Filthy Lucre? Innovative Communities, Identity, and Commercialization

Organization Science, Forthcoming

Ethan Mollick
The Wharton School
University of Pennsylvania
2026 SD-DH
3620 Locust Walk
Philadelphia, PA 19104
E-mail address: emollick@wharton.upenn.edu

Abstract:

Online communities play an increasingly important role in developing new innovations. However, relatively little is known about the ways in which community affiliation may change the incentives to commercialize those new innovations. By examining Open Source Software (OSS) as an example of an innovation community, and using both a quasi-experiment and a longitudinal survey, I seek to shed light on this issue. In the quasi-experiment using the launch of the Apple App Store, I find a lower propensity towards commercialization among individuals associated with online community innovation. I then examine the mechanisms for this lower commercialization with a novel longitudinal survey of entrepreneurial activity among OSS community members. Despite the history of OSS as an anti-commercial community, I do not find that anti-commercial attitudes play a role in commercialization decisions. Instead, differences in self-identity between community-based innovators and entrepreneurs have large significant effects on the propensity to commercialize innovations. I conclude with a discussion of the implications of these findings for both the literatures on entrepreneurial identity and community innovation.

Acknowledgements: I would like to acknowledge the support of the Wharton Entrepreneurship and Family Business Research Centre at CERT and The Centre of Excellence for Applied Research and Training Term Fund. Significant help in gathering data was provided by Isaac VanDuyn, Jason Johnson, and anonymous members of the iPhone hacking community, including Big Boss. I would also like to thank Iwan Barankay, Matthew Bidwell, Adam Cox, Emilie Feldman, Eric von Hippel, Nancy Rothbard, Tyler Wry, attendees at the Bowman Seminar at Wharton, the University of Maryland Entrepreneurship Conference, and the Wharton Junior Faculty Group, and the MIT User Innovation Conference for their input and insight.

Introduction

Innovations become revenue-generating goods and services through the process of commercialization. Individual innovators may choose from a variety of paths to commercialize their ideas, including entrepreneurship (Shane and Venkataraman 2000), licensing (Stuart and Ding 2006), or offering it to a current employer in the hopes of a reward (Klepper and Thompson 2010). All of these methods result in an idea being commercially exploited, with value being captured by the entrepreneur and created for society at large (Lepak et al. 2007, Schumpeter 1942). On the other hand, innovations that are not commercialized are less likely to have an economic impact, and may not be diffused as easily or widely in the absence of economic activity (Rogers 2010). While the commercialization decision process has been discussed in the entrepreneurship literature (Grégoire et al. 2011, McMullen et al. 2006), the focus has been on individuals facing the decision to commercialize in isolation, despite the evidence that many individuals generate new ideas and products as part of communities that jointly work on shared problems (Hienerth et al. 2013, Jeppesen and Frederiksen 2006, Shah and Tripsas 2007). These online communities create arenas where "knowledge collaboration can occur in unparalleled scale and scope" (Faraj et al. 2011) and hence represent profoundly generative environments for new innovation. Indeed, one of the most studied examples of innovative online communities, Open Source Software (OSS) (Bagozzi and Dholakia 2006, Von Krogh and von Hippel 2006, Lerner and Tirole 2002), includes over 800,000 individuals and has produced software code that is both worth tens of billions of dollars and is critical to the vast majority of large corporations (Crowston et al. 2012).

Despite the growth of communities like OSS and their increasing role in innovation, we know very little about the process by which the innovations and products generated in these communities are commercialized (Haefliger et al. 2010). Further, what limited literature exists establishes contrasting expectations for how communities might influence commercialization choices. On one hand, an emerging stream of scholarship examining a related phenomenon, entrepreneurship among user innovators, has found that communities can encourage commercialization of innovation by providing evidence of demand

and helping refine and improve ideas (Adams et al. 2015, Hienerth 2006, Shah and Tripsas 2007, 2012). On the other, scholars have argued that communities represent an alternative organizational form that provides different incentives, values, and ways of working that could discourage commercialization (Faraj et al. 2011, Puranam et al. 2014), to the extent that some OSS projects expend considerable effort to undermine attempts at commercialization (O'Mahony 2003). Underdevelopment of the mechanisms by which communities operate on individual decisions to commercialize makes it difficult to adjudicate between these views, and a shortage of empirical evidence has limited the ability of scholars to test among alternatives.

In order to resolve this tension and address this gap in our knowledge of commercialization, I develop theory about the ways in which community membership may be related to the individual propensity to commercialize. I hypothesize that high levels of community affiliation should be associated with a decreased likelihood of pursuing commercialization. I use the launch of the Apple App Store and its effect on underground innovation communities (Mollick 2005) as a quasi-experiment to examine this issue. Drawing on the existing literature, I suggest that this decreased commercialization activity may be the result of one of two potential mechanisms: a general dis-utility of profit seeking among community members or else the self-identity of community members (Fauchart and Gruber 2011, Hogg et al. 1995, Tajfel and Turner 1986). In a second study, I explore these potential mechanisms using data from an original longitudinal survey of open source developers.

I find that affiliation with innovation communities is linked with decreased entrepreneurship at the individual level. However, the potential anti-commercial motivations of OSS communities do not seem to play a significant role in discouraging commercialization. Instead, it is the self-identity of individuals as OSS developers that is associated with significantly lower levels of commercialization. There appears to be a large gap between conceptualizing oneself as an OSS developer and viewing oneself as money-making commercializer. With these results, this paper contributes to the literature first

by offering an initial theoretical and empirical examination of how members of innovation communities make decisions about when and how to commercialize their innovations. It also adds to our understanding of the relationship between innovation and communities by suggesting that community-based innovation is associated with a variety of important constraints on the commercialization process, perhaps explaining why so many user innovations in community settings only lead to entrepreneurship accidentally (Shah and Tripsas 2007).

Next, I will develop the theory around the commercialization decision of individuals operating in community contexts. After laying out the two potential mechanisms that might affect individual choices to commercialize, I will generate formal hypotheses. To test these, I conducted two studies: a quasi-experiment and a longitudinal survey. The quasi-experiment allowed me to examine the differences between OSS and non-OSS developers, while the longitudinal survey allowed me compare within the community of OSS developers to examine the mechanisms by which OSS affiliation operates on commercialization. The use of two different empirical approaches provides within-methods triangulation that helps better establish the results of community affiliation on commercialization (Jick 1979).

Theory and Hypotheses

Most studies of commercialization occur within the literature on entrepreneurship and examine when individuals choose to start their own ventures in order to take advantage of an opportunity they discover or create. These existing models, however, view commercialization decisions as something faced solely by individuals, or small groups of actors. An increasingly large amount of innovation, however, occurs not in an individual setting, but instead in large, often virtual, communities (Dahlander and Wallin 2006, Faraj et al. 2011, Franke and Shah 2003, O'Mahony and Lakhani 2011). In settings where individuals operate as part of communities, such as OSS, the dynamics of commercialization may change dramatically from the individual cases previously mentioned. How might communities influence the commercialization decision?

Little research directly addresses this question, providing fertile ground for theorizing and testing. I argue that communities are likely to decrease the likelihood of commercialization through two potential pathways. First, they may alter the incentives around commercialization, creating a dis-utility to profit-making. Second, communities can lead individuals to assume self-identities as open source developers that could make transitioning to commercialization challenging. In addition, I will also consider alternative mechanisms, such as intellectual property concerns that might discourage commercialization by making innovation easy to copy[1], as well as self-efficacy towards entrepreneurship. All of these concerns would suggest that community members should have a lower propensity to commercialize than individuals in other settings. Before generating the formal hypotheses to test, however, it is important to first discuss the theories behind the two main mechanisms.

Communities and the negative utility of commercialization

The first possible mechanism that would explain why communities might lower the propensity to commercialize is that profit may actually produce a non-economic negative utility for individuals involved in OSS. That means that individuals associated with some innovative communities may view economic motivation as undesirable, though this need not be true of every community. Prior research has found that the in the open source and hacker communities the rewards for developing products are generally not financial, but come from a mix of intrinsic motivation, skill development, and community interaction (Von Krogh et al. 2012, Lakhani and Wolf 2005, Raymond 2001, Shah 2006). Indeed, in some communities such as OSS, scholars have identified ideologies that are directly anti-commercial (Frederiksen and Rullani 2015, Von Krogh et al. 2012). For example, the widely-published Hacker Ethic states that individuals participating in the open source software space have "the belief that information-sharing is a powerful positive good, and that it is an ethical duty of hackers to share their expertise by writing open-source code and facilitating access to information and to computing resources wherever

[1] I would like to thank an anonymous reviewer for pointing out the importance of this mechanism.

possible" (Himanen et al. 2002). Working on open source, free software is more than an economic choice; it is also a philosophic approach. Free flow of information, and its formal expression in the open source movement, represents an idealistic statement about the nature of property and ownership, which, in turn, motivates the communities of open source developers (Bagozzi and Dholakia 2006). This perspective is not limited to open source developers, and has been found in other communities as well, such as among innovators or scientists whose goal is to increase their standing within a peer community (Jeppesen and Frederiksen 2006, Stern 2004).

