IMPACT OF PLATFORM VENTURE CAPITAL INVESTMENTS ON THE INTRODUCTION AND WITHDRAWAL OF COMPLEMENTARY PRODUCTS

ABSTRACT

How do platform venture capital (PVC) investments—platform provider firms' minority equity investments in complementor firms—affect product introductions and withdrawals in their ecosystem? Because platform providers have a triadic informational advantage, the existence of which is common knowledge among complementors, we hypothesize that complementors view PVC investments as an opportunity rather than a threat. Therefore, complementors are more likely to introduce and less likely to withdraw products following a PVC investment. Evidence for this argument comes from the Salesforce.com's platform. We also show that the inclination to introduce products is weaker for complementors with greater niche experience, and that complementors with wider product scopes refrain from product withdrawals after a PVC investment. We refine our insights through interviews with multiple complementor firms.

Keywords:

Platform Strategic Actions; Platform Governance; Venture Capital Investments; Complementors; Platform Ecosystems; Triadic Information Advantage

Running Head: The Impact of Platform Venture Capital Investments

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Multi-sided platforms are increasingly prevalent in many industries (Boudreau & Hagiu, 2009; Eisenmann, Parker, & Van Alstyne, 2006; Gawer & Cusumano, 2002). Platforms facilitate transactions between at least two groups of actors, such as customers and sellers in the case of Amazon, riders and drivers in the case of Uber, and businesses and application developers in the case of Microsoft Dynamics. The mutual presence of these actors brings value to one another and to the platform at large (Cennamo & Santalo, 2013; Parker & Van Alstyne, 2005; Rochet & Tirole, 2003). With the rise of platforms, their ecosystems have also emerged as increasingly important areas of business activity (Boudreau, 2012; Eckhardt, 2016; Kapoor & Agarwal, 2017). By now, a variety of firms, small and large, have built their entire business developing and selling complementary products or services around platforms (Yin, Davis, & Muzyrya, 2014)

Since the value of platforms critically depends on participation by complementors, effectively guiding their innovation efforts is an important concern for platform provider firms (Gawer & Cusumano, 2002; Schilling, 2003). Because platform providers cannot simply command complementors on what they should do, they utilize an array of strategic actions, including setting the degree of openness of the platform (e.g., Boudreau, 2010), access pricing (e.g., Hagiu, 2006), selective promotion of complementary products (e.g., Rietveld, Schilling & Bellavitis, 2019), and quality vetting procedures for those products and services (e.g., Claussen, Kretschmer, & Mayrhofer, 2013) to channel the efforts of complementors into the desired direction. Scholars interested in the platform governance and the strategic actions it encompasses have especially taken an interest in investigating the implications of platform provider firms entering in direct competition with complementors, either through the acquisition of a complementor or by introducing new products into the ecosystem (Cennamo, 2018; Eisenmann, Parker, & Van Alstyne,

2011; Foerderer *et al.*, 2018; Hagiu & Spulber, 2013; Li & Agarwal, 2017; Zhu & Liu, 2018; see Zhu, 2019 for a recent review). As the platform provider is likely to expropriate much of the value once belonging to complementors, platform providers' involvement in complementary markets is consequential to complementors' survival (Ceccagnoli *et al*., 2012; Gawer & Henderson, 2007).

However, the nature and type of platform strategic actions vary in intent and scope; not all platform strategic actions represent a case of envelopment—a platform provider firm's actual and immediate foray into the platform ecosystem (Eisenmann *et* al., 2011). There are other prevalent types of strategic actions that platform providers engage in, such as *platform venture capital* (PVC) *investments*. We define PVC as platform provider firms making minority equity investments in the complementor firms that are active within their own platform ecosystem (Gompers & Lerner, 2000). Apple, General Electric, Google, Intel, Microsoft, and Salesforce are merely some of the examples of platform providers that recently set up corporate venturing programs to engage in PVC investments (Basu, Phelps, & Kotha, 2011; Da Gbadj, Gailly, & Schwienbacher, 2015). It is intuitive to anticipate that a PVC investment in an investee (i.e., backed) complementor will substantively affect the considerations of other (i.e., non-backed) complementors, but the exact consequences of PVC investments for the introduction or withdrawal of products in the platform ecosystem are non-obvious.

On the one hand, PVC investments constitute a potential threat. PVC investments could be viewed as the "extended arm" of the platform provider, ultimately resulting in the platform provider directly competing with complementors (Ceccagnoli *et al.*, 2012; Gawer & Henderson, 2007; Zhu & Liu, 2018). Venture capital investments are often motivated by a platform provider firm's interest in the technology of a complementor firm (Dushnitsky & Lenox, 2006), suggesting the possibility of future envelopment of the investee complementor's technology by the platform

(Eisenmann *et al.*, 2011). In addition, owing to the investee complementor's increased access to the platform provider and the associated increase in credibility among customers, investee complementors might have a substantial competitive edge over their rivals (Hsu, 2004; Maula, Autio, & Murray, 2005; Zhang & Li, 2010). Consequently, PVC investments may decrease the likelihood of subsequent product introductions and increase the likelihood of subsequent product withdrawals in the platform ecosystem market niche where the investment took place.

On the other hand, PVC investments could also constitute an opportunity. PVC investments might connote current or future customer interest in a market niche (Foerderer *et al.*, 2018; Li & Agarwal, 2017). A PVC investment may also lead to the anticipation that further venture capital investments in the same market niche will follow, representing a viable opportunity for complementors to acquire the resources necessary to grow their venture (Lee, Lee, & Pennings, 2001; Pfeffer & Salancik, 1978). Therefore, PVC investments might instead increase the likelihood of product introductions and decrease the likelihood of product withdrawals in the affected niche.

In this research, we set out to examine this puzzle by asking: *what impact do platform venture capital investments have on the introduction and withdrawal of products within a platform ecosystem?* Empirically, we conduct our study in the context of Salesforce.com's business-to-business (B2B) platform ecosystem. Salesforce is a leading provider of enterprise cloud computing services. Its platform serves as a foundation upon which software applications (hereafter referred to as "apps") are produced by complementor firms that can then be downloaded from their app store, called AppExchange, by Salesforce's customers.

Our theorization, augmented by an initial round of qualitative data collection through interviews, observations, and interactions with Salesforce complementors,[1] holds that the answer

[1] One of the authors attended Salesforce's platform conference (called "Dreamforce") for three consecutive years, was an observer in eighteen Q&A sessions between complementors and Salesforce executives, visited six complementor

to the question "whether complementors will come to view PVC investments as a signal of opportunity or threat," depends on the interpretive significance that complementors attach to such an event. First, we develop this notion of "triadic information advantage" that a platform provider firm has over complementors and customers (cf. Davis, 2016), owing to the triadic exchange structure that unfolds around platforms (Boudreau & Hagiu, 2009). Platform providers are involved in all transactions flowing through the platform, enabling them to pinpoint successful and promising market niches. Complementors lack such "ecosystem-level" access, yet it is "common knowledge" (Chwe, 2001) among them that the platform provider has access to superior information. Second, we argue that it is this common knowledge among complementors about the platform provider's triadic information advantage that in turn shapes complementors' perceptions of PVC investments. Accordingly, reinforced by our initial interactions and interviews with complementors, we anticipate that complementors, on average, view PVC investments positively rather than negatively. Hence, we hypothesize that PVC investments are positively related with the likelihood of product introductions and negatively related with the likelihood of product withdrawals in the affected market niche within the platform ecosystem.

Nevertheless, we anticipate heterogeneity in the extent to which complementors perceive PVC investments as a universal signal of opportunity. More specifically, we argue that the inclination to introduce new products following PVC investments weakens with complementors' niche experience. Complementors with niche experience can, by and large, learn about the viability of the market niche by carefully monitoring their own products, which makes them less reliant on PVC investments as a source of information. This reduces their univocally positive perceptions of

meetup events, and was present at three customer-focused Salesforce conferences in New York, Boston, and San Francisco. Moreover, we signed up for a "developer" account to be part of the communication system and mailing list for Salesforce complementors.

PVC investments. We also argue that the negative relationship between PVC investments and the likelihood of product withdrawal strengthens with complementors' scope—the number of different market niches in which a complementor has products—because the perceptions of complementors with smaller scopes will be more susceptible to the potential negative consequences of PVC investments. Evidence for these predictions is provided by constructing an event history of Salesforce.com's venture capital investments involving complementors, and analyzing their consequences for product introductions and withdrawals in the AppExchange platform ecosystem. We further unpack the proposed mechanism using evidence from another round of qualitative data collection through 62 interviews with representatives from 24 complementor firms. We explicate that complementors view PVC investments as a "middle ground" form of platform strategic action, as compared to other strategic actions such as envelopment, which are viewed with more scrutiny by complementor firms.

This research contributes to the literature on platform governance in multiple ways (Cennamo, 2018; Cennamo & Santalo, 2013; Claussen *et al.*, 2013; Gawer & Henderson, 2007; Foerderer *et al.*, 2018; Rietveld *et al.*, 2019; Schilling, 2003; Wen & Zhu, 2018; Zhu & Liu, 2018). While scholars have started to unpack the consequences of platform strategic actions beyond platform pricing, the bulk of prior work has focused on a platform provider's *direct* foray into the platform ecosystem. We turn the attention to a less invasive form of strategic action: PVC investments. Moreover, empirical evidence concerning the implications of platform strategic actions has been mixed. Whereas some scholars documented positive consequences (Foerderer *et al.*, 2018; Li & Agarwal, 2017), others found evidence of adverse effects (Wen & Zhu, 2018; Zhu & Liu, 2018), sometimes for the same strategic action (Zhu, 2019). Our findings suggest that the outcome of platform strategic actions is contingent on the severity of the action as well as the

eventual interpretation of the action by complementors given their own information and experience (cf., Gawer & Henderson, 2007). We also make an empirical contribution to the literature by investigating the consequences of platform governance in the context of a B2B platform. In such B2B contexts, the complementary products are not low-cost "throwaway" products that could be quickly developed and deployed. Rather, they are typically complex business applications; the complementor firm, therefore, needs to invest a substantial amount of time and effort toward developing and introducing such product into the ecosystem—a costly signal of their intent to participate. As such, our research focus on B2B platform lies in contrast to much of prior work which has almost exclusively examined these issues in the context of consumer-facing (B2C) platforms such as retail platforms and mobile app stores (Foerderer *et al.*, 2018; Kapoor & Agarwal, 2017; Yin *et al.*, 2018; Zhu & Liu, 2018), where the cost and effort needed to develop and deploy a complementary product is typically lower. In broader terms, we also contribute by showing that the consequences of PVC investments spill over beyond the investor-investee dyad.

