* × *highIPR,* and *partner* × *highTrademark*. Following prior literature on the use of instrumental variables in nonlinear (in variables) settings (Gallant 1987, p. 440), we instrument for these variables using the predicted values of partner using the method above, and the interaction of this variable with *highIPR, highTrademark,* and other exogenous variables such as age, age-squared, and sales growth. In total, we have eight instruments for three endogenous variables.

Instrumental variables estimates for our sales regressions are included in column 6 of Table 5.[23] Our results are qualitatively robust to the use of instrumental variables and fixed effects. The coefficient estimates show that partnership will only be associated with an increase in sales in the presence of *highIPR* and *highTrademark*. The coefficient for the interaction of *partner* with *highIPR* remains significant at the 10 percent level. The interaction of *partner* with *highTrademark*, while not significantly different than zero at conventional levels, remains statistically significant at the 12.5 percent level.

[23]Instrumental variable results related to the IPO equation with interactions are not shown due to the poor fit of the model (negative R-squared) and the inability to identify the effects under study. We believe that this is due partly to the difficult data environment: In the IPO regressions, our dependent variable is binary, a particularly challenging setting to estimate via nonlinear IV (instrumenting for partnership and its interactions) using only the *within* firm variation (because of our use of firm fixed effects). Further, as noted above, the effect of *highTrademark* is inherently more difficult to identify in this setting because of the aggregate time series trend in *highTrademark* and *partner*.

Table 7. Summary of Results and Implications

Hypothesis	Inference	Implications
(H1) An ISV's participation in an enterprise software platform ecosystem is associated with an increase in sales.	Supported	• On average, ISVs can achieve significant benefits through participation in a platform ecosystem. • By joining the platform and enhancing compatibility with the platform, ISVs avoid the duplication of costly complementary assets (i.e., investments needed to integrate the software and effectively signal compatibility to reach the installed base). • Provides empirical evidence of cocreated value through participation in a platform.
(H2) An ISV's participation in an enterprise software platform ecosystem is associated with an increase in the likelihood of issuing an IPO.	Supported	
(H3a) The marginal effect of an ISV's participation in a platform ecosystem on sales is greater when the ISV is better protected by IPRs such as patents and copyrights.	Supported	• ISVs without downstream marketing or service capabilities or without IPRs such as patents and copyrights will appropriate less of the cocreated value generated from compatibility with the platform. • Establishes a set of boundary conditions on the extent to which cocreated value is captured by ISVs. • Results suggest that strong IPRs will indirectly benefit the platform owner by nurturing the ecosystem.
(H3b) The marginal effect of an ISV's participation in a platform ecosystem on sales is greater when the ISV has stronger downstream capabilities.	Supported	
(H4a) The marginal effect of an ISV's participation in a platform ecosystem on the likelihood of issuing an IPO is greater when the ISV is better protected by IPRs such as patents and copyrights.	Supported	
(H4b) The marginal effect of an ISV's participation in a platform ecosystem on the likelihood of issuing an IPO is greater when the ISV has stronger downstream capabilities.	Not Supported	

Conclusions

To summarize, we report participating in a platform ecosystem serves as a new and viable innovation commercialization strategy employed by small ISVs. Our results demonstrate that, on average, ISVs can achieve significant benefits through participation in a platform ecosystem—benefits that can translate into significant increases in sales and an increased likelihood of eventually attaining an IPO, a widely recognized measure of success for start-up firms. However, there exists considerable heterogeneity in the extent to which ISVs can capture the value cocreated by these partnerships. In particular, ISVs without downstream marketing or service capabilities or without IPRs such as patents and copyrights will appropriate less of the cocreated value generated from compatibility with the platform. These results are robust to a battery of robustness checks, including instrumental variables analysis and a falsification exercise. Table 7 summarizes our key results and their implications.

Limitations

We believe that our study represents a careful analysis of the impact of platform participation on ISV business performance. However, like any empirical study, it does have several limitations. One potential issue arises from sample definition, in particular how to determine the "at-risk" set of potential participants in the ecosystem. As noted above, in this study, we identify the set of at-risk firms as those software firms producing manufacturing and warehousing/distribution software. We chose not to extend our sample to firms producing other product types for two reasons. First, many of the software firms in our sample produce other types of products beyond manufacturing and warehousing/distribution. Thus, our sample includes a much broader cross-section of software products than might appear at first glance. For example, among our sample of 1,210 ISVs, 474 also produce accounting software, 323 provide utility systems software, and 256 also provide sales/marketing software.

Second, selecting on other software product types would introduce significant unobserved heterogeneity into our sample by adding many firms whose products are unrelated to SAP's software and for whom the benefits of partnership are likely to be extremely low. For example, if we add producers of accounting software to our list (SOF-AC, the group with the next highest hazard rate of partnership), it would increase our sample size by over 2,000 firms, but would add only 14 partners. Another limitation is that our study examines one particular setting, the SAP platform ecosystem. In the next subsection, we discuss implications for other industry environments, however leave it to future work to empirically study whether our findings generalize to other settings.