Many communities of innovators thus emphasize making innovations free, including communities around sports equipment (Franke and Shah 2003, Hienerth 2006), video games (Edery and Mollick 2009), and those supporting the early development of the airplane and personal computers (Meyer 2007). Non-economic, and often anti-commercial, motivation extends to scientists, who historically have given up potential profits in order to be allowed to participate in the scientific community (Stern 2004), and are less inclined to engage in commercial activity if the norms of their institutions do not support economic motivations (Gans et al. 2002, Stuart and Ding 2006). Thus, non-economic incentives can be in direct opposition to economic incentives among many groups of innovative individuals. Indeed, as O'Mahony (2003) demonstrated, some larger open source projects spend considerable effort avoiding the expropriation of their software by for-profit entities. In describing Firefox, the community-developed OSS browser, politician Derek Wall stated, "Marx would have been a Firefox user," as (Wall 2005). This does not mean that current OSS development is anti-commercial in general, or that the majority of developers are adherents to the ideologies of the free software movement, but anti-commercial attitudes have certainly played a large role in OSS communities in the past (Von Krogh et al. 2012).

Self-identity

A second possible mechanism that would explain why communities might lower the propensity to commercialize has to do with the self-identity assumed by community members. Self-identity is "the

extent to which performing [a] behavior is an important part of one's self concept" (Terry et al. 1999: 226), and is shaped by both personal and social factors (Brewer 1991, Stryker and Burke 2000). A recent stream of research has demonstrated the importance of self-identity in decisions associated with both entrepreneurship and commercialization (Fauchart and Gruber 2011, Jain et al. 2009, Powell and Baker 2014) and innovation communities (Bagozzi and Dholakia 2006).

There are a number of ways in which elements of self-identity are conceptualized by scholars, and the constructs used to describe various forms of identity can overlap or compete with each (e.g. Hogg et al. 1995, Powell and Baker 2014, A. Randel and Jaussi 2003, Stets and Burke 2000, Stryker and Burke 2000, Tajfel 1982). For example, social identity theory has primarily focused on identity that derives from collectives such as gender, race, and other social groups (Brewer and Gardner 1996, Randel and Jaussi 2003, Tajfel and Turner 1986, Tajfel 1982). On the other hand, role identity theory developed in a parallel fashion, but focuses primarily on identity that derives from roles such as work and family (Hoang and Gimeno 2010, Powell and Baker 2014, Stryker and Burke 2000). In settings like OSS self-identity combines elements of the social (individuals operate in a community setting) and role (individuals might occupy the role of developer across many communities), so this paper does not attempt a fine-grained differentiation among these concepts, instead focusing on self-identity as an OSS developer compared with that of an entrepreneur.

Research has uncovered several facets of entrepreneurial self-identity (Cardon et al. 2009), many of which are in conflict with the self-identities developed in communities, making it especially challenging for individuals with those community-based identities to adopt an entrepreneurial identity. Jain, George, and Maltarich's (2009) study of the challenges facing scientists who enter entrepreneurship highlights several of these incompatibilities in the areas of norms, processes, and outputs between community-focused scientists and entrepreneurs. For example, the norms of community members in science are based on advancing knowledge through shared and collective work, while entrepreneurs

emphasize private property and having unique advantages over competitors. Scientists also engage in wide-ranging, long-term experimental processes, while entrepreneurs focus on short term goals. Outputs and rewards differ as well, as academics seek communal peer recognition and status (Stern 2004) while entrepreneurs aim to produce products and generate profits. This difference in identification makes it extremely challenging for academics to become entrepreneurs without first gradually transitioning their self-concept from that of a scientist to entrepreneur.

The identity of an innovation community member looks much more like that of an academic than an entrepreneur. Similar to scientists, the norms of community members such as those in OSS take collectivist approaches to production that are very different than those found in for-profit companies (Von Hippel and Von Krogh 2003, Von Krogh et al. 2012, O'Mahony and Ferraro 2007). The processes also differ, as entrepreneurs go through a process of short-term focus to get a job done, while community projects often involve stewardship of an evolving team or process (O'Mahony 2003). As for outputs, advancement and recognition for community members occurs when individuals are viewed as being active contributors to both projects and community, (Jeppesen and Frederiksen 2006, Von Krogh et al. 2012, O'Mahony and Ferraro 2007), rather than profit-seeking. There are thus many potential identity conflicts between the self-identities of commercializers and OSS developers.

These conflicts are important because recent scholarship has focused extensively on the importance of self-identity in the decision to commercialize or become an entrepreneur (Cardon et al. 2009, Dobrev and Barnett 2005, Hoang and Gimeno 2010, Powell and Baker 2014). Passion for entrepreneurship is dependent on individuals seeing themselves in an entrepreneurial identity (Cardon et al. 2009), and the choice to become an entrepreneur is strongly influenced by an individual's identity (Murnieks et al. 2014). Not only are career transitions to entrepreneurship affected by identity, but people who do not identify as entrepreneurs may process information in a way that causes them to see fewer

entrepreneurial opportunities (Hoang and Gimeno 2010, Mathias and Williams 2014). Self-identity may therefore play a large role in the decision to commercialize.

An OSS identity does not necessarily imply an anti-commercial ideology. Indeed, studies of individuals within communities have found that they can be enthusiastic about the commercialization of their work, whether that commercialization is led by others (Jain et. al, 2009), or else by those "communitarian" founders who were able to transition from community to entrepreneurial self-identities (Fauchart and Gruber 2011). Instead, lower commercialization rates would be due to the challenges of transitioning between identities, and the resultant changes needed in how the individual understands their own norms, processes, and outcomes.

Hypotheses

There are thus multiple reasons to suspect that community affiliation lowers the likelihood of commercialization. Regardless of which of the mechanisms might be acting, and in what combination, OSS communities would influence their community members in two different ways. First, the mechanisms may act as selection criteria, as individuals drawn to open source may already have personal characteristics that match those of the OSS movement. Alternately, OSS community membership may influence individuals after they join, reinforcing these characteristics through peer interaction. Likely, both selection and influence are at work, as communities both attract individuals who are inclined to associate with them, while also reinforcing and building those character.

In any case, the relative impact of selection or influence is of less concern than the mechanisms by which they operate, and, even more importantly, whether issues of affiliation or identity actually affect commercialization outcomes. To actually understand the impact of OSS affiliation on commercialization, we need to examine a context where individuals, with varying levels of affiliation to OSS communities, are faced with a commercialization choice around innovations that already have some commercial appeal, and where actual costs to commercialize are low:

H1. Increasing affiliation with OSS communities decreases the likelihood that individuals will commercialize their existing innovations, even when economic costs to do so are minimal.

H1 could result from any of the two proposed mechanisms, or from multiple mechanisms acting in combination. While it is not possible to definitively rule out alternative explanations, it is worth examining the two theoretical approaches discussed above. The two mechanisms have different implications, both for scholarly research and for managers.

The first mechanism is a potential anti-commercial attitude among OSS community members. While the assumption that individuals in OSS and related communities are generally anti-commercial is widespread, there is limited testing of its potential impact. A general dis-inclination towards commercialization is certainly central to some communities related to OSS, such as the Free Software movement, though anti-commercial attitudes are generally less explicitly clear in OSS and most other innovation communities. I therefore look within the OSS community and hypothesize:

H2. Increased anti-commercial attitudes among OSS-affiliated individuals is associated with lower levels of commercialization through entrepreneurship.

The second potential mechanism is that individuals associated with OSS may adopt a self-identity that is based around the norms, processes, and outcomes of OSS development. Because this identity is distant from conventional entrepreneurial roles, OSS developers, like scientists, will find it challenging to transition from their self-identity as community member to that of for-profit entrepreneur.

H3. Increased self-identity among OSS-affiliated individuals is associated with lower level of commercialization through entrepreneurship.