Next, we develop our hypotheses on the consequences of PVC investments for the introduction and withdrawal of products in platform ecosystems. Subsequently, we outline our study context and methods of data collection and analysis. After presenting our findings, we close with a discussion of their implications.

THEORY AND HYPOTHESES

The effect of platform venture capital investments on the likelihood of introduction and withdrawal of complimentary products

Platforms facilitate transactions between sets of actors who may or may not have been able to transact otherwise (McIntyre & Srinivasan, 2017). Typically, platforms connect at least two groups of actors: firms or individuals who produce complements (i.e., complementors), and firms or

individuals that buy or consume those complements (i.e., customers). Owing to this multi-sidedness, platforms are characterized by a *triadic exchange structure* (Boudreau & Hagiu, 2009; Gawer & Cusumano, 2002; Rochet & Tirole, 2003). If customers want to gain access to products that are produced by complementor firms, then both customers and complementors have to somehow interact with the platform (cf. Davis, 2016). This essentially gives rise to three distinct sets of exchanges. To illustrate, video game consoles such as Microsoft's Xbox or Sony's PlayStation serve as platforms for game developers to produce and sell games to customers. This represents the first set of exchanges. However, to be eligible and able to produce those games, game developers have to contract with the platform provider firm, signifying the second set of exchanges. Analogously, customers have to purchase the platform provider's video game console in order to play the games produced by game developers; the third set of exchanges that take place around the platform. As a consequence, the platform provider firm occupies a unique structural position in the *triad* (Boudreau & Hagiu, 2009; see also Simmel, 1964), allowing them to track, monitor, and analyze information flowing across all sets of exchanges (i.e., between customers and complementors, between customers and platform provider, and between complementors and platform provider). Due to this capability to capture and analyze information, platform providers have a *triadic information advantage* over complementors and customers.

To elaborate, platform providers are able to capture a wealth of information about the platforms' customers. They can document granular customer usage logs and apply analytics to pinpoint what platform ecosystem market niche has more growth potential, and predict which ones would have continued customer traction in the long-run. In addition to capturing and analyzing revealed customer preferences, owing to their direct access to customers they can also conduct customer surveys, focus groups, and interviews to gain an insight into latent preferences of

customers, such as their future needs and wants. This may, among others, enable platform providers to predict the type of complementary products that customers are most likely to use (Hult, Ketchen, & Slater, 2005; Slater & Narver, 1998). Complementors, on the contrary, may capture this information at the level of the customers of their own products, but not for products of their competitors, let alone for all the other market niches in the platform ecosystem. Thus, they do not have information on customer needs and usage at the "ecosystem" level. Only the platform-provider has access to such ecosystem-level information.

Similarly, platform providers have extensive information about the population of complementors in their platform ecosystem (Gawer & Cusumano, 2002; Iansiti & Levien, 2004), including the type of products that are produced and planned by complementors, as well as how well those products are performing. Careful cross-referencing of this information may enable platform providers to pinpoint those market niches with the highest growth potential. By contrast, complementors are limited in the information they possess about the current and future directions of the platform, beyond what they can acquire from interactions with the platform provider firm.

In our initial interactions with complementors, many complementors indicated that they are generally aware of their disadvantaged position relative to the platform provider. For example, the Director of Theta,[2] a complementor in the sales contract management niche, noted:

> I have a 2-person team running the numbers [on the customer usage of the Theta app], but that just provides us with operational – or at best, tactical info – on what we should improve, where we should get our act together... But it doesn't provide us with any strategic info on what we should do next, because, honestly, we are limited to [accessing information] just our current customers, not to our future customers in the ecosystem or even beyond. But we know they [platform provider firm] have full access to such information, and that they also run the numbers but at a scale that we cannot even think of. I'm sure they have at least a 50-member team running the numbers… Analytics on not just customer usage, but also competitive app performance and what not. So yeah, they have an enormous advantage that way, so it becomes important for us to understand what they [platform provider firm] know and what they are planning to do with it.

[2] To protect anonymity of the participants, all the names of the complementor firms are pseudonyms.

Such individual awareness about the triadic information advantage that a platform provider has over complementors develops into "common knowledge" (Chwe, 2001)— what everyone knows that everyone knows—when complementors share information and insights concerning the actions of the platform provider with other complementors in venues such as platform conferences and complementor meetups, which are common in platform contexts (Gawer & Cusumano, 2002; Foerderer, 2018; Zuckerman and Sgourev, 2006). Indeed, we also frequently observed that such information sharing (and at times, trading) about "what the platform provider firm is up to" is common during complementors' informal interactions at these conferences and meetups. As the Vice President of Zeta, a complementor in the sales methodologies niche, noted:

> We [complementors] talk to each other at Dreamforce, and continue that conversation in the local developer groups. We build upon the same platform, so we give demos and tech know-hows to each other. Some of us are competitors, but most are not, so we also share information on what they [platform provider firm] are up to these days, and pay close attention to what their platform evangelists say… and to the [platform provider's] press releases. That's how we keep up to date on what is going on, and we share it freely because in case if we missed something someday, for sure we will get to know that in no time from others [complementors] in our meetup group.

Viewed from the perspective of non-backed complementors (i.e., all complementors apart from the ones who received PVC investments), both positive as well as negative effects could be argued to emanate from PVC investments in one of the platform ecosystem's market niches. On the upside, PVC investments may signal areas of customer traction and growth. After all, platform providers often leverage their triadic information advantage to shape the trajectory of their platform ecosystem (Gawer & Henderson, 2007; Keil, Autio, & George, 2008; Rietveld *et al.*, 2019). Anticipatory venture capital investments have been observed in contexts such as patenting (Lahr & Mina, 2016). PVC may also spark increased awareness or renewed attention among customers for the other offerings in the market niche (Foerderer *et al.*, 2018; Li & Agarwal, 2017). On the downside, PVC investments may be the first step towards the platform provider entering in direct competition with complementors, in which case it is likely to expropriate much of the

value once captured by complementors (Eisenmann *et al.*, 2011; Zhu & Liu, 2018). Even if platform envelopment does not occur, the net effects of PVC investments may still turn out negative, simply owing to the investee complementor's privileged position and direct access to the platform provider firm (Hsu, 2004; Maula *et al.*, 2005; Zhang & Li, 2010).

We argue that it is the process of interpretation and sensemaking of manifested strategic actions by the platform provider that dictates complementors' eventual response to PVC investments (Gawer & Henderson, 2007). Prior research suggests that it is especially under conditions of high information asymmetry that firms are most likely to follow or imitate those whom they believe to hold superior information (Lieberman & Asaba, 2006; Ozalp & Kretschmer, 2018; Simon & Lieberman, 2010). In our case, this is the platform provider firm. Given that the platform providers' informational advantage is common knowledge, we anticipate complementors to connote PVC investments positively, a marker of customer traction and growth, rather than negatively. Hence, we hypothesize that complementors will be more likely to introduce products and less likely to withdraw products in market niches following PVC investments.

Hypothesis 1a: Platform venture capital investments are positively related with the likelihood of product introduction into the platform ecosystem by complementors.

Hypothesis 1b: Platform venture capital investments are negatively related with the likelihood of product withdrawal from the platform ecosystem by complementors.

Heterogeneous responses to platform venture capital investments

Thus far, we focused on the *average effect* of PVC investments on the likelihood of product introductions and withdrawals by complementor firms in the affected market niche. However, there are reasons to expect there to be heterogeneity in complementors' responses to PVC investments. Complementors vary in the amount of information they hold about the affected

market niche, and the spillover effects of PVC investments are more severe in case they turn out negative for some than they are for others, and this shapes complementors' perceptions of PVC. We focus on two such factors that could affect complementors' perceptions of PVC investments and therewith their product introductions and withdrawals in response to such events.

The first factor we consider is the complementors' niche experience. As noted, other than from interactions with the platform provider and their peers, complementors are by and large bound to deriving their information from analysis of customer usage of their own products. They can monitor their products' periodic download or sales volumes, collect customer usage logs, and scrutinize user reviews. This is especially true in the context of platform ecosystems, where complementary products are by and large digital, and indicators of product performance, user reviews, and logs of customer usage are widespread and easily trackable (Yoo *et al.*, 2012).

The information that complementors can gain from analyzing this data also enables them to pick up on trends at the level of their market niche. This is especially true as their presence in the niche increases. As they introduce more products, complementors develop an increasing understanding of its growth potential and viability, and thus their decision to introduce new products. As the co-founder of Omega, a complementor firm with multiple products within the customer service niche, described:

> I think we [Omega] know this space [customer service] inside out, more than anyone else including Salesforce, and we want to focus our energies here... We have apps that deal with different lifecycles of service tracking and response, so we have a better sense of what is going on...There is a lot of noise out there, and I filter some of them out but I trust what our team finds through their own analysis [of customer logs] across our apps... than inferring something based on what Salesforce said, and second-guessing stuff that I don't have full knowledge about.