Implications for Other Industry Environments

Our study follows prior work that has used case studies of individual industries to examine the implications of platforms for producer and user behavior (Adomavicius et al. 2008; Nair et al. 2004). We believe this approach is appropriate for the study of platform industries insofar as it reduces unobserved heterogeneity across observations and improves internal validity. However, our focus on platform ecosystems is valid across a wide variety of settings. Large ecosystems have been fundamental to the success (in terms of platform sales and ultimate business survival) of IT platforms such as Ethernet (13 vendors supported Ethernet in 1982 compared to the 3 vendors supporting Token Ring; Von Burg 2001); Microsoft Windows (38,338 vendors, including 3,817 ISVs; Iansiti and Levien 2004); Palm Handhelds (that claimed over 140,000 developers for its standard in 2001; Nair et al. 2004); and iPhone (50,000 applications as of June 2009),[24] as well as real estate platforms like Multiple Listing Service (12,322 listings in the Madison, Wisconsin, area according to Hendel et al. 2009).

Moreover, the key platform issues that we study—the benefits of joining a platform from signaling technological compatibility and the risks of entry from the platform owner—also have widespread validity. For example, complementors benefit from compatibility with platforms such as Microsoft Windows, the Cisco Internetwork Operating System, and Intel microprocessors, however the threat of incursion from the platform owner into the complementor's market has been a focus of theoretical work and case studies in all three industries (Eisenmann et al. 2011; Gawer and Cusumano 2002; Gawer and Henderson 2007).

[24]http://tech.fortune.cnn.com/2009/06/10/apple-fact-check-50000-iphone-apps/.

While our setting shares many features with other IT platforms, one key difference is that ISVs in our setting have the option to choose between joining a platform and selling platform-independent, stand-alone applications. In particular, in our setting, the platform plays the role of reducing compatibility costs among heterogeneous components, rather than providing an infrastructure that includes components required for complementary applications to run. In that way, our setting shares similarity with environments like Cisco's Internetwork Operating System platform (which reduces the costs of communication among heterogeneous routers and switches) rather than the Microsoft Windows or Xbox platforms (which includes key infrastructure required for complementors' applications to run). More empirical research is needed in this latter, important area.

It is important to state how ecosystem partnerships are distinct from other forms of IT value cocreation (Kohli and Grover 2008). Like other settings of IT value cocreation, in our setting IT is "instrumental in creating a product to cocreate business value" (Kohli and Grover 2008). However, in other settings IT is used to cocreate value by facilitating standardization of business processes or improving information flows between heterogeneous systems of individual firms (Markus et al. 2006). In this way, IT facilitates value cocreation by reducing transaction costs through interorganizational systems that, among other things, strengthen supply chain relationships (Bharadwaj et al. 2007; Clemons et al. 1993; Gerbauer and Buxmann 2000; Melville et al. 2004). In our setting, partnership aids in the standardization of interfaces between software products that are used to cocreate business value. In so doing, we add to the evolving work in Information Systems that seeks to understand how firms cocreate value through IT platforms (Dhar and Sundararajan 2007).

Theoretical Implications

Platform ecosystems present an interesting setting for studies on the dynamics of interorganizational collaboration and competition. An increasing body of theoretical work has examined firm strategies in platform markets, including decisions on the extent to which a platform should be opened (Eisenmann et al. 2009; Parker and Van Alstyne 2008; West 2003) and vendor reactions to open and closed platforms (Lee and Mendelson 2008; Mantena et al. 2007). However, there has been little research that measures the value cocreated through participation in such a platform. Our study takes initial steps to investigate these issues from the perspective of small, complementary solution providers in the enterprise software industry.

Perhaps most significantly, we establish a set of boundary conditions on the extent to which this value is captured by small ISVs. These findings extend and complement Huang et al. (2009), who show that highly innovative ISVs are more likely to join a platform ecosystem. Interestingly, while this focus on establishing the conditions for appropriating value from IT investment has long been a focus on other ecosystems studied in the information systems literature such as supply chain relationships (Grover and Saeed 2007; Subramani 2004), it has drawn relatively little attention in empirical work on software platforms. We feel this is a fruitful area for future research.

Finally, our contributions to the markets for technology literature stems naturally from our focus on the enterprise software industry. In this setting, technology commercialization by entrepreneurial companies may be facilitated by joining the platform ecosystem. Such partnerships represent a natural setting for the identification of the effect of IPRs on technology commercialization and firm performance, a key objective of this paper and the markets for technology literature (Arora and Ceccagnoli 2006; Arora et al. 2001; Cockburn and MacGarvie 2006, 2009; Gans et al. 2002). Indeed, unintended knowledge spillovers are particularly salient during enterprise software certification, which requires partnering firms to closely integrate their product interface designs. This highlights a clear tradeoff for technology commercialization by ISVs. Our results imply that strong IPRs directly influence this tradeoff by affecting the likelihood of platform owner entry. Further, strong IPRs will indirectly benefit the platform owner by nurturing the platform ecosystem with innovative software solutions. In other words, IPRs appear to favor both value appropriation and value cocreation in the enterprise software industry.