I began by testing H1—the effects of OSS communities on the actual commercialization choices made by individuals—using a quasi-experiment. In that study, I examined a population in which some, but not all, individuals facing commercialization decisions had an OSS affiliation. This allowed me to

exploit variation in OSS affiliation to examine the effects of affiliation on commercialization. I then conducted a second study examining H2 and H3—attitudes towards future commercialization or entrepreneurship—through a survey of OSS developers. In this case, all the individuals are operating within an OSS context, which allowed me to examine the mechanisms by which OSS affiliation might decrease commercialization.

Study 1: Quasi-Experiment

Context

The iPhone, released in 2007, was a radical change in cellphones, and attracted considerable interest from programmers who wanted to develop software for it. For the first year after its release, from June 2007 to July 2008, the iPhone was technically a closed system; only the original Apple-supplied software programs were officially permitted. However, as would be expected from the literature on underground innovation (Mollick 2005), it was not long before dedicated individuals began to "hack," or modify, the iPhone operating system, writing their own software for the iPhone platform (Al-Zarouni and Al-Hajri 2007). Moving beyond creating original software, these enterprising individuals also created their own shadow distribution system for this software, so that anyone who opened their iPhone to modifications was also able to download a wide range of software. Using these underground software packages required a process called "jailbreaking." Jailbreaking modified the iPhone in a manner harmless to the phone, but which was strongly discouraged by Apple (installing outside applications would void the warranty of the phone, among other issues). Despite this, millions of iPhones were jailbroken, a minimum of 25% of all iPhones sold (Krazit 2007).

Since the iPhone operating system was closely related to the Macintosh OS, which in turn was derived from UNIX, it proved a relatively easy programming environment for computer enthusiasts. The result was, in the words of *Wired* magazine, "an entire underground ecosystem: the Jailbreak community" (Chen 2009). Hundreds of jailbroken applications were developed, the vast majority of them as free software, some also as OSS. Programmers in this period developed key new software categories for the

iOS platform: the first photography applications, the first games, the first electronic reading applications, and many others. To support these individuals, large number of websites served as foci for community members developing applications, and as areas where new applications were discussed.

This period of furious underground innovation ended on July 12, 2008, when Apple created the iPhone Application Store while simultaneously updating the software of the iPhone. With the new software, users of the iPhone could purchase (or download for free) software by outside developers that was legally developed for the iPhone and distributed through Apple's own App Store. Such software was approved by Apple, so it had to meet certain relatively well-defined criteria. However, Apple allowed developers to price software as they saw fit, and gave developers 70% of the revenue from any sales. Within two months 3,465 applications were listed on iTunes. In short, Apple created the possibility of commercialization, where previously there had been none.

In this new environment, individuals who had written pre-existing software faced a choice as to whether they would exploit the opportunity afforded by the Application Store. All software was written for earlier versions of the iPhone operating system and had to be updated to the new system, but this was a trivial procedure, according to the interviews I conducted. In the words of one developer, "It was an incredibly easy process; you are writing the same code [as you did before the App Store launched]. The difference is that Apple is providing the documentation in one case, and in the other you have to reverse engineer it. It is the same application." Thus, opportunity costs, a key consideration in economic decision-making, were minimal for the developers of jailbroken apps.

After conversion to the new system was done, individuals could either continue to make the software available for free or begin to charge for it using Apple's App Store. Apple handled all of the commercial aspects of the sale of the software, simply sending checks to the developers. In addition to the low barriers to selling apps, the iPhone application market represents a substantial opportunity: one jailbroken application sold over $1m a month in revenue after it was released on the Application Store.

If, on the other hand, a developer's software products did not meet Apple's standards, or if the developer simply refused to work through the App Store, they could still make their software available for free through the underground distribution methods that the community maintained. Adding to the options for commercialization, the underground distribution system, now called Cydia, was modified to allow individuals to charge for software, creating a commercialization channel outside of the official App Store.

The launch of the App Store and its effect on the vibrant jailbreak community provides an excellent quasi-experiment to test H1. The major change with the introduction of the Apple App Store was structural, creating a market where there had previously not been one. Prior to the App Store, individuals had already created valuable applications for the iPhone, and given them away for free, since there were no other options. Now, at the same moment, and in the same strategic context, these developers now sorted into one of three categories: (1) those who commercialized their work (either through Apple or through the underground distribution system, Cydia), (2) those who continue their commitment to free software by updating them and continuing not to charge, or else (3) those who walk away and abandon their projects without updating them.

Figure 1 illustrates the three options and the timeline. Originally, developers made their jailbreak applications available for free. A few individuals in these early days had attempted to sell their jailbroken application, but this was rare (less than 5% of developers) and difficult because there were no trusted mechanisms available by which individuals could charge customers. For the vast majority of developers, their first opportunity to commercialize their work occurred when the new App Store was released. They could choose to update their software for the new operating system version, or else abandon their projects. If they did choose to update the software, they were faced with a second choice, they could also choose continue to offer it for free or commercialize it. The potential economic profit associated with commercialization proved to be vast. For example, one firm that was started by innovators in the jailbreak community was later sold to the Walt Disney Company for over $40 million. Thus, studying the

context of jailbreaking provides a useful way of examining the choice to commercialize an innovation that had previously been developed as part of a community.

[INSERT FIGURE 1 HERE]

Methodology

For Study 1, all of the variables, except for outcome data, came from the period before the launch of the App Store, when only the unofficial jailbreak community existed. Data was collected on individual applications from the largest distribution site for software before the App Store, and was supplemented by email correspondence with approximately 20% of the developers of the software, and conducted interviews with several of the most notable. The initial data from the software distribution site consisted of the name of the application developed, the number of downloads, and the number of versions of the software that were released. This data was recorded continuously throughout the entire period before the launch of the App Store, and ends on the date the App Store was launched. For each piece of software, two research assistants collected additional data using a variety of online directories of iPhone apps. Additionally, the price of any software identified in the iTunes Application Store was noted, as was any additional software by that developer. It is possible that through a combination of name changes and title changes, some applications may have been listed in the iTunes Application Store but not identified, but interviews with developers did not locate any errors. I dropped from the sample those programs that did not represent traditional apps: add-ons for other software, ebooks, images, or graphical themes.

The final sample consisted of 88 developers who released all of their applications for free prior to the launch of the App Store. This represents the complete universe of developers at that time. Of these, 75% had created a single jailbroken application and an additional 12.5% had created two applications.

Dependent and Explanatory Variables

The dependent variable is *Commercialization*, which has one of three states, corresponding to the three possible commercialization outcomes open to developers: (1) update at least one application and

charged for access to at least one application (n=38, labelled *Commercial*); (2) update at least one application and keep all of the updated applications available for free (n=18, labelled *Free*); or else (3) abandon all of their applications and do not update them (n=32, labelled *Abandon*). Both the second and third states are different variations on the choice not to commercialize. For a developer to be placed in the *Free* category, all of their software needed to be available for free after the launch of the App Store. For a developer to be considered to be *Commercial*, at least one application needed to be listed for sale on either the App Store or through Cydia. Additionally, if a developer created a new paid application within two years after the launch of the App Store, they were considered to be *Commercial*, even if they kept their jailbroken applications updated and free.

The explanatory variable of *OSS Community Affiliation* was measured by the proportion of a developer's applications where the source code was listed on an open source site before the launch of the App Store. Making code publicly available requires additional effort, and may have disadvantages to (such as making software easy to copy), so doing so is a good indication of open source affiliation. Importantly, the listing of source code on an open source site does not broadly prohibit commercialization. In most cases, open source licenses, including the most restrictive used by the iPhone developers in the sample, do not restrict the ability to sell software, instead setting up requirements to share source code under various conditions. It is also worth noting that the young jailbreak community overlapped with, but was not completely part of, the older OSS community (and the even broader "hacker" community of intrinsically-driven software hobbyists). Thus, the *OSS Community Affiliation* measure provides a way of measuring the connection to a particular long-standing software community (O'Mahony and Ferraro 2007), but not one that every iPhone developer felt part of.

Control Variables

To the extent that profit drives commercialization decisions, higher potential profit should be associated withincreased commercialization, given low uncertainty and a similar opportunity cost (Amit et al. 1995) among individuals. Specifically, as Choi (2004) argues, the more information a potential

entrepreneur has about their customer needs and potential interest, the more likely they are to exploit an opportunity. Thus, *Market Interest* was measured as the mean number of times each piece of software created by a developer was downloaded during the period before the Application Store was opened by Apple, though the number of downloads for the most popular app for each developer was also tested, with the same result. Downloads are a strong indicator of demand for a product, and act as a very direct signal of market interest. The level of data provided to the individual about interest in their product from potential customers was therefore quite precise – highly downloaded products were more likely to be in high demand after the legal release of the App Store. This logic is supported by the first publicly available survey of installed applications, conducted seven months after the launch of the iPhone. Of the top ten most installed iPhone applications (out of over 32,000 available applications at that time), two had originated within the jailbroken community, and they represented the first and second most downloaded original games before the launch of the Application Store (Jurutka 2009), demonstrating that pre-App Store downloads acted as a strong signal of actual demand. In the study, due to its skewed distribution, the log of *Market Interest* was used.