Prior research suggests that firms tend to overlook external sources of information when they have internal information at their disposal (Baum & Ingram, 1998; Guillen, 2002; Simon & Lieberman, 2010). For example, Ozalp and Kretschmer (2018) show that game developers are in

principle more likely to introduce games into markets that are populated by a mass of other firms, but that this effect becomes weaker if game developers had entered that market before. Following this logic, we anticipate that complementors with greater niche experience generally attach less weight to PVC investment, and in light of their own information, will be less inclined to view PVC investments as a universally positive signal of opportunity. As a consequence, they will respond less opportunistically to PVC events so that the positive effect of PVC investments on the likelihood of product introduction weakens.

> **Hypothesis 2:** The positive relationship between platform venture capital investments and the likelihood of product introduction in the platform ecosystem by complementors weakens with complementors' niche experience.

Complementors also differ in their scope—the extent to which their products span across multiple niches—and this likely affects their propensity to act upon PVC investments as a signal of opportunity. Some complementors have a concentrated product portfolio that consists of one or more products targeted at a single market niche, while others diversify by straddling their products across market niches (Boudreau, 2012).

Recall that the consequences of PVC investments are multifaceted and non-obvious, but that they can also be possibly negative. Therefore, our intuition is that non-backed complementors with concentrated scopes (i.e., those that are by and large invested in the affected market niche) are more inclined to withdraw their products following a PVC investment rather than staying in the market niche. It is likely that the investee complementor will come to expropriate the bulk of value that is created (Eisenmann *et al.*, 2011; Gawer & Cusumano, 2008; Hsu, 2004; Maula *et al.*, 2005), and those negative consequences will be most severe for complementors with concentrated scopes. Our interviews with complementors further strengthened this intuition. The founder of

Beta, a non-backed complementor with a concentrated product scope around the marketing automation niche, described the future of their company after a recent PVC investment by Salesforce in another complementor that operates in the same market niche:

> We are at a stage now where we are still processing [the news about the Salesforce's recent PVC investment] and figure out what we should do next. Many of my developers are quite pissed at the whole thing, but we want to move ahead. Most of the senior team agree that we should just pull our app out [from AppExchange] and try to make it more of a standalone product... because we know that they [Salesforce] are going to prominently display and promote it [app of the investee/backed complementor], and if we stick around, ours will most likely go down the drain

We expect the negative perceptions of PVC investments by complementors with a concentrated scope to be most manifest when considering the implications of PVC for product withdrawals. After all, the negative effects of PVC investments have the biggest bearing on those complementors that are by and large dependent on the affected market niche. Consequently, their perceptions of PVC investments likely are the most negative. By corollary, we anticipate that it is especially complementors with wider scopes that will choose to not withdraw their products from the platform ecosystem and stick around following a PVC investment, so that the negative relationship between PVC investments and the likelihood of product withdrawal strengthens with complementors' scopes.

> **Hypothesis 3:** The negative relationship between platform venture capital investments and the likelihood of product withdrawal from the platform ecosystem by complementors strengthens with complementors' scope.

METHODS AND DATA

Study context and data collection

We test our predictions by constructing a dataset with both quantitative and qualitative data from the Salesforce.com platform and its AppExchange platform ecosystem. Salesforce is a leading "on-demand" enterprise cloud computing provider, focusing primarily on sales automation and customer relationship management. Salesforce and its platform ecosystem provide an appropriate

research context for multiple reasons. First, Salesforce is an example of a platform provider firm that is actively involved in corporate venturing through its Salesforce Ventures corporate investment group. Halfway 2014, Salesforce had already invested in more than 100 start-ups. Second, contrary to B2C software platforms such as Apple's iOS App Store or Google's Play Store that routinely serve as the study context for research on platforms (Claussen *et al.*, 2013; Foerderer *et al.*, 2018; Kapoor & Agarwal, 2017; Li & Agarwal, 2017; Yin *et al.*, 2014), developing B2B apps for AppExchange requires significant dedication of resources from complementors, both in terms of time necessary and effort required. For example, for an app to be introduced into AppExchange, a mandatory security review fee of $2,700 is due, supplemented by an annual listing fee of $300 for paid apps. By contrast, the security review fee for an app in the iOS App Store equals $99. Hence, PVC investments have the potential to influence the app introduction considerations of complementors. The B2B market is also populated by several competing platforms, including Oracle CRM Cloud, Microsoft Dynamics, NetSuite, and Zoho. These platforms make product withdrawals following PVC investments a realistic and potentially viable option for Salesforce.com complementors. Third, as shown in Figure 1, apps in AppExchange are organized into 42 narrowly-defined market "niches" that are nested in 9 overarching "categories." For example, the "sales" *category* contains *niches* such as sales intelligence, productivity, dashboard and reports, and contract management. The "marketing*" category* contains *niches* such as marketing automation, event management, and mass emails. This allows us to trace the effect of Salesforce's PVC investments back to an actual market niche, rather than the overarching category that typically is more heterogeneous.

--- Insert Figure 1 about here ---

In order to perform a substantive test of our hypotheses, we constructed an event history of Salesforce's corporate venturing activity between March 2013 and July 2014 using CrunchBase (http://www.crunchbase.com); a public database that provides an extensive overview of venture capital investments in the Information Technology industry. It is an increasingly prevalent data source for research on venture financing (Bertoni, Colombo, & Quas, 2017; Dutta & Folta, 2014; Ter Wal *et al.*, 2016). CrunchBase is particularly attractive for our purposes because it also documents whether and when press releases and news items appeared announcing a venture capital investment.[3] This is important, because platform providers tend to hold abreast information about ongoing research and development projects such as corporate venturing (Mohamed & Schwienbacher, 2016). As a consequence, complementor firms are by and large reliant on press releases and media coverage to learn about and interpret Salesforce's investments (Narayanan, *et al.*, 2000). Indeed, this was also emphasized in our interactions with complementors, as for instance illustrated in a quote by the CEO of Gamma:

> There are a bunch of things that we get to know [ahead of time] through our networks, like an upcoming product release or a functionality upgrade for the next Salesforce release cycle… But there are also other things that are closely guarded, VC investments [by Salesforce], for example. They [Salesforce] keep a tight lid on it, for understandable reasons. We learn about it through the industry news trackers or through Salesforce press releases. But once the news it out, it spreads very fast like a wildfire. I receive a dozen emails if the investment pertains to our category [niche], and we talk about it a lot within our company on what does it mean to us.

We complemented Salesforce's venture capital investment history with weekly observations on all 2,202 apps by non-backed complementor firms in AppExchange during the same time period, which we constructed using an automated programming script. Manually pairing Salesforce-backed ventures with complementors from AppExchange allowed us to identify those investments by which Salesforce took a stake in a complementor, and examine the effect of PVC

[3] We also independently constructed Salesforce's corporate venturing history by searching for press releases in Businesswire, PR Newswire, and Salesforce's company website as a sanity check. This did not result in the discovery of any additional corporate venture capital investments that might have been omitted from CrunchBase.

investments on product introductions and withdrawals in AppExchange. We identified seventeen venture capital investments involving a complementor from Salesforce's platform ecosystem, and recorded 578 app introductions and 156 app withdrawals.

Variable specifications and analyses

Dependent variables and empirical analyses. The first dependent variable designates the market niche into which an app is introduced. Given that a complementor chooses from the 42 narrowly-defined market niches in AppExchange, a single app introduction is thus represented by 42 rows in our dataset; one row per market niche. An indicator variable designates the niche that was chosen with a positive value, while all other niches are coded zero.

We modeled complementors' decisions to introduce their app into a particular market niche using a discrete choice approach (McFadden, 1974). Prior research has extensively relied on conditional logit estimation to model similar firm-level decisions, such as platform selection (Venkatraman & Lee, 2004), market choice (Greve, 2000; Ozalp & Kretschmer, 2018), and technological entry (Carnabuci, Operti, & Kovacs, 2015). However, conditional logit models assume the Independence of Irrelevant Alternatives (IIA), or more simply stated, that the error terms are independent across complementors and niches. In practice, this implies that a complementor's choice to introduce an app into a particular market niche is a function of observed niche-level factors, regardless of the exact niches that are in its consideration set. Because niches in AppExchange are nested in categories, this assumption is likely violated. Therefore, we performed our estimations using a nested logit model, which permits proportional substitution between market niches within the same category, such that the IIA assumption holds (Train, 2003).

The typical production of an app in our setting takes at least ten to twelve weeks, followed by another four to six weeks of security review. As the CTO of SalesLabs, a complementor firm in the sales intelligence niche described:

> We spent around 8 weeks, with 11 full-time developers and our offshore team - so that's over four thousand man-hours - to come up with the base version [of our app for the Salesforce platform]. And then, we spent few more weeks fixing the bugs... So it takes time not because the platform is complex, but [because] our application is... Finally, there is the dreaded security review, which took another 5 weeks, they take their own sweet time but they do a good job to make sure the application is robust... So it's a real deal, it's not easy like cranking out an iOS app. I used to do that, I was in-charge of development when I used to work at [company name], but when you are developing enterprise apps that will be listed on AppExchange, you need to make sure it works perfectly. It's a lot of work, there are a lot of moving pieces...

Therefore, we lag all independent and control variables by sixteen weeks in the app introduction analyses. That way, our models more accurately reflect complementors' considerations at the time they decide to develop and introduce a new app.

The second dependent variable is an indicator variable denoting whether a complementor decided to permanently withdraw its app from AppExchange during a given week.[4] We used a Cox proportional hazards model to test the association between PVC investments and the likelihood of app withdrawal (Cox, 1972). Models for event history analysis, such as the Cox proportional hazards model used here, consider how the time to withdrawal of an app is influenced by the variables of interest (Allison, 1984). Apps are at risk of being withdrawn following their introduction into AppExchange, and remain at risk throughout the observation period. We tested the proportional hazards assumption underlying our hazard models by checking if the slope of the regression equation of scaled Schoenfeld residuals is non-zero for the full model and all individual variables (Grambsch & Therneau, 1994). We found that it is not violated. We lag all independent and control variables to accommodate the time that it takes for the information about a PVC investment to spread and for an app to be withdrawn from AppExchange.