Managerial Implications

Our findings have important implications both for platform sponsors as well as those who participate in the platform ecosystem. First, our results suggest that, under certain conditions, ISVs that join a platform ecosystem will see gains in operational performance. However, ISVs whose innovations are not protected by IPRs or downstream complementary capabilities should be cautious about initiating partnerships. To prevent entry from the platform owners, they should actively seek IPR protection, or secure complementary downstream capabilities first. Finally, we believe that it is critical for the platform owners to understand the incentives of complementary product providers. In particular, the appropriate management of the appropriability concerns of its smaller yet most innovative entrepreneurial partners represents a potential strategy to sustain their platform ecosystems.

Generally, our results suggest some conditions under which a "virtuous cycle" may be realized in a software platform ecosystem. As is well known, there is significant variation in the extent to which formal appropriability mechanisms like patents and copyrights are effective at protecting firms' intellectual property (Cohen et al. 2000). Our results suggest that ISVs that participate in markets for which appropriability mechanisms like patents are strong will see greater returns from partnership. These greater returns will in turn encourage new partners to join the ecosystem, and will also draw in additional customers (and, in turn, additional partners). Our results similarly suggest conditions under which this virtuous cycle is unlikely to occur, however. In environments where appropriability mechanisms are weak, our results suggest that the expected gains from partnership are relatively low, and under such conditions the platform ecosystems are most likely to be unsuccessful in attracting complementary innovation.

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Appendix

SAP Enterprise Software Platform Ecosystem for ISVs Details

To join SAP's partner program, an ISV develops a product and then obtains a certification from SAP, which endorses the interoperability between the product and the SAP platform. In particular, ISVs that plan to achieve software integration with SAP solutions work with one of the local SAP integration and certification centers (ICCs) to have their product certified. The process typically involves a feasibility study, service offer processing, and extensive testing by SAP. If successful, SAP issues a formal SAP ICC contract for the ISV to sign and applicable fees are paid by the ISV and the certified integration is publicly listed online in the SAP partner information center. Interestingly, the ICC contract includes a section that stipulates the governance of IPRs and recognizes the exclusive rights of software vendor in its patents, trademarks, copyrights, and trade secrets.

By making its product SAP-certified, an ISV effectively signals its compatibility with the SAP platform. This will strengthen the ISV's ability to sell to SAP's large installed base. For example, LogicTools Inc. is a software company that provides an integrated suite of strategic supply chain planning solutions that optimize the supply chain by simultaneously optimizing account production, warehousing, transportation, and inventory costs, as well as service level requirements. It became an SAP software partner in January 2004 (Simchi-Levi et al. 2006). Since then, LogicTools' customer base has been growing rapidly, adding 30 new clients in 2005 alone, with its sales growing by over 50 percent in 2005 (Business Wire Inc. 2006). According to the press release, "LogicTools' software partnership with SAP and certified integrations make LogicTools' solutions an easy choice for many companies." In addition, by teaming up with a prestigious industry leader, ISVs gain endorsements, enhance their social legitimacy, and signal their technological excellence (Stuart et al. 1999). As an example, TIBCO Software Inc. (www.tibco.com), an ISV that provides enterprise application integration solutions, certified its interface for SAP R/3 solutions and became a member of the SAP Complementary Software Partner program in 1998 (Business Wire Inc. 1998). Since then, it has become the *de facto* standard for event-driven computing and enterprise application integration in finance, manufacturing, construction, electronic commerce, and other industries, and obtained an initial public offering on NASDAQ one year later (Business Wire Inc. 1999). This IPO was highly successful with a strong first day of trading, when its stock price increased from $15 to $32.375. The reputation consequences of strategic partnership are particularly important in high-technology industries, which are noted for pervasive uncertainty (Tushman and Rosenkopf 1992).

On the other hand, joining SAP's platform ecosystem is not costless for ISVs. Besides the fixed cost of developing a platform-compliant version of the software solution, certification application fees, and yearly membership fees, there may be considerable risks for ISVs due to the extensive knowledge sharing involved in the relationship. AMC Technology, a leading provider of multichannel integration solutions that allow contact centers to more efficiently manage all types of customer interactions, has been a certified SAP software partner since 1998. With its introduction of the product suite mySAP CRM 5.0 in 2005, SAP folded the multichannel integration functionality into its platform and entered into AMC's product territory with a "CRM Interaction Center" module, which allegedly contained copyrighted AMC code from AMC's "Multi-Channel Management Suite" product. AMC soon filed a lawsuit that claimed vicarious copyright infringement, breach of contract, and appropriation of trade secrets by SAP (SAP 2005; Shapiro 2005).