A number of other control variables were also included. An individual's personal commitment to the software package was measured by the number of times a developer updated their free software before the release of the Application Store, labelled *Commitment* in the tables. Individual psychology and risk tolerances may affect how an opportunity is perceived (Brockhaus and Horwitz 2002). Thus, I would expect the effort that an individual expends exploring an opportunity to have an impact on how an opportunity is perceived, and therefore whether it is exploited. This is because sunk costs and escalation of commitment are likely to bias an individual (Brockner 1992, Staw 1981), but also because effort is an indicator of serious interest on behalf of a developer in continuing to create a program, and therefore a positive bias.

Another control variable, *Banned*, indicated whether or not the developer had software that was banned from the App Store by Apple. Apple bans software for a variety of reasons, most notably because it duplicates other Apple functions, is offensive, or allows users to modify the underlying features of how an iPhone works. Banned software can still be sold through Cydia, but I would expect bans to suppress commercialization. A variable, *Game*, was also used to indicate what proportion of software created by a developer were games, since it might be expected that entertainment applications had different characteristics than utilities or other applications. A final variable, *Donationware*, was used to indicate whether the developer had previously asked for donations to support their free software effort prior to the launch of the App Store. This usually consisted of a request in the application description for financial support via PayPal, and likely shows an greater desire to generate revenue from an innovation. Table 1 shows the summary of variables by developer, and Table 2 shows the correlation matrix.

[INSERT TABLE 1 HERE]

[INSERT TABLE 2 HERE]

Study 1: Results

The state of each developer before and after the launch of the App Store is summarized in Figure 1. As can be seen, the advent of the App Store had an obvious effect on the market, as the number of developers commercializing their products went from under 5% of all developers to nearly 68%. The descriptive statistics in Table 1 shows that those developers who commercialized their apps generally had lower open source affiliation than those that did not, while also producing more versions and more apps overall. They also developed more games and had the highest rates of donationware.

To examine H1, I next used a multinomial logistic regression. There are three outcomes: commercialization (*Commercial*), or two non-commercial options: making all apps free (*Free*), or abandonment of all applications (*Abandon*). Table 3 reports the results and the marginal effects for ease of interpretation. As predicted in H1, affiliation with open source significantly decreases the likelihood

that a developer will commercialize their work versus abandoning it. Affiliation with open source is also associated with marginally significantly increases in the likelihood of a developer choosing to distribute all apps for free versus commercializing them (the lower significance is possibly due to the low number, 18, of developers that made products available for free). The result indicates that going from no affiliation with open source communities to having only open source apps is associated with increased likelihood of abandonment compared to commercialization by 34%, and the likelihood of releasing apps for free compared with commercialization by 35%. Interestingly, however, market interest is not strongly related to whether or not individuals choose to commercialize. This result proved robust across a variety of alternative specifications at the developer level.

[INSERT TABLE 3 HERE]

A supplementary analysis shows that while market interest did not predict who would commercialize, it did predict which applications out of their portfolio individuals chose commercialize, among those who chose commercialization. For this analysis, instead of looking at the population of developers, I instead examined the population of 47 apps created by developers who had decided to commercialize at least one of their applications. I used a logistic regression to predict which apps among that population were commercialized, clustering errors by developer. As can be seen in Table 4, within the population of individuals who chose to commercialize their applications, market interest is a significant factor in commercialization. Individuals who respond to economic profit by commercializing are therefore consistent in their application of economic logic, commercializing their most valuable innovations. This is consistent with a self-identity mechanism, suggesting that, among those individuals with an identity that supported commercialization, they reacted with standard economic logic.

[INSERT TABLE 4 HERE]

Qualitative context

Discussions with several of the early App Store developers provided some context and color for these findings. In interviews, it was common for developers to refer to their identity as OSS developers, and to explicitly discuss their distance from more commercially-oriented identities. An open source developer who had created a number of innovative apps with millions of free downloads reported that "It is not that I have some allergy to making money. I know how stupid I have been to not make money. But I don't have the resources to put together the business stuff." From the perspective of someone with a more commercial self-identity, statements like these make no sense. Apple handles all of the business operations for developers, developers merely have to submit an application and accept a check for 70% of revenues. The gap between their identity as an OSS developer and "business stuff" was difficult to bridge.

Instead of invoking the processes, norms, and goals of commercialization, OSS developers referred to those of the open source community. For example, one developer of a highly downloaded open source application wrote that, "I released my app as open source, and I intended not to break it, so I would've had to do this all for free." This is not actually true under any type of OSS license – there is neither an obligation to support software for free, nor do most OSS licenses forbid sale of an app, as long as the source code is available. However, this sentiment makes sense in the context of the self-identity of an OSS developer, operating in the norms of OS development where individuals answer community questions for free. Instead of focusing on the goal of commercialization, those who self-identified with OSS development sometimes emphasized the joy of pure discovery and innovation typical of hackers (Lakhani and Wolf 2005, Mollick 2005). As one developer told me, "there is a certain degree of satisfaction to pushing the boundaries of what is possible" by developing novel applications for the "beautiful" iPhone operating systems (for other examples of the centrality of "beauty" in OSS development, see Von Krogh et al. 2012).

The developers who chose to commercialize their applications tended to have very different self-identities. They did not mention OSS, or community expectations or free work, and instead emphasized

the many ways that they attempted to profit from their development work. This could be remarkably overt: one developer had created a video application for children for the App Store and a separate pornographic version for adults, sold via Cydia. They wrote to me about their commercialization attempts: "I have sold copies of both jailbreak and app store applications, done consulting work, and am currently employed full time as a senior iPhone developer. About 80% of my life is consumed with iOS development in some form." This represents a different self-conception from those who were motivated by beauty, and makes the difference in self-identities between these two groups clear.

The results of Study 1 support H1. In a setting where commercialization is easy to accomplish, individuals showing commitment to OSS were less likely to commercialize, even in the face of demonstrable interest. The expected economic value of commercialization (as determined by number of downloads prior to the launch of the App Store) was not predictive of whether or not individuals commercialize. We next turn to examine H2 and H3, the specific mechanisms by which OSS commitment may lower commercialization.

Study 2: Longitudinal Survey

The quasi-experiment allowed me to compare the commercialization decisions of between OSS and non-OSS developers. However, identifying the mechanisms by which OSS commitment impacts commercialization choices requires an examination of the variation in commercialization activities within the OSS community itself. For a second study, I use a longitudinal survey design that measures the attitudes towards commercialization and OSS self-identity of individual OSS developers, followed by a second survey 15 months later that examines whether those individuals have actually engaged in commercialization. This design allows me to shed light on the factors that predict future commercialization choices.

In August 2014, an online survey was sent to 2,379 randomly selected active developers out of over 3.4 million on Github, the largest open source repository. The criteria for selection was that

individuals needed to have contributed at least three commits (updated code) to a project that included at least three other developers. The individuals were randomly sampled from within that group and a random drawing for prizes was used to incentivize participation. Partial responses were given by 768 respondents (32%), of which 493 (20.6%) were complete and could be matched with full Github data. A follow-on survey was sent 15 months later (in January, 2015), which received 161 partial responses (32.6% of the original respondents) and 127 complete responses (25.8% of the original respondents). There was little evidence of response bias in either survey. For the first survey, in univariate testing, there was no significant differences between complete respondents and non-respondents in terms of their effort (commits and recent commits), the number of fellow developers whose updates they followed, or the number of projects to which they contributed. While one factor—log number of followers—differed significantly, the two groups had identical medians, though the sample had fewer individuals with extremely high numbers of followers, and this factor was not significant in regressions. Respondents to the second survey, compared to the respondents in the first wave, did not differ significantly on any of these dimensions, nor by factors such as reported hours spent per week doing open source work in the first survey, gender, or in their attitudes towards open source. Thus, the response rate is in line with other online surveys (see Kriauciunas et al. (2011) for a comprehensive review of response rates) and response biases appear to be minimal.