Independent and moderating variables. The independent variable, PVC in niche, reflects the number of distinct corporate venture capital investments by Salesforce in its complementors

[4] In exceptional cases, it is conceivable that an app may disappear from AppExchange to then reappear a short time after. Hence, we considered an app as permanently withdrawn only if it did not reappear in the platform ecosystem at a later point in time.

over a moving window of eight weeks. To operationalize this measure, we linked each PVC event to one or more niches by identifying those areas in which the investee complementor had apps when Salesforce's involvement in the investment round became public. We chose to measure this variable using a moving window because events in the recent past likely affect complementors' decisions concerning the introduction or withdrawal of apps. Indeed, prior work has documented enduring effects of similar duration for platform strategic actions such as quality vetting procedures (Claussen *et al.*, 2013) and envelopment (Li & Agarwal, 2017).

Complementors' niche experience is the moderating variable in the app introduction analyses. It captures the number of apps by a complementor in a market niche. We log-transformed this variable since it is highly skewed, and because there are likely diminishing returns to niche experience (Ozalp & Kretschmer, 2018). The moderating variable in the app withdrawal analyses is complementors' scope. It is measured as a count of the number of market niches in which a complementor has apps (Boudreau, 2012).

Control variables. In all our models, we control for several niche-level factors that likely affect a complementor's choice to introduce or withdraw products in a particular market niche in AppExchange. We include a count of the number of apps in a niche minus those produced by the focal complementor, apps in niche, to capture the absolute amount of competition in a niche (Boudreau, 2012). Because the nature of competition likely varies with the relative prevalence of free and paid apps (Eckhardt, 2016), the ratio of paid apps equals the fraction of rival paid to total apps in a niche. We also account for new app introductions by Salesforce, coded as the number of first-party app introductions in a market niche using a moving window of eight weeks, similar to the operationalization of our independent variable. We anticipate that complementors might be more hesitant to enter and more prone to withdraw those niches in which Salesforce introduces

new apps (Gawer & Cusumano, 2008; Wen & Zhu, 2018; Zhu & Liu, 2018). In the app introduction analyses, we further control for the likelihood of diversification (Palepu, 1985; Rumelt, 1984), by including a measure of niche overlap. This measure is computed as the average normalized angle between the complementor population of a focal niche and that of all other niches in AppExchange. It equals zero if all complementors in a focal niche are unique to it, and one if a focal niche solely harbors complementors that also have apps in all other niches.

In the app withdrawal analyses, we further account for some app-level characteristics that might influence a complementor's decision to withdraw. We account for an app's performance by including its inverse category-based sales rank. Because customers might be more likely to download apps for which extensive documentation is available (Ghose & Han, 2014), app description length captures the number of words in the app's description. We control for external indicators of app quality through the number of submitted user ratings and the valence of those ratings between one and five stars (Eckhardt, 2016; Ghose & Han, 2014). We also include niche fixed effects to account for the fact that the baseline hazard rate of app withdrawal across niches.

Qualitative refinement

To further unpack our proposed mechanism and deepen our understanding of complementors' decision making in response to PVC investments, we conducted a further round of qualitative data collection. More specifically, we wanted to understand how complementors made sense of PVC investments, what meaning and interpretive significance they attach to such events, and why they reacted to PVC investments in the manner they did.

To this purpose, we conducted 62 semi-structured interviews with representatives of 24 different Salesforce complementor firms. We used "purposive sampling" (Patton, 2002) along the following dimensions to identity complementor firms: (1) type of complementor firm (i.e.,

independent software vendor (ISV) and smaller complementors; complementors with different levels of niche experience and scope); (2) the number of years a firm has been involved as a Salesforce complementor; (3) complementor firms in niches where PVC investments happened and complementor firms in niches where no PVC investments happened; and (4) complementor firms who chose to remain in AppExchange following PVC investments and complementor firms who chose to withdraw from AppExchange following PVC investments.

To structure our interviews, we used naturalistic interview guidelines (Lincoln & Guba, 1985) following the critical-incident technique (Flanagan, 1954) centered around specific platform strategic actions (including PVC investment events) that happened recently as probes during the interviews to mitigate retrospective bias (Miller, Cardinal, & Glick, 1997). All formal interviews lasted between 45 and 75 minutes, and most were recorded and transcribed. Data collection and analysis unfolded in an iterative manner (Strauss & Corbin, 1997).

We used the constant comparative method to analyze the data (Glaser, 1965), following Charmaz's (2006) approach to data coding of interview transcripts and field notes. In the first phase, we did "initial coding" to uncover how complementors made sense of PVC investment as a form of strategic action performed by Salesforce, as compared to other forms of platform strategic actions such as envelopment. At this phase, responses were coded on the basis of "in vivo" codes—phrases and terms offered by informants. As new observations emerged, we revised the codes to identify emergent themes (Miles & Huberman, 1994). In the second phase, we explored the heterogeneous nature of complementor reactions to PVC investments. Therefore, at this stage, we did "focused coding" to compare complementor reactions to PVC investments based on our proposed moderators. Hence, we focused on complementors with more niche experience versus less niche experience, and on complementors with broader scopes versus more concentrated

scopes. We did this to unpack the meanings that these complementors' attach to PVC investments by Salesforce. We then organized our findings into different thematic categories, aimed at providing further insights about the heterogeneous response of complementors to PVC investment.

HYPOTHESES TESTS

App introductions by complementor firms

Table 1 reports descriptive statistics and pairwise correlations for the explanatory variables in the app introduction analyses. We find that the correlations between the variables are low to moderate, with the exception of the correlation between niche overlap and the ratio of paid to free apps. To verify that collinearity is not an issue, we reran our analyses removing either one, or both, of those variables. The obtained estimations are similar to the ones we report here. Table 2 presents the results of the nested logit regressions. In Model 1, we specify the baseline model that includes only control variables. The estimation results show that complementors are, on average, significantly less inclined to introduce apps into market niches with a large number of other apps.

--- Insert Table 1 about here ---

--- Insert Table 2 about here ---

In our first hypothesis, we postulated that PVC would be positively related with the likelihood of app introduction. Examining Model 2, we find support for this hypothesis. The coefficient for PVC in niche is positive and significant ($\beta = 0.567$, $p = 0.017$). We take the exponent of the coefficient to obtain the odds ratio, suggesting that a PVC investment is associated with an average increase of 76.22 percent in the relative likelihood of app introduction.

We test our second hypothesis in Model 3, by introducing the interaction between PVC in niche and complementors' niche experience. We predicted that the positive relationship between PVC and the likelihood of app introduction would weaken with complementors' prior niche

experience. Model 3 offers support for this assertion. The interaction between PVC in niche and complementors' niche experience is negative and significant ($\beta = -1.755$, $p = 0.012$).

We conducted a number of checks to confirm the robustness of those findings. We report the results in Table A1 and A2 of Appendix A. First, we experimented with alternative variable specifications and estimation approaches. To verify whether our results are sensitive to using an eight-week moving window in coding the effect of PVC investments, we analyzed the effect of PVC using a six and ten-week moving window, respectively. In another model, we replaced our measure of complementors' prior experience with a simpler measure, an indicator variable that denotes whether a complementor had previously introduced an app into a niche. In both cases, the estimation results remain qualitatively similar to our main result. We also ran analyses at the level of the market niche. We reason that if our hypothesis is correct, i.e., PVC is positively related to the likelihood of app introduction, then we should be able to observe greater numbers of app introductions in a niche following such an event. Accordingly, we estimated the weekly number of app introductions in a market niche as a function of the niche-level variables from our main models and niche and time fixed effects, using a Poisson regression model with robust standard errors. We find that the number of app introductions is greater in the period after a PVC investment.

Second, we explored some alternative explanations for our findings. In our main models, we estimated the likelihood of app introduction as a function of niche-level characteristics, essentially abstracting away any complementor heterogeneity beyond niche experience. To factor in other aspects of complementor heterogeneity into the app introduction decision-making process, we introduced interactions of niche-level explanatory variables with app and complementor-level characteristics (Greene, 2002). Specifically, we introduced cross-level interactions with four such characteristics. We included complementor experience, the log-transformed number of months

that a complementor has been active in the Salesforce platform ecosystem, and complementor scope to account for any experiential effect that may cause more experienced complementors to attribute different meanings to PVC investments. A paid app indicator variable is included to control for the fact that app introduction considerations may differ for paid as opposed to free apps (Eckhardt, Ciuchta, & Carpenter, 2018). We also incorporated an indicator variable denoting whether a complementor is a smaller complementor or ISV, based on a count of complementors' employees and their company description in AppExchange. We designated a complementor as small if it had fewer than ten employees and had no other business activities outside of Salesforce's platform ecosystem. Even after including cross-level interactions of complementor-specific variables with all independent and control variables, our findings hold.

Because complementors likely only consider introducing apps into market niches where they hold complementary assets, we also carried out a matched sample analysis. Drawing on techniques for text-based industry classification (Hoberg & Phillips, 2016), we used complementors' company descriptions in AppExchange to match a focal complementor with a control group, variable in size, of comparable incumbent complementors. We did so by computing the normalized angle between the word vectors of the company description of a focal complementor and that of all incumbent complementors, then designating an incumbent complementor similar to a focal complementor if their description similarity was two standard deviations above the mean similarity value for the focal complementor. Subsequently, we constrained the consideration set of a focal complementor to those niches in which it, or one or more of its matched incumbent complementors, had apps. The results from this matched sample nested logit regression continue to lend support for our hypotheses.