For those individuals who engaged in commercialization activity after the first survey wave by engaging in either independent contracting or entrepreneurship, it was clear that OSS was a central part of commercialization activities: 79% of contractors agreed or strongly agreed that their work involved OSS projects with which they were involved (only 4% disagreed), and 58% of entrepreneurs said that their company's products and services were mostly based on OSS (31% disagreed or strongly disagreed). Additionally, these numbers are likely to underrepresent the role that OSS community involvement played in providing opportunities for commercialization, as direct measures of OSS-related tasks undercount the degree to which these communities represent sources for innovation beyond software code

alone. Nonetheless, dropping all cases where founders did not agree or strongly agree with these questions does not significantly change the results.

Dependent and Explanatory Variables

As a dependent variable, I examined new commercialization activity by respondents after the first wave of the survey was complete. I asked respondents in the second wave of the survey: "Since August, 2014 [the date of the first wave of the survey], have you worked as an independent contractor or started your own business?" Those who answered that they had either started a new business or started work as an independent contractor were considered to have commercialized (the *Commercialization* dummy variable has a value of 1 in these cases). This allows a direct measurement of the choice to commercialize innovations through entrepreneurial action.

The first explanatory variable is the degree to which individuals who are part of OSS hold anti-commercial attitudes. I included two separate items using a 5-point Likert scale ("Strongly Disagree" to "Strongly Agree"), one from the first wave of the survey, and one from the second. These two items measure slightly different versions of anti-commercial attitudes: whether anyone should be able to make money from OSS, and whether the respondent themselves have adopted the radical OSS belief that all software should be free (see Stallman 1992). Thus, from the first wave of the survey, *Disutility: Time1* is the reverse coding of "It is good that startups make money from FLOSS, provided they adhere to appropriate licenses." From the second wave of the survey, *Disutility: Time2* is the response to "I believe software should be free."

The measure of *OSS Self-Identity* came from the first wave of the survey. I used the 4-item scale for the self-identity of OSS developers modified by Daniel et al. (2011) from the work of Randel and Jarussi (2003). The four items were: "In general, my role as a developer in this project is an important part of my self-image"; "My role as a developer in this project is unimportant to my sense of what kind of person I am" [Reversed]; "Overall, my role as a developer in this project has little to do with how I feel

about myself" [Reversed]; and "My role as a developer in this project is an important reflection of who I am." Each item used a 5-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). Cronbach's α for this scale was .85.

These items were asked with regard to a particular OSS project the developers were active participants in and where there were at least three other developers. For individuals with more than one project that met this criteria (the mean number of qualifying projects per developer was 1.48, sd=.91), I selected randomly among these projects. I concentrated on projects, rather than asking about OSS in general, since that both focused the participants on their actual contributions and also allowed more accurate measurement of individual commitment to OSS on a project basis. Additionally prior work on identity in innovation communities have focused on connections to subunits of wider movements, such as individual LEGO user groups (Bagozzi and Dholakia 2006).

Control variables

I also included a number of control variables that might serve as alternative explanations for why individuals associated with communities may chose not to commercialize their innovations. One potential confounding factor is the difficulty of dealing with intellectual property (IP) rights. The ability to protect IP, whether by secrecy or patent, is important for incentivizing the development of commercial inventions (Arrow 1962), and plays an key role in determining whether entrepreneurs benefit from innovation (Teece 1986). In many communities, and in OSS in particular, the ability to maintain control over IP is explicitly given away by community members, who publically post and share their work. Instead, there is often an embrace of a "private-collective" model of IP that focuses less on directly commercializing innovations and more on the collective benefit of community work to individuals and organizations (Von Hippel and Von Krogh 2003).

This creates a variety of disincentives to commercialize an innovation. First, it suggests that any successful innovation in a community like OSS is easily copied, as it is protected by neither secrecy nor

formal patents. The fact that entrepreneurs may find their innovations quickly duplicated by either large established firms or new entrants may give many innovators pause before investing the money and time into commercialization. Secondly, there could be confusion over ownership rights. Products created collectively may either explicitly or implicitly bind creators to share ownership of IP. It is uncommon for these IP arrangements to prevent commercialization. Even the GPL license, the OSS license most restrictive of commercial activity does not restrict the ability to commercialize applications. At the same time, innovators may be worried that the collective nature of IP in community settings could leave them vulnerable to legal action from co-inventors.

To measure concerns about intellectual property, I used three items capturing three dimensions of concerns about IP rights. Each item used a 5-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). To measure concerns about IP liability in a setting with collective innovation, I asked: "If I started a company based on my FLOSS [Free, Libre, Open Source Software] work, I would worry about intellectual property lawsuits from other contributors," the response is labelled as *IP: Worry about legal* in the tables. To examine concerns about the risks of others appropriating the individual's innovations, I asked two other items: "If I attempted to start a venture based on FLOSS, it would be easily copied," (labelled as *IP: Easy to copy*) and "The ease of copying FLOSS makes it hard to make money from" (labelled as *IP: Hard to make money*). These items were taken from the second wave of the survey, but concerns about IP in OSS should be consistent across time periods.

I also controlled for entrepreneurial propensity as measured in the first wave. To determine entrepreneurial propensity (*Self Employed Propensity*), I used a modified version of Kolvereid's (1996) entrepreneurial choice criteria, asking on 7-point Likert scales: "If you were to choose between running your own business and being employed by someone, what would you prefer?" Controlling for this factor (which proved to be predictive of entry into entrepreneurship in the second wave surveys) reduces the

impact of self-selection based on career goals[2]. I also controlled for a variety of human capital and other factors taken during the first wave survey using dummy variables: gender (*Female)*, student status (*Student at T1*), employment in technology industries (*Worked in Tech*), and whether individuals had prior entrepreneurial or independent contractor experience (*Previous Entrepreneur*). Additionally, models contain fixed effects for the year of joining Github and the education level of the respondent (*Year FE* and *Education FE*, respectively).

Study 2: Results

Correlations and summary statistics are available in Table 5. Of note are the low levels of correlation between *OSS Self-Identity* and the disutility of profit variables, supporting the theoretical contention that these concepts are distinct. Table 6 gives the results of the regression analysis, with Models 1-4 being logits with robust standard errors predicting whether people are entrepreneurs or not after the first survey wave. The baseline Model 1 shows results with controls alone, and no explanatory variables. Interestingly, fears of legal action over IP did not prove to be a significant factor in predicting commercialization, nor did a general concern that the ease copying of OSS makes commercializing innovations difficult. However, high levels of agreement with the specific statement "If I attempted to start a venture based on FLOSS, it would be easily copied," were associated with lower entrepreneurial activity. In many ways, it is unsurprising that this narrow concern discourages commercialization, and, with the lack of significant results to the other two IP items, the positive results of this item means that IP rights are unlikely to be a primary driver of commercialization activity. Previous entrepreneurial experience and being female is associated with increased odds of commercialization.

[Insert Table 5 Here]

[2] Self Employment Propensity is also a potential alternative measure of self-identity, as it asks people to select whether they view themselves in the identity of entrepreneur. To the extent that it is an identity measure, it operates in the same way as the self-identity measure above, and is also a significant predictor of entrepreneurial activity, though in the expected positive, rather than negative, direction.

[Insert Table 6 Here]

To test H2, we turn to Model 2, which includes the two variables used to measure anti-commercial motivations, or the potential disutility of profits to individuals. Neither *Disutility:1* nor *Disutility:2* are significant, suggesting that there is no support for H2. I find no evidence that anti-commercial attitudes are associated with the commercialization choice.

Model 3, however, shows that, as predicted in H3, higher levels of OSS self-identity in the first wave are also associated with lower rates of direct commercialization through entrepreneurial action after the first wave. These results remain significant in the fully-specified model (Model 4). The effect is significant – examining the marginal effects of the full model, and holding all other variables at their means, individuals with the lowest reported levels of OSS self-identity have a 53% mean predicted probability of commercializing, while the individuals with the highest levels of OSS self-identity have a 19% mean predicted probability of commercializing.

Alternative Explanations

An alternative explanation is that the *OSS Self Identity* measure is simply capturing a lack of confidence with other methods of producing products; individuals may feel less confident about running a startup because their experience is based entirely on cooperative production. To test this, I ran a series of OLS regressions using OSS self-identity as an explanatory variable, with a variety of self-efficacy measures gathered during the second wave of the survey as DVs. First, I tested a four item scale of self-efficacy over entrepreneurial outcomes (with a Cronbach's α of .87) that included questions like "I know the necessary practical details to start an entrepreneurial venture," and "I tried to start an entrepreneurial venture, I would have a high probability of succeeding," (Krueger et al. 2000). Using the same approach Model 6 of Table 6, self-identity did not significantly predict perceived control (*b*= -.08, t-ratio=-.93, p=.357). I also used a 14-item scale asking participants about the confidence in carrying out specific functions required for entrepreneurship from "identify the need for a new product or service" to "manage

the financial aspects of my business" (Liñán and Chen 2009). Again, self-identity did not significantly predict either the full scale (F12, 112=2.17, *b*=-.033, t-ratio=-.43, p=.66) nor any of the five specific subscales. I also conducted a binary mediation analysis to examine whether self-efficacy moderated the effects of self-identity on commercialization. I found no evidence of mediation. Bootstrapped standard errors (with 1500 replications) reveal bias-corrected confidence intervals that include 0 for the total indirect and indirect effects, while the direct effect remains significant (Baron and Kenny 1986, Preacher and Hayes 2008). Self-efficacy or perceived competence do not appear to be the mechanisms by which self-identification with the OSS community lowers entrepreneurial propensity.