To ensure that the demonstrated positive effect of PVC is not simply the consequence of niche-level popularity, i.e., if complementors inherently favor some market niches over others and these are also the niches that Salesforce targets its PVC investments towards then our analyses may be picking up on this, we performed a placebo test. We coded a variable, placebo PVC in niche, that takes a positive value in the *eight weeks prior* to PVC investments taking place (instead of the eight weeks *after* a PVC investment). We observe that the coefficient of the placebo variable flipped relative to the demonstrated effect of PVC in niche, reduced in magnitude, and lost its statistical significance. We interpret this as additional support for our main results.

App withdrawals by complementor firms

The summary statistics and correlation matrix for the explanatory variables in our withdrawal analyses are presented in Table 3. The estimation results from the Cox proportional hazards models are in Table 4. Model 4 is the baseline model only including control variables. Positive (negative) coefficients are indicative of a higher (lower) likelihood of app withdrawal following a one unit change in a given variable. Apps are less likely to be withdrawn from niches with many other apps.

--- Insert Table 3 about here ---

--- Insert Table 4 about here ---

We revisit our first hypothesis, in which we also predicted that PVC would be negatively related with the likelihood of app withdrawal. We assess this prediction in Model 5. The coefficient for PVC in niche is negative and significant (β = -1.063, p = 0.027), suggestive of a negative relationship between PVC and the likelihood of app withdrawal. Taking the exponent of the coefficient of PVC in niche to obtain its corresponding hazard ratio, we find that a PVC investment is associated with a decrease of 65.46 percent in the relative likelihood of app withdrawal.

In Model 6 we introduce the interaction between PVC in niche and complementor scope to test hypothesis 3, which postulated that the negative relationship between PVC and the

likelihood of app withdrawal would be strengthened by complementors' scope. The estimation results illustrate the non-obvious and multifaceted nature of the anticipated effects of PVC investments. With the introduction of the interaction between PVC in niche and complementor scope, the main effect of PVC in niche now represents the effect of PVC on the likelihood of app withdrawal for complementors whose scope is constrained to the affected market niche. As the coefficient of PVC in niche has turned positive and significant ($\beta = 4.565$, $p = 0.000$), our results suggest that for those complementors PVC investments spur app withdrawals. Meanwhile, the interaction effect between PVC in niche and complementor scope is negative and significant ($\beta = -5.598$, $p = 0.000$), suggesting that complementors become less likely to withdraw apps following PVC as their scope increases. Taken together, those results provide firm support for our hypothesis.

The results of a number of robustness checks are in Table A3 and A4 in Appendix A. First, we ran a number of alternative models. We repeated our analyses using a six and ten-week moving window for the effect of PVC in niche, and estimated the number of weekly app withdrawals from a niche as a function of niche-level variables, and niche and time fixed effects, using a Poisson regression model with robust standard errors. The results remained consistent.

Second, we probed some alternative explanations. Similar to the app introduction analyses, we conducted a placebo test by coding a variable that takes a positive value in the eight weeks leading up to a PVC investment. The coefficient of this placebo variable is appreciably smaller compared to the PVC in niche variable in our main models, and loses statistical significance.

Because complementors owe an annual listing fee for the continued inclusion of a paid app in AppExchange, the de-facto likelihood of withdrawal for a paid app might be different compared to a free app. Therefore, we repeated our estimations, now stratified by a paid app indicator variable to allow the baseline hazard rate to differ for paid and free apps. Similarly, we ran a model

stratified by the small complementor indicator variable, to ensure that our results are not influenced by any systematic difference in the baseline app withdrawal considerations of ISVs and smaller complementor firms. Our results hold.

It might be that some app withdrawals are per definition idiosyncratic to PVC investments by the platform provider firm because they are driven by factors unobserved in our data. This is especially true if the withdrawal of an app coincides with a complementor ceding its business in AppExchange altogether. In this case, app withdrawal might reflect a new strategic direction of the complementor firm as dictated by its management, among others, instead of an actual response to a PVC investment, so that our estimation results might overstate the true effect of PVC. Therefore, we performed a competing-risks analysis in which 35 out of 156 app withdrawals are specified as a competing event; leaving AppExchange (Fine & Gray, 1994). The competing risk analysis represents a more conservative test of our hypothesis, because the estimation results solely reflect the considerations concerning app withdrawals by complementors that remain active in AppExchange. The results from the competing risk analysis are broadly consistent with our main results. The average effect of PVC in niche is negative and significant. After introducing the interaction term between PVC in niche and complementor scope, the independent effect of PVC in niche disappears, most probably because the majority of app withdrawals by complementors with a scope confined to the focal niche are conflated with withdrawal from AppExchange. The interaction effect between PVC in niche and complementor scope remains negative and significant.

QUALITATIVE REFINEMENT: COMPLEMENTORS' DIFFERENTIAL MEANING MAKING OF PVC INVESTMENTS AS MIDDLE-GROUND ACTION

To gain a deeper understanding of complementors' responses to PVC, we conducted semi-structured interviews with complementors. We especially wanted to gain more insights into the

meaning and significance that complementors attach to PVC investments, which in turn will help us further unpack the underlying mechanisms and that way refine our insights.

First, we were intrigued by why complementors, on average, reacted more favorably to PVC investments as compared to some other forms of platform strategic actions such as envelopment (Gawer & Cusumano, 2008; Wen & Zhu, 2018; Zhu & Liu, 2018). Several complementors described that they viewed PVC investments as representing a platform strategic action that clearly signaled areas of customer demand. Some complementors also infer PVC as the strategic direction that Salesforce wants to take its ecosystem in the future. While several complementors mentioned that they generally feel "pissed off" at actions such as envelopment by the platform provider, they view PVC investments as occupying a "middle ground" in the platform strategic actions available to Salesforce. As one complementor described PVC investments *"... come across not as predatory, because here at least they have taken a bet on a company and invested some real money in it so there are real things at stake here – so at least to me, that is more or less fair game… than just including that [app] in their next release cycle [envelopment] – that pisses me off, yeah yeah yeah I know that's how the game is played here, but still it seems screwed up and unfair."*

Several other complementor firms that we interviewed echoed similar sentiments. Whereas envelopment is perceived as unfair and an act of trust-breach, even if interestingly enough most of them were cognizant that these actions also constitute an integral part of platform business; PVC investments were viewed as a middle-ground form of strategic action by the platform provider. This is because PVC investments signal Salesforce's credible commitment to the complementor that they had invested in as well as to that complementary market niche at large, while at the same time, not derailing the "rules of the game" within the platform ecosystem through other forms of

platform strategic actions such as envelopment, first-party entry, and full subsidy. In that sense, PVC investments are viewed by complementors as a balancing act where Salesforce shows that it has "skin in the game," but by not fully subsidizing the backed complementor (and therefore, not indulging in an "ex-post squeeze" of other complementors or significantly driving down their returns), it is also asking the backed complementor firm to put their skin in the game as well.

All of this suggests that complementors indeed attach differential meanings to various types of platform strategic actions, where PVC investments are viewed as a middle-ground form of platform strategic action, while full subsidy and envelopment are viewed as extreme forms of platform strategic actions. The Vice President of CTech described their perspective as follows:

> Talk is cheap, Salesforce can say that their Service Cloud is doing very well and ask us [complementors] to build apps around their Service Cloud offering. Some [complementors] even jump the bandwagon, but only when there is investment in that category, we know for sure that the category is growing. Even better, if it is their own VC money flowing in, then we can confirm that they are not just trying to seed [the category] and then hope for some action [in that category], but rather, they are committed to guiding and growing that category.

Second, we wanted to further deepen our understanding of why complementors place a high value on PVC investments in structuring their own actions. We found that the majority of small complementor firms we interviewed mentioned the issues they faced in accessing the end-customers of Salesforce. Consequently, they encountered difficulties obtaining information pertaining to customer priorities and preferences in their use of the Salesforce platform. This, in turn, translated into uncertainty regarding their own strategic decisions, such as whether they should focus on adding more functionalities to the current app or allocate resources to develop a new app in a different niche. As the CEO of DLabs reflects:

> We are just a small firm with 6 employees and although our app is pretty successful, we still don't have direct access to the end-customers… Of course, we do run analytics of our users, but the customer base of Salesforce is pretty large, and we don't have access to that entire population… or the level of information that Salesforce would have, because they have direct access [to end-customers] plus they also have their platform to track the customer usage and needs, so they know where the specific demand is and so they try to take their ecosystem toward that [direction].

In addition, complementors described the challenges they faced in getting access and information about the strategies of the platform provider. On the one hand, complementors need to work with the "current" priorities, rules, and structures set by Salesforce. On the other hand, they also need to interpret and make sense of the "future" priorities and strategies of Salesforce.

As a consequence of these two factors i.e., limited access to the end-customers of Salesforce and uncertainty about their strategic direction, complementors assign more weight to visible actions such as PVC investments, as it provides a more credible and costly signal concerning areas of customer traction as well as the strategic priority of the platform provider. Vice President of Zeta, a long-time complementor of Salesforce, described:

> Over the years, Zeta has released many apps in AppExchange. It takes time to develop these apps … So where do we go to when we want to develop a new app? We see what Salesforce is doing and we try to work around that… Say when they are investing in this app or that new start-up, we take notice of all that. Talking to the Salesforce Platform Marketing folks is one thing, but looking at what Salesforce actually does is quite another… we watch carefully [on what Salesforce does], take notice, and plan our next steps… This business has a lot of churn, so we need to constantly push out apps… But now you know where they [Salesforce] want to take their platform next, and what the customer wants in the next few years.

At events such as platform conferences and developer meetup groups, such information gets shared among complementors. They talk about the access that Salesforce has to its end-customers, including the capability to track customer usage and perform analytics at the level of the entire ecosystem, and how they themselves can access this information only at their individual app or customer level. Complementors also believe that having such information access will enable Salesforce to not just predict customer demand, but also "nudge" its end-customers to drive more adoption and usage of apps in market niches that Salesforce considers to be the platform's future.

> If Salesforce is investing money [on the complementor apps] from its pockets, then they are not going to sit quiet and hope for customer demand, hope for downloads, hope for some magic, to happen. They usually put their money where their mouth is, but even if the demand is initially slow, then they can always steer demand. Give freebies. Free trials, and what not. Give the customers a taste of it, and that will create demand. You know, they can play both the sides [VP of CTech, a Salesforce complementor firm]

Third, although most complementors view PVC as a form of middle-ground strategic action taken by the platform provider, we also observed the differential meanings they attach to it. We anticipated that complementors with greater niche experience attach less weight to PVC investments as a universally positive signal of customer traction in the affected market niche. We also hypothesized that the negative relationship between PVC investments and the likelihood of product withdrawal strengthens for those complementors with wider scopes. Our quantitative analysis validated these claims. Complementors with more niche experience described that although they lacked access to the rich and fine-grained data that Salesforce had, they nevertheless believe that they have a more "on-the-ground understanding" of the customer needs and industry trends within their niche than Salesforce does. Some of these complementors also mentioned that as the platform provider, Salesforce needs to focus on a lot of issues, including apps in multiple niches, but they themselves do not have any such compulsions and therefore, are more knowledgeable about their niche. A senior executive at IGS, a complementor with deep niche experience in the project management niche, described:

> ...We all know this, Salesforce has too many things going on. They are acquiring many companies, investing money here and there. Sometimes I don't even understand why they're getting into a new area like chatter [an enterprise collaboration app] and I get a sense that they are spreading themselves too thin. When they get it right, works great. But I also feel that sometimes they jump onto a bandwagon, like the investments they are doing in AI and analytics now, and [they] go after the next greatest fad. Before, I used to take their venture investments at face value and think THAT is the hot-area we as a company should focus on. But I've been around for sometime now, and especially after creating these many apps in project management, listing and updating them in AppExchange, I have a better sense of where this world [of project management] is going than Salesforce, so I don't read too much into their next press release or their next acquisition or investment decisions.

Complementors with greater scopes noted that *"we didn't put all of our eggs in the same basket, so we don't feel the compulsion to pull any of our apps from AppExchange"* after a PVC investment. As a complementor with a diversified portfolio in multiple niches described:

> Yeah, it sucks that they [Salesforce] didn't write us a check [i.e., PVC], but we hope that we will get it someday if we continue to do what we are doing. But it [PVC] doesn't affect us much...

> because we are sufficiently de-risked... We don't overreact and do anything stupid like taking our app out from the listing or sending a stinker email to Rudy [Head of the Complementor Partnership Program at Salesforce]. Of course, we do go back to the drawing board and decide what we are doing next, where to redistribute our resources, but we still continue to learn and be part of the Salesforce ecosystem and partner community.

Taken together, our qualitative findings indicate that while most complementors view PVC investments as a middle-ground form of platform strategic action, they nevertheless attach differential meanings to it, which provides further insights into their heterogonous response to PVC investments via new app introductions and app withdrawals, or the lack thereof

DISCUSSION

Noting that platform provider firms are increasingly involved in corporate venturing, we wanted to understand the consequences of those venture capital investments involving complementors (i.e., PVC) for product introductions and withdrawals in the platform provider's ecosystem. Based on our analysis of Salesforce's platform ecosystem, we find that complementors are more likely to introduce, and less likely to withdraw, products in market niches following PVC investments. These effects can be attributed to the interpretive significance that complementors attach to PVC investments; given the inherent information asymmetry that exists around platforms, complementors are more likely to connote PVC investments positively rather than negatively. Platform provider firms occupy a unique structural position in the *triadic* exchange pattern that unfolds among customers, complementors, and platform provider. Owing to its central structural position, the platform provider firm possesses a triadic information advantage, both concerning the current and future needs of the platform's customers as well as the performance and ongoing efforts of the platform's complementors. Complementors, on the contrary, do not have access to ecosystem-level information and therefore, they find it difficult to gauge the needs of the platform's entire customer base. Given that it is common knowledge among complementors that the platform provider is in possession of such ecosystem-level information, they connote PVC

investments as a proxy for customer traction and the strategic direction that the platform provider is planning to take in the future. However, we also show heterogeneity among complementors' in this regard. Complementors with greater niche experience have better internal information about the affected market niche, and therefore attach less value to PVC investments so that they are also less inclined to perceive PVC as a universal signal of opportunity. Moreover, it is especially those complementors with wider scopes that stick around in a market niche affected by PVC, because they are less concerned with the potential negative consequences of PVC investments.

Our paper follows in a series of empirical efforts to better understand the implications of platform strategic actions for complementors (Boudreau, 2010; 2012; Claussen *et al.*, 2013; Foerderer *et al.*, 2018; Gawer & Henderson, 2007; Rietveld *et al.*, 2019; Schilling, 2003; Wen & Zhu, 2018; Zhu & Liu, 2018). We contribute to this literature in at least three ways. First, we broaden the scope of prior empirical research on platform governance by considering the consequences of PVC investments for product introduction and withdrawal in the platform ecosystem. As such, we not only focus the attention towards a new and emergent platform strategic action (Basu *et al.*, 2011; Da Gbadj *et al.*, 2015), but we also broaden our view when it comes to the possible consequences of platform governance, from product performance and innovation to product introductions and withdrawals. This is important, because a vibrant ecosystem constituting a constantly changing volume and variety of complementary products contributes to greater platform value (Cennamo & Santalo, 2013; Parker & Van Alstyne, 2005; Rochet & Tirole, 2003).

Second, our study offers new explanations concerning the implications of platform strategic actions for complementors. Whereas some studies document positive consequences of platform strategic actions (Foerderer *et al.*, 2018; Li & Agarwal, 2017), others document adverse effects (Wen & Zhu, 2018; Zhu & Liu, 2018), sometimes even for the same platform strategic

action (Zhu, 2019). The prevailing explanation has been that the implications of platform strategic actions might differ across contexts (Zhu, 2019), or over time (Cennamo, 2018). We offer a complementary view. Our interviews with complementors suggest that the eventual implications of platform strategic actions depend on the interpretive significance that complementors attach to the event. Ever since Gawer and Henderson's (2007) foundational study on platform governance, the question of how complementors perceive the strategic actions of the platform provider and how the platform provider, in turn, manages the perceptions of complementors became central to advancing our understanding of what constitutes effective governance in platform ecosystems. Yet, most of prior research has examined the strategic actions of the platform provider per se, and its subsequent impact on the evolution of the platform ecosystem, without an explicit focus on the interpretive significance that complementors attach to such strategic actions. Through this research, we show how and why various types of platform strategic actions are interpreted differently by the complementors, and how such interpretations render the particular platform strategic action as "fair" or not (Gawer & Henderson, 2007, in turn shaping the subsequent actions of complementors. Going even further, we also show that the same platform strategic action may intermittently, or even simultaneously, be interpreted as a signal of opportunity and a signal of threat depending on the niche experience and product scope of the complementors. With view on the continuum of platform strategic actions that platform providers enact to govern their platform, these explanations provide a fruitful starting point for future research concerning the differential meaning that complementors attach to various types of platform strategic actions, and the heterogeneous impact these may in turn have on the rate and direction of innovation in the platform ecosystem as well as the growth and survival of complementor firms.

Third, while prior research on platform governance has by and large been conducted in B2C contexts (Boudreau, 2012; Claussen *et al.*, 2013; Kapoor & Agarwal, 2017; Li & Agarwal, 2017; Yin *et al.*, 2018; Wen & Zhu, 2018), we make an empirical contribution to this literature by considering the implications of platform governance in the context of a B2B platform. This is important, because the ecosystems around business-facing platforms are likely characterized by substantially different dynamics. For one, developing products for business-facing platforms requires significant time and effort, and is therefore often accomplished by entrepreneurial firms and independent software vendors. This in contrast to customer-facing platforms, such as Apple's iOS, where profit-seeking firms and hobbyists often jointly vie for the attention of the same group of customers (Eckhardt, 2016). Consequently, our context provides fertile ground to develop a more complete understanding of platform governance.

We also contribute to the literature on corporate venture capital. Prior work in this area has extensively considered the consequences of corporate venture capital investments for investor firms, investee firms, or both (Benson & Ziedonis, 2009; Cox-Pahnke, Katila, & Eisenhardt, 2015; Dushnitsky & Lenox, 2005; 2006; Keil *et al.*, 2009; Lahr & Mina, 2016; Park & Steensma, 2012). We show that the consequences of corporate venture capital investments might spill over beyond the investor-investee dyad to the platform ecosystem as complementors take note of the investment, interpret it, and adjust their own strategies accordingly. By the same token, these spillovers may manifest beyond the immediate context of platforms and ecosystems, such as in markets or industries. Here, competitors of the investor and investee may similarly make sense of corporate venture capital investments and adjust their strategies accordingly. Given that venture capital investments tend to be surrounded by secrecy (Mohamed & Schweinbacher, 2016), this would suggest that investor and investee may exert some influence on the decisions or actions of

others firms within their industry through the strategic revelation of information (Hannigan, Seidel, & Yakis-Douglas, 2018; Narayanan *et al.*, 2000).

The findings from our study are subject to some limitations that open up new questions for future research. Our findings are limited to a single empirical context, a business-facing platform ecosystem, and their validity thus needs to be established across other contexts. From our interviews, it seems that the positive effects of PVC on the entry and exit dynamics in the platform ecosystem might be particularly pertinent in the context of business-facing platforms, where it is generally more difficult to access and obtain detailed information on the needs and wants of the platform's customers, simply because these customer organizations themselves are typically large businesses. It would be particularly interesting to investigate whether the consequences of PVC investments are similar, or different, in customer-facing platform ecosystems. Due to data limitations, our analyses were limited to considering the immediate, or short-run, the impact of PVC investments for the product introduction and withdrawal considerations by complementor firms. Using a longer time horizon, future research might explore the long-run consequences of PVC investments for the vitality of the ecosystem, or whether there are limits to the positive effects of PVC, so that excessive PVC activity by the platform provider firm might deteriorate trust and credibility. It may also consider whether there are other spillovers of PVC investments, for instance in customer demand, complementors' innovation incentives, the inclination of investee complementors to further refocus their business towards the platform of the investor, or the performance implications for a backed complementor vis-à-vis its non-backed counterparts.