Discussion and Conclusion

The results from both studies show that OSS community affiliation is associated with decreased propensity to commercialize, even in scenarios where commercialization is almost trivially easy, and where there is a reasonable expectation of strong demand. Despite the reputation of OSS as anti-commercial, I did not find evidence that anti-commercial attitudes influenced commercialization choices. There was some evidence that IP issues may discourage commercialization, but only in a limited way. Instead, the primary mechanism associated with the lower propensity to commercialize appeared to be attributable to the difference in self-identity between community-based innovators and entrepreneurs. The iPhone and Github developers who did not commercialize despite high market interest did not conceive of themselves as entrepreneurs and therefore were unable to make the transition to the norms, processes, and outcomes of commercialization.

These findings contribute to the discussion on the importance of self-identity in entrepreneurship by providing quantitative evidence that identity measurably impacts commercialization across two different contexts. While prior work has examined the importance of entrepreneurial self-identity in commercialization activities (Cardon et al. 2009, Fauchart and Gruber 2011, Hoang and Gimeno 2010, Jain et al. 2009, Powell and Baker 2014), these studies have largely been case-based or retrospective in

nature, making it hard to generalize the relative impact of self-identity in the decision to commercialize. In the current study, I am able to demonstrate economically significant effects of identity directly. In the full model used in Study 2, individuals who had the lowest reported levels of OSS self-identity had a 53% mean predicted probability of commercializing between the first and second waves of the survey, while those with the highest had a significantly lower predicted probability – 19%. These are large differences, and they suggest that self-identity is an important part of the selection into entrepreneurship.

This paper also contributes to the growing literature on user and community innovation, as there is reason to believe that the findings apply to communities beyond OSS. This is especially true because the more potentially idiosyncratic elements of OSS communities, such as an anti-commercial context and particular attention to IP rights, were not significant factors in influencing individual commercialization decisions. Instead, it is a factor that is more universal in innovation communities – self-identity as a community member – that is associated with lower commercialization. This is important because active community members in general represent a vital and potentially economically important pool of founders. Higher levels of community self-identity, however, caused developers to be less likely to found businesses, as both the quasi-experiment and survey showed. There is therefore an important trade-off between commercialization and community-based approaches to creating and distributing innovation.

Evidence of the often "accidental" or even reluctant nature of commercialization in community contexts supports the idea that identity transition is a challenging and often gradual process for community members. Shah and Tripsas (2007) observed that 82 percent of the founders of juvenile product firms were non-professional user innovators, usually parents, who created products based on their own needs and interests. Rather than planning on becoming entrepreneurs, amateur innovators only gradually realize the value of their solution to a wider market, taking input from the community of users as they continued to refine their innovation. While the community may play a role in helping individuals recognize and refine their innovations (Haefliger et al. 2010, Shah and Tripsas 2007), such

commercialization is usually at the end of a long process by which innovators gradually transition from a community identity to a commercial one. For example, Shah and Tripsas (2012) describe the "Hawaiians," a group of innovative windsurfers who, when faced with demand for their product, went down a long road to commercialization: first they attempted to get a manufacturer to make the product (without asking for anything in return), then they freely shared the design with friends, and only after a long process and repeated requests by individuals looking to purchase their product did they begin to commercialize. This pattern is a common one in user communities (Harhoff et al. 2003, Von Hippel 2005). Innovative communities encourage their members to develop very different identities than that of entrepreneur, thus lowering the ability of community members to see themselves as commercializers. Thus, while previous studies have found that innovators in communities approach commercialization through a process of "accidental" discovery of market demand (Hienerth 2006, Shah and Tripsas 2007), this paper suggests that the reason for this slower process may be a result of the ways in which self-identification affects the decisions of individuals to approach commercialization.

Finally, this paper adds to the literature on the non-economic incentives associated with entrepreneurship. There has been research on a variety of ways in which individuals gain non-economic positive utility from starting a company, including through association with a product or service (Scott Morton and Podolny 2002), resolution of disagreements (Klepper and Thompson 2005), and control (Hurst and Pugsley 2010). This literature, however, has tended to focus on the positive non-economic utility associated with starting firms. In contrast, this paper suggests the existence of *negative* non-economic utility that can be associated with firm formation. In other words, the dissonance associated with moving to an entrepreneurial identity creates negative utility that offsets the profit that could be gained from launching a new organization.

There are some limitations to this research, as well as some potential strengths. First, the iPhone jailbreaking community is an unusual subgroup, and may not be representative of open source as a whole.

However, while it is certain that there are idiosyncrasies around the iPhone development community, qualitative evidence from the interviews (along with the fact that the results from both studies show similar outcomes with regard to commercialization) suggests that there is substantial overlap between the view of iPhone hackers associated with OSS and the more diverse open source community as a whole. A second potential concern in the quasi-experiment is that individuals may have anticipated the launch of the App Store and created free products to create demand prior to charging for them. This view is not supported by the interviews that I conducted, which indicated that the nature of the App Store was a surprise, and that individuals did not anticipate the market, but this cannot be ruled out. Further, there was no indication of any two-sided markets for free applications in the analysis—free applications were not launched as vehicles for advertising or demonstration versions. On the other hand, a strength of the paper is that the OSS longitudinal study was able to confirm and build on the findings of the quasi-experiment in a second setting, allowing within-method triangulation (Jick 1979).

Beyond OSS, community-based innovation is increasingly common in fields ranging from science (Franzoni and Sauermann 2014) to new product development (Afuah and Tucci 2012, Poetz and Schreier 2012) to crowdfunding (Mollick 2014). In most of these settings, communities innovate, but other organizations generally commercialize the innovations. This research suggests that the presence of commercial entities may be important, as individuals associated with online communities may develop many innovations that are potentially profitable and valuable, but which are nonetheless never commercialized. If handled correctly, the partnerships between for-profit entities and communities could be valuable for each. Both managers and academics need to consider how community affiliation affects not just innovation, but which innovations are commercialized, and the degree to which companies can take advantage of community innovation. Future work is needed to better understand how community-based innovators and profit-seeking organizations can best cooperate to bring important innovations to the market.

References

Adams, P., R. Fontana, F. Malerba. 2015. User-Industry Spinouts: Downstream Industry Knowledge as a Source of New Firm Entry and Survival. *Organ. Sci.* **27**(1).

Afuah, A., C. L. Tucci. 2012. Crowdsourcing as a solution to distant search. *Acad. Manag. Rev.* **37**(3) 355–375.

Al-Zarouni, M., H. Al-Hajri. 2007. Taxonomy of iPhone Activation and SIM Unlocking Methods. *Inf. Secur. Manag. Conf.* 157.

Amit, R., E. Muller, I. Cockburn. 1995. Opportunity costs and entrepreneurial activity. *J. Bus. Ventur.* **10** 95–106.

Arrow, K. 1962. Economic welfare and the allocation of resources for invention. *rate Dir. Inven. Act. Econ. Soc. factors*. Princeton University Press, 609–626.

Bagozzi, R., U. Dholakia. 2006. Open source software user communities: A study of participation in Linux user groups. *Manage. Sci.* **52**(7) 1099.

Baron, R. M., D. A. Kenny. 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *J. Pers. Soc. Psychol.* **51**(6) 1173.

Brewer, M. 1991. The social self: On being the same and different at the same time. *Personal. Soc. Psychol. Bull.*

Brewer, M. B., W. Gardner. 1996. Who is this“ We”? Levels of collective identity and self representations. *J. Pers. Soc. Psychol.* **71**(1) 83.

Brockhaus, R., P. Horwitz. 2002. The psychology of the entrepreneur. N. Krueger, ed. *Entrep. Crit. Perspect. Bus. Manag.* Routledge.

Brockner, J. 1992. The escalation of commitment to a failing course of action: Toward theoretical progress. *Acad. Manag. Rev.* **17**(1) 39–61.

Cardon, M., J. Wincent, J. Singh, M. Drnovsek. 2009. The nature and experience of entrepreneurial passion. *Acad. Manag. Rev.* **34**(3) 511–532.

Chen, B. 2009. Jailbreakers Battle Apple for Control of iPhone. *Wired*.

Choi, Y., D. Shepherd. 2004. Entrepreneurs’ Decisions to Exploit Opportunities. *J. Manage.* **30**(3) 377–395.

Crowston, K., K. Wei, J. Howison, A. Wiggins. 2012. Free/Libre open-source software development: What we know and what we do not know. *ACM Comput. Surv.* **44**(2) 7.

Dahlander, L., M. W. Wallin. 2006. A man on the inside: Unlocking communities as complementary assets. *Res. Policy* **35**(8) 1243–1259.

Daniel, S., L. Maruping, M. Cataldo, J. Herbsleb. 2011. When cultures clash: Participation in open source communities and its implications for organizational commitment. *ISIC*.

Dobrev, S., W. Barnett. 2005. Organizational roles and transition to entrepreneurship. *Acad. Manag. J.*

Edery, D., E. Mollick. 2009. *Changing the Game: How Video Games are Transforming the Future of Business*. New York, Financial Times Press.

Faraj, S., S. Jarvenpaa, A. Majchrzak. 2011. Knowledge collaboration in online communities. *Organ. Sci.*

Fauchart, E., M. Gruber. 2011. Darwinians, Communitarians, and Missionaries: The Role of Founder Identity in Entrepreneurship. *Acad. Manag. J.* **54**(5) 935.

Franke, N., S. Shah. 2003. How communities support innovative activities: an exploration of assistance and sharing among end-users. *Res. Policy* **32**(1) 157–178.

Franzoni, C., H. Sauermann. 2014. Crowd science: The organization of scientific research in open collaborative projects. *Res. Policy* **43**(1) 1–20.

Frederiksen, L., F. Rullani. 2015. Problem- formulation and problem- solving in self- organized communities: How modes of communication shape project behaviors in the free open- source software community. *Strateg. Manag. J.*

Gans, J., D. Hsu, S. Stern. 2002. When does start-up innovation spur the gale of creative destruction? *RAND J. Econ.* **33**(4) 571–586.

Grégoire, D. A., A. C. Corbett, J. S. McMullen. 2011. The Cognitive Perspective in Entrepreneurship: An Agenda for Future Research. *J. Manag. Stud.* **48**(6) 1443–1477.

Haefliger, S., P. Jäger, G. Von Krogh. 2010. Under the radar: Industry entry by user entrepreneurs. *Res. Policy*.

Harhoff, D., J. Henkel, E. Von Hippel. 2003. Profiting from voluntary information spillovers: how users benefit by freely revealing their innovations. *Res. Policy* **32**(10) 1753–1769.

Hienerth, C. 2006. The commercialization of user innovations: the development of the rodeo kayak industry. *R&D Manag.* **36**(3) 273–294.

Hienerth, C., E. Von Hippel, M. Berg Jensen. 2013. User community vs. producer innovation development efficiency: A first empirical study. *Res. Policy* **43**(1) 190–201.

Himanen, P., L. Torvalds, M. Castells. 2002. *The Hacker Ethic*. Random House.

Von Hippel, E. 2005. *Democratizing innovation*. the MIT Press.

Von Hippel, E., G. Von Krogh. 2003. Open source software and the "private-collective" innovation model: Issues for organization science. *Organ. Sci.* **14**(2) 209–223.

Hoang, H., J. Gimeno. 2010. Becoming a founder: How founder role identity affects entrepreneurial transitions and persistence in founding. *J. Bus. Ventur.*

Hogg, M., D. Terry, K. White. 1995. A tale of two theories: A critical comparison of identity theory with social identity theory. *Soc. Psychol. Q.*

Hurst, E., B. Pugsley. 2010. The Non Pecuniary Benefits of Small Business Ownership. *Univ. Chicago, Work. Pap.*

Jain, S., G. George, M. Maltarich. 2009. Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. *Res. Policy*.

Jeppesen, L., L. Frederiksen. 2006. Why do users contribute to firm-hosted user communities? The case of computer-controlled music instruments. *Organ. Sci.* **17**(1) 45.

Jick, T. D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Adm. Sci. Q.* 602–611.

Jurutka, B. 2009. *Tapulous's Tap Tap Revenge Has Been Downloaded by 1 out of 3 iTunes Application Users*. Reston, VA.

Klepper, S., P. Thompson. 2005. Spinoff entry in high-tech industries: motives and consequences. *Econ. Perspect. Innov. Cambridge …*.

Klepper, S., P. Thompson. 2010. Disagreements and intra-industry spinoffs. *Int. J. Ind. Organ.* **28**(5) 526–538.

Kolvereid, L. 1996. Prediction of employment status choice intentions. *Entrep. Theory Pract.* **21**(1) 47.

Krazit, T. 2007. Apple: 250,000 iPhones bought to Unlock. *CNet News*.

Kriauciunas, A., A. Parmigiani, M. Rivera-Santos. 2011. Leaving our comfort zone: Integrating established practices with unique adaptations to conduct survey-based strategy research in nontraditional contexts. *Strateg. Manag. J.* **32**(9) 994–1010.

Von Krogh, G., S. Haefliger, S. Spaeth, M. W. Wallin. 2012. Carrots and rainbows: Motivation and social practice in open source software development. *Mis Q.* **36**(2) 649–676.

Von Krogh, G., E. von Hippel. 2006. The promise of research on open source software. *Manage. Sci.* **52**(7) 975.

Krueger, N., M. Reilly, A. Carsrud. 2000. Competing models of entrepreneurial intentions. *J. Bus. Ventur.* **15**(5) 411–432.

Lakhani, K., R. G. Wolf. 2005. Why hackers do what they do: Understanding motivation and effort in free/open source software projects. J. Feller, ed. *Perspect. Free Open Source Softw.* Cambridge, MA.

Lepak, D. P., K. G. Smith, M. S. Taylor. 2007. Introduction to special topic forum: Value creation and value capture: a multilevel perspective. *Acad. Manag. Rev.* **32**(1) 180–194.

Lerner, J., J. Tirole. 2002. Some simple economics of open source. *J. Ind. Econ.* **50**(2) 197–234.

Liñán, F., Y. Chen. 2009. Development and Cross-Cultural application of a specific instrument to measure entrepreneurial intentions. *Entrep. Theory Pract.* **33**(3) 593–617.

Mathias, B. D., D. W. Williams. 2014. The Impact of Role Identities on Entrepreneurs' Evaluation and Selection of

Opportunities. *J. Manage.* 0149206314544747.
McMullen, J. S., D. Shepherd, A. Shepherd. 2006. Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. *Acad. Manag. Rev.* **31**(1) 132.
Meyer, P. 2007. Network of Tinkerers: A Model of Open-Source Technology Innovation. *BLS Work. Pap. No. 413*.
Mollick, E. 2005. Tapping into the underground. *MIT Sloan Manag. Rev.* **46**(4) 21.
Mollick, E. 2014. The Dynamics of Crowdfunding: Determinants of Success and Failure. *J. Bus. Ventur.* **29**(1) 1–16.
Murnieks, C. Y., E. Mosakowski, M. S. Cardon. 2014. Pathways of Passion Identity Centrality, Passion, and Behavior Among Entrepreneurs. *J. Manage.* **40**(6) 1583–1606.
O'Mahony, S. 2003. Guarding the commons: how community managed software projects protect their work. *Res. Policy* **32**(7) 1179–1198.
O'Mahony, S., F. Ferraro. 2007. The emergence of governance in an open source community. *Acad. Manag. J.* **50**(5) 1079–1106.
O'Mahony, S., K. R. Lakhani. 2011. *Organizations in the shadow of communities*. Emerald Group Publishing Limited.
Poetz, M., M. Schreier. 2012. The value of crowdsourcing: can users really compete with professionals in generating new product ideas? *J. Prod. Innov. Manag.* **29**(2).
Powell, E., T. Baker. 2014. It's what you make of it: founder identity and enacting strategic responses to adversity. *Acad. Manag. J.*
Preacher, K. J., A. F. Hayes. 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav. Res. Methods* **40**(3) 879–891.
Puranam, P., O. Alexy, M. Reitzig. 2014. What's" new" about new forms of organizing? *Acad. Manag. Rev.* **39**(2) 162–180.
Randel, A., K. Jaussi. 2003. Functional Background Identity, Diversity, and Individual Performance in Cross-Functional Teams. *Acad. Manag. J.* **46**(6) 763–774.
Raymond, E. S. 2001. *The cathedral and the bazaar: musings on Linux and open source by an accidental revolutionary*. O'Reilly & Associates, Inc. Sebastopol, CA, USA.
Rogers, E. M. 2010. *Diffusion of innovations*. Simon and Schuster.
Schumpeter, J. 1942. *Capitalism, Socialism and Democracy*. Harper.
Scott Morton, F. M. S., J. M. Podolny. 2002. Love or Money? The Effects of Owner Motivation in the California Wine Industry. *J. Ind. Econ.* **50**(4) 431–456.
Shah, S. 2006. Motivation, governance, and the viability of hybrid forms in open source software development. *Manage. Sci.* **52**(7) 1000–1014.
Shah, S. K., M. Tripsas. 2012. When Do User Innovators Start Firms? A Theory of User Entrepreneurship, Revolutionizing Innovation: Users, Communities and Open Innovation.
Shah, S., M. Tripsas. 2007. The accidental entrepreneur: The emergent and collective process of user entrepreneurship. *Strateg. Entrep. J.* **1**(1) 123–140.
Shane, S., S. Venkataraman. 2000. The Promise of Entrepreneurship as a Field of Research. *Acad. Manag. Rev.* **25**(1) 217–226.
Stallman, R. 1992. Why software should be free.
Staw, B. M. 1981. The escalation of commitment to a course of action. *Acad. Manag. Rev.* **6**(4) 577–587.
Stern, S. 2004. Do scientists pay to be scientists? *Manage. Sci.* **50**(6) 835–853.
Stets, J., P. Burke. 2000. Identity theory and social identity theory. *Soc. Psychol. Q.*
Stryker, S., P. J. Burke. 2000. The past, present, and future of an identity theory. *Soc. Psychol. Q.* 284–297.
Stuart, T., W. Ding. 2006. When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in Academic Life Sciences. *Am. J. Sociol.* **112**(1) 97–144.