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Figure 1. AppExchange Categories and Market Niches

Table 1. Descriptive statistics and pairwise correlations for the entry analyses

	Mean	S.D.	Min	Max	1	2.	3	4	5
1. PVC in niche	0.05	0.24	0.00	2.00					
2. Complementor niche experience (ln)	0.01	0.10	0.00	2.08	0.03				
3. App introductions by platform provider	0.08	0.30	0.00	2.00	-0.04	0.01			
4. Apps in niche	49.28	43.07	7.00	280.00	0.34	0.11	0.25		
5. Niche overlap	0.03	0.01	0.00	0.05	0.04	0.04	0.21	0.35	
6. Ratio paid to free apps	0.63	0.17	0.19	0.92	0.03	-0.02	-0.35	-0.25	-0.63

Table 2. The effect of platform venture capital investments (PVC) in a niche on app entry, nested logit regressions

	Model 1	Model 2	Model 3
PVC in niche		0.567	0.689
		(0.238)	(0.232)
		[0.017]	[0.003]
Complementor niche experience (ln)	4.026	3.932	4.215
	(0.476)	(0.465)	(0.482)
	[0.000]	[0.000]	[0.000]
PVC in niche x Complementor niche experience (ln)			-1.755
			(0.702)
			[0.012]
Niche characteristics			
App introductions by platform provider	0.011	0.245	-0.210
	(0.213)	(0.220)	(0.234)
	[0.958]	[0.265]	[0.369]
Apps in niche	-0.031	-0.047	-0.044
	(0.011)	(0.013)	(0.013)
	[0.005]	[0.000]	[0.001]
Niche overlap	72.967	66.709	71.569
	(36.101)	(33.868)	(35.679)
	[0.043]	[0.049]	[0.045]
Ratio paid to free apps	1.573	1.156	1.252
	(2.659)	(2.524)	(2.533)
	[0.554]	[0.647]	[0.621]
Number of entries	578	578	578
Number of niches	42	42	42
Number of observations	24,276	24,276	24,276
Log pseudolikelihood	1,810.571	1,807.152	1,802.115

The dependent variable is app introduction into a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.

Table 3. Descriptive statistics and pairwise correlations for the exit analyses

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10
1. PVC in niche	0.12	0.36	0.00	2.00										
2. Complementor scope	1.71	1.21	0.00	30.00	0.00									
3. App introductions by platform provider	0.18	0.49	0.00	2.00	0.03	0.07								
4. Apps in niche	87.26	71.61	6.00	285.00	0.41	0.07	0.51							
5. Ratio paid to free apps	0.61	0.17	0.00	1.00	0.04	-0.11	-0.37	-0.41						
6. Length app description	39.47	8.05	3.00	62.00	-0.06	0.06	0.05	0.06	-0.06					
7. Number of ratings (ln)	1.14	1.34	0.00	6.70	0.04	0.10	0.01	0.00	-0.03	0.16				
8. Ranking	232.98	232.16	0.00	952.00	0.17	0.07	0.17	0.30	-0.12	0.12	0.37			
9. Rating valence	3.06	2.20	0.00	5.00	0.01	0.09	0.02	0.03	-0.03	0.18	0.58	0.24		
10. Paid app	0.68	0.47	0.00	1.00	-0.02	-0.03	-0.11	-0.14	0.30	0.04	0.02	-0.13	0.07	
11. Small complementor	0.17	0.38	0.00	1.00	0.02	0.06	0.10	0.13	-0.20	-0.02	0.06	0.08	0.05	-0.08

Table 4. The effect of platform venture capital investments in a niche (PVC) on app exits, Cox proportional hazard models

	Model 4	Model 5	Model 6
PVC in niche		-1.063	4.565
		(0.478)	(0.948)
		[0.027]	[0.000]
Complementor scope	-1.220	-1.220	-1.102
	(0.583)	(0.578)	(0.516)
	[0.036]	[0.035]	[0.033]
PVC in niche x complementor scope			-5.598
			(1.016)
			[0.000]
Niche characteristics			
App introductions by platform provider	-0.166	-0.232	-0.233
	(0.244)	(0.251)	(0.255)
	[0.496]	[0.355]	[0.360]
Apps in niche	-0.045	-0.052	-0.056
	(0.013)	(0.014)	(0.015)
	[0.000]	[0.000]	[0.000]
Ratio paid to free apps	-4.524	-4.013	-3.006
	(4.478)	(4.522)	(4.500)
	[0.312]	[0.375]	[0.504]
App characteristics			
Length app description	-0.006	-0.006	-0.006
	(0.010)	(0.010)	(0.010)
	[0.576]	[0.576]	[0.542]
Number of ratings (ln)	0.040	0.036	0.028
	(0.107)	(0.107)	(0.109)
	[0.706]	[0.735]	[0.797]
Ranking	0.001	0.001	0.001
	(0.001)	(0.001)	(0.000)
	[0.142]	[0.130]	[0.101]
Rating valence	-0.134	-0.134	-0.136
	(0.053)	(0.053)	(0.054)
	[0.012]	[0.012]	[0.011]
Niche fixed effects	Included	Included	Included
Number of apps	2,195	2,195	2,195
Number of exits	156	156	156
Number of observations	79,048	79,048	79,048
Log pseudolikelihood	1,107.711	1,104.083	1,094.718

The dependent variable is app exit from a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.

Appendix A: Robustness Checks

Table A1: Robustness checks entry analyses (alternative specifications)

	Model A1 Six-week duration	Model A2 Six-week duration	Model A3 Ten-week duration	Model A4 Ten-week duration	Model A5 Niche experience dummy	Model A6 Poisson regression of niche entries
PVC in niche	0.506	0.673	0.660	0.754	0.693	0.411
	(0.241)	(0.229)	(0.207)	(0.191)	(0.225)	(0.152)
	[0.036]	[0.003]	[0.001]	[0.000]	[0.002]	[0.007]
Complementor prior niche experience (ln)	3.953	4.277	3.874	4.095		
	(0.465)	(0.479)	(0.468)	(0.484)		
	[0.000]	[0.000]	[0.000]	[0.000]		
PVC in niche x Complementor prior niche experience (ln)		-2.272		-1.515		
		(0.794)		(0.503)		
		[0.004]		[0.003]		
Complementor has niche experience					3.492	
					(0.343)	
					[0.000]	
PVC in niche x complementor has niche experience					-1.369	
					(0.453)	
					[0.002]	
Niche characteristics						
App introductions by platform provider	0.188	0.150	0.307	0.273	0.172	0.145
	(0.221)	(0.235)	(0.216)	(0.220)	(0.224)	(0.154)
	[0.396]	[0.522]	[0.155]	[0.214]	[0.442]	[0.345]
Apps in niche	-0.042	-0.040	-0.053	-0.049	-0.044	-0.030
	(0.013)	(0.012)	(0.013)	(0.012)	(0.012)	(0.008)
	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Niche overlap	68.565	74.288	62.584	66.295	79.754	35.992
	(34.435)	(36.498)	(32.850)	(34.187)	(35.380)	(26.421)
	[0.046]	[0.042]	[0.057]	[0.052]	[0.024]	[0.173
Ratio paid to free apps	1.215	1.337	0.998	0.954	1.358	-0.179
	(2.564)	(2.576)	(2.454)	(2.405)	(2.499)	(1.979)
	[0.636]	[0.604]	[0.684]	[0.692]	[0.587]	[0.928]
Time fixed effects						Included
Number of entries	578	578	578	578	578	
Number of niches	42	42	42	42	42	42
Number of observations	24,276	24,276	24,276	24,276	24,276	2,940
Log (pseudo)likelihood	1,807.845	1,801.150	1,804.756	1,798.964	1,806.312	1,322.113

Model A1 to A5: the dependent variable is app introduction into a niche. Model A6: the dependent variable is the number of app introductions into a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.

Table A2: Robustness checks entry analyses (alternative explanations)

	Model A7 App and complementor heterogeneity	Model A8 App and complementor heterogeneity	Model A9 Restricted niche consideration set	Model A10 Restricted niche consideration set	Model A11 Placebo test
PVC in niche	0.761	0.675	0.657	0.753	
	(0.317)	(0.316)	(0.260)	(0.255)	
	[0.016]	[0.032]	[0.012]	[0.003]	
Complementor niche experience (ln)	5.058	5.229	2.092	2.220	4.066
	(0.727)	(0.720)	(0.275)	(0.273)	(0.478)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PVC in niche x complementor niche experience (ln)		-1.780		-1.224	
		(0.676)		(0.694)	
		[0.008]		[0.073]	
Placebo PVC in niche					-0.250
					(0.246)
					[0.309]
Niche characteristics					
App introductions by platform provider	-0.067	-0.071	0.320	0.307	0.014
	(0.346)	(0.347)	(0.228)	(0.229)	(0.220)
	[0.847]	[0.838]	[0.160]	[0.181]	[0.950]
Apps in niche	-0.044	-0.043	-0.041	-0.040	-0.035
	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)
	[0.000]	[0.000]	[0.001]	[0.001]	[0.004]
Niche overlap	70.371	69.823	92.676	93.111	68.959
	(37.070)	(37.000)	(35.919)	(36.157)	(36.671)
	[0.058]	[0.059]	[0.010]	[0.010]	[0.060]
Ratio paid to free apps	-0.467	-0.369	2.173	2.315	1.480
	(2.444)	(2.441)	(2.566)	(2.574)	(2.685)
	[0.849]	[0.880]	[0.397]	[0.369]	[0.581]
App and complementor heterogeneity					
PVC in niche x complementor experience	0.055	0.099			
	(0.083)	(0.073)			
	[0.508]	[0.175]			
PVC in niche x complementor scope	-0.083	0.089			
	(0.262)	(0.227)			
	[0.751]	[0.696]			
PVC in niche x paid app	-0.364	-0.260			
	(0.326)	(0.307)			
	[0.263]	[0.397]			
PVC in niche x small complementor	-0.217	-0.150			
	(0.408)	(0.399)			
	[0.595]	[0.707]			
Complementor prior niche experience (ln) x complementor experience	-0.135	-0.103			
	(0.083)	(0.088)			
	[0.105]	[0.246]			
Complementor prior niche experience (ln) x complementor scope	-0.456	-0.489			
	(0.238)	(0.236)			
	[0.055]	[0.038]			
Complementor prior niche experience (ln) x paid app	0.752	0.777			
	(0.516)	(0.516)			
	[0.263]	[0.132]			
Complementor prior niche experience (ln) x small complementor	-0.949	-0.888			
	(0.818)	(0.828)			
	[0.246]	[0.284]			

Table A2: Continued

	Model A7 App and comple-mentor heteroge-neity	Model A8 App and comple-mentor heteroge-neity	Model A9 Restricted niche considera-tion set	Model A10 Restricted niche considera-tion set	Model A11 Placebo test
App introductions by platform provider x complementor experience	0.072 (0.077) [0.349]	0.077 (0.079) [0.330]			
App introductions by platform provider x complementor scope	0.108 (0.185) [0.560]	0.097 (0.195) [0.618]			
App introductions by platform provider x paid app	0.413 (0.363) [0.255]	0.409 (0.367) [0.266]			
App introductions by platform provider x small complementor	-0.078 (0.420) [0.853]	-0.094 (0.425) [0.825]			
Apps in niche x complementor experience	-0.001 (0.001) [0.228]	-0.001 (0.001) [0.192]			
Apps in niche x complementor scope	-0.001 (0.002) [0.469]	-0.001 (0.002) [0.493]			
Apps in niche x paid app	-0.002 (0.002) [0.274]	-0.002 (0.002) [0.270]			
Apps in niche x small complementor	0.004 (0.003) [0.105]	0.004 (0.003) [0.108]			
Niche overlap x complementor experience	3.840 (2.327) [0.099]	3.823 (2.360) [0.105]			
Niche overlap x complementor scope	-0.756 (4.907) [0.878]	-1.358 (4.931) [0.783]			
Niche overlap x paid app	13.825 (16.061) [0.381	13.090 (16.198) [0.419]			
Niche overlap x small complementor	-13.106 (21.359) [0.539]	-13.917 (21.693) [0.521]			
Ratio paid to free apps x complementor experience	-0.187 (0.113) [0.097]	-0.195 (0.115) [0.087]			
Ratio paid to free apps x complementor scope	0.520 (0.432) [0.229]	0.517 (0.430) [0.230]			
Ratio paid to free apps x paid app	4.130 (1.076) [0.000]	4.123 (1.080) [0.000]			
Ratio paid to free apps x small complementor	-3.867 (1.554) [0.013]	-4.023 (1.566) [0.010]			
Number of entries	578	578	572	572	578
Number of niches	42	42	Variable	Variable	42
Number of observations	24,276	24,276	6,211	6,211	24,276
Log (pseudo)likelihood	1,762.009	1,758.223	1,071.913	1,069.676	1,809.802

The dependent variable is app introduction into a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.

Table A3. Robustness checks exit analyses (alternative specifications)

	Model A12 Six-week duration	Model A13 Six-week duration	Model A14 Ten-week duration	Model A15 Ten-week duration	Model A16 Poisson regression of niche exits
PVC in niche	-1.247	3.859	-0.804	4.757	-0.737
	(0.532)	(0.988)	(0.391)	(0.872)	(0.362)
	[0.019]	[0.000]	[0.040]	[0.000]	[0.041]
Complementor scope	-1.222	-1.156	-1.222	-0.929	
	(0.588)	(0.547)	(0.582)	(0.415)	
	[0.035]	[0.035]	[0.036]	[0.025]	
PVC in niche x complementor scope		-5.282		-6.043	
		(1.032)		(0.806)	
		[0.000]		[0.000]	
Niche characteristics					
App introductions by platform provider	-0.214	-0.210	-0.256	-0.172	-0.899
	(0.246)	(0.247)	(0.259)	(0.252)	(0.547)
	[0.385]	[0.396]	[0.322]	[0.495]	[0.101]
Apps in niche	-0.055	-0.058	-0.049	-0.055	-0.041
	(0.014)	(0.015)	(0.013)	(0.015)	(0.021)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.055]
Ratio paid to free apps	-4.176	-3.501	-3.968	-3.072	-1.625
	(4.491)	(4.468)	(4.545)	(4.438)	(6.128)
	[0.385]	[0.433]	[0.383]	[0.489]	[0.791]
App characteristics					
Length app description	-0.006	-0.006	-0.001	-0.006	
	(0.010)	(0.010)	(0.010)	(0.010)	
	[0.525]	[0.546]	[0.577]	[0.584]	
Number of ratings (ln)	0.035	0.031	0.037	0.015	
	(0.107)	(0.108)	(0.107)	(0.115)	
	[0.739]	[0.772]	[0.730]	[0.897]	
Ranking	0.001	0.001	0.001	0.001	
	(0.001)	(0.001)	(0.001)	(0.001)	
	[0.128]	[0.107]	[0.133]	[0.203]	
Rating valence	-0.134	-0.136	-0.134	-0.138	
	(0.053)	(0.054)	(0.053)	(0.055)	
	[0.012]	[0.011]	[0.012]	[0.011]	
Niche fixed effects	Included	Included	Included	Included	
Time fixed effects					Included
Number of apps	2,195	2,195	2,195	2,195	
Number of exits	156	156	156	156	
Number of niches					28
Number of observations	79,048	79,048	79,048	79,048	1,960
Log (pseudo)likelihood	1,103.769	1,099.426	1,105.264	1,079.172	240.669

Model A10 to A13: the dependent variable is app exit from a niche. Model A14: the dependent variable is the number of app exits from a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.

Table A4. Robustness checks exit analyses (alternative explanations)

	Model A17 Stratified by paid app dummy	Model A18 Stratified by paid app dummy	Model A19 Stratified by small comple-mentor dummy	Model A20 Stratified by small comple-mentor dummy	Model A21 Compe-ting risks model	Model A22 Compe-ting risks model	Model A23 Placebo test
PVC in niche	-1.050	5.163	-1.081	4.520	-1.230	0.735	
	(0.471)	(1.097)	(0.491)	(0.917)	(0.608)	(0.711)	
	[0.026]	[0.000]	[0.028]	[0.000]	[0.047]	[0.301]	
Complementor scope	-1.235	-1.117	-1.220	-1.103	-0.222	-0.198	-1.220
	(0.577)	(0.515)	(0.574)	(0.512)	(0.115)	(0.110)	(0.583)
	[0.032]	[0.030]	[0.034]	[0.031]	[0.048]	[0.071]	[0.036]
PVC in niche x complementor scope		-6.529		-5.941		-1.741	
		(1.142)		(0.996)		(0.452)	
		[0.000]		[0.000]		[0.000]	
Placebo PVC in niche							-0.093
							(0.362)
							[0.797]
Niche characteristics							
App introductions by platform provider	-0.266	-0.265	-0.217	-0.218	-0.146	-0.147	-0.167
	(0.251)	(0.254)	(0.258)	(0.262)	(0.265)	(0.265)	(0.243)
	[0.288]	[0.296]	[0.400]	[0.404]	[0.582]	[0.580]	[0.492]
Apps in niche	-0.050	-0.054	-0.055	-0.059	-0.070	-0.071	-0.047
	(0.014)	(0.012)	(0.015)	(0.016)	(0.015)	(0.015)	(0.014)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
Ratio paid to free apps	-3.475	-2.384	-3.865	-2.903	-1.050	-0.974	-4.536
	(4.515)	(4.507)	(4.569)	(4.545)	(5.090)	(5.083)	(4.471)
	[0.441]	[0.597]	[0.398]	[0.523]	[0.836]	[0.848]	[0.310]
App characteristics							
Length app description	-0.005	-0.005	-0.006	-0.006	-0.015	-0.015	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)
	[0.640]	[0.604]	[0.562]	[0.531]	[0.152]	[0.147]	[0.578]
Number of ratings (ln)	0.049	0.042	0.035	0.027	-0.325	-0.327	0.040
	(0.109)	(0.111)	(0.108)	(0.110)	(0.127)	(0.118)	(0.107)
	[0.650]	[0.706]	[0.746]	[0.807]	[0.005]	[0.005]	[0.709]
Ranking	0.001	0.001	0.001	0.001	0.002	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.225]	[0.180]	[0.128]	[0.100]	[0.056]	[0.052]	[0.143]
Rating valence	-0.131	-0.134	-0.133	-0.136	-0.052	-0.053	-0.134
	(0.053)	(0.054)	(0.053)	(0.054)	(0.050)	(0.050)	(0.053)
	[0.014]	[0.013]	[0.012]	[0.012]	[0.295]	[0.291]	[0.012]
Niche fixed effects	Included	Included	Included	Included	Included	Included	Included
Number of apps	2,195	2,195	2,195	2,195	2,195	2,195	2,195
Number of exits	156	156	156	156	121	121	156
Number of observations	79,048	79,048	79,048	79,048	79,048	79,048	79,048
Log pseudolikelihood	998.168	987.998	1,038.352	1,029.002	857.667	854.558	1,107.667

The dependent variable is app exit from a niche. Values in table are coefficients; robust standard errors in parentheses; *p*-values in brackets.