Tajfel, H. 1982. Social psychology of intergroup relations. *Annu. Rev. Psychol.* **33**(1) 1–39.

Tajfel, H., J. C. Turner. 1986. The social identity theory of intergroup behavior. G. Austin, S. Worchel, eds. *Psychol. Intergr. Relations*. Nelson- Hall, 7–24.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Res. Policy* **15**(6) 285–305.

Terry, D. J., M. A. Hogg, K. M. White. 1999. The theory of planned behaviour: self-identity, social identity and group norms. *Br. J. Soc. Psychol.* **38**(3) 225–244.

Wall, D. 2005. *Babylon and beyond: the economics of anti-capitalist, anti-globalist and radical green movements*. Pluto Press.

Figure 1: Outcomes of App Store Launch

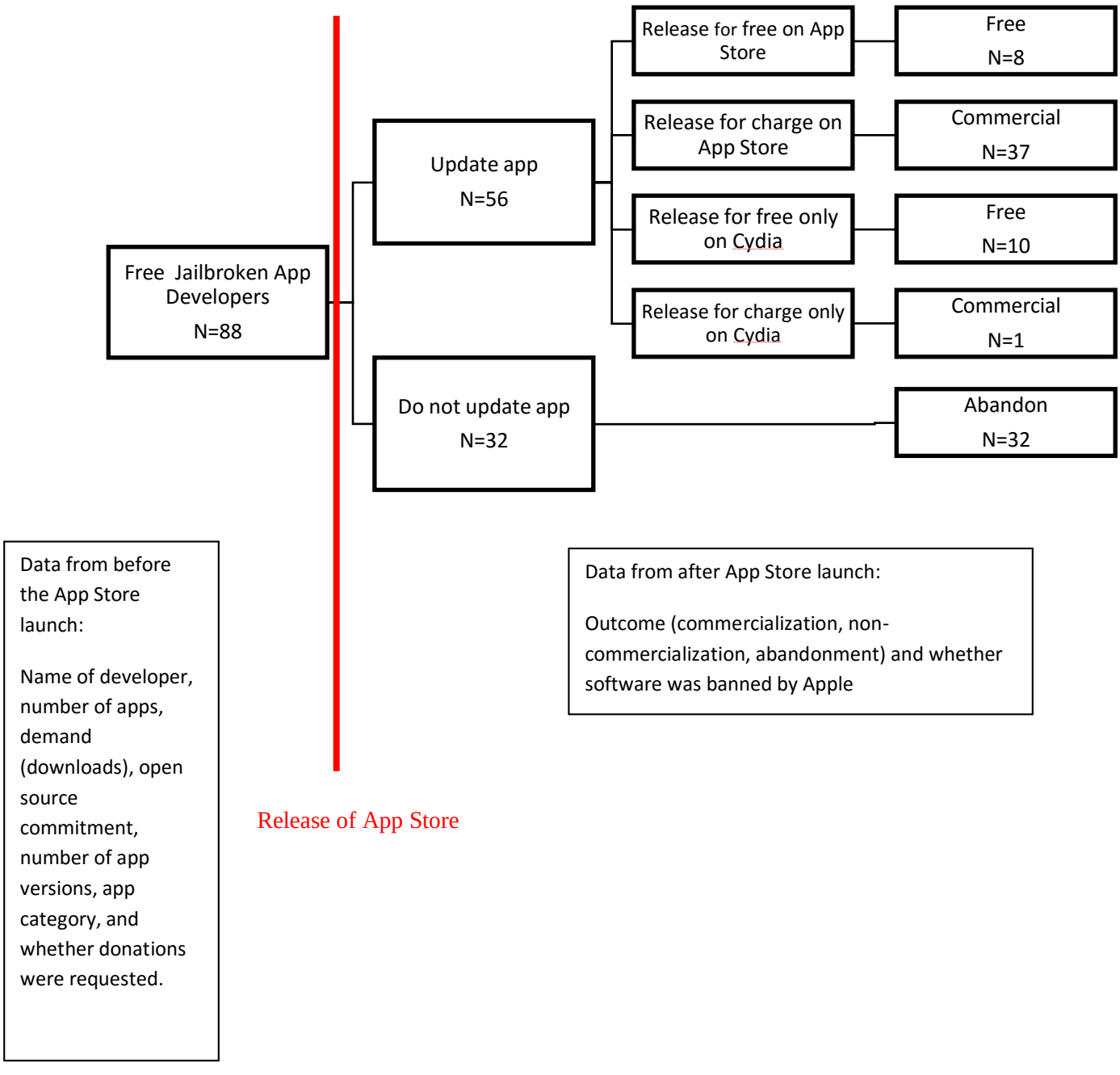

Table 1. Summary Statistics by Developer for Quasi-Experiment

	Abandoned	Commercial	Free
VARIABLES			
Observations	32	38	18
N Apps	1.188	2.500	1.500
	(0.471)	(4.329)	(1.425)
Commitment	3.609	5.509	3.008
	(4.130)	(5.067)	(2.995)
Market Interest	428,023	538,349	538,421
	(349,986)	(485,411)	(812,888)
Opensource	0.563	0.259	0.528
	(0.504)	(0.415)	(0.499)
Games	0.0469	0.184	0
	(0.195)	(0.393)	(0)
Banned	0.0938	0.158	0.389
	(0.296)	(0.370)	(0.502)
Donationware	0.203	0.213	0.0833
	(0.399)	(0.405)	(0.257)

Notes: Observations at the developer level. Commercializing any application is coded as Commercial, updating at least one app while keeping all apps free of charge coded as Free, and abandoning all apps is coded as Abandon. Means are shown in the first line, SDs in parentheses below.

Table 2. Correlation Table by Developer for Quasi-Experiment

	Commercial	Apps	Versions	lInterest	Opensource	Game	Ban
Commercial	1						
N Apps	0.07	1					
Commitment	0.05	-0.02	1				
L(Market Interest)	0.02	0.07	0.24	1			
Opensource	-0.10	-0.14	0.07	0.11	1		
Games	-0.02	-0.06	0.23	0.13	-0.12	1	
Banned	0.25	0.25	-0.02	0.12	0.11	-0.14	1
Donationware	-0.08	-0.05	0.17	0.08	-0.08	0.21	-0.12

Table 3: The Impact of Open Source Affiliation and Other Factors on the Decision of Developers to Commercialize Any Applications

	Multinomial Logit Estimates †			Change in Predicted Probabilities‡		
	Commercial versus Abandon	Free versus Abandon	Free versus Commercial	Abandon	Free	Commercial
Opensource	0.222**	0.765	3.453*	.34	.01	-.35
	(0.136)	(0.522)	(2.535)			
N Apps	2.138*	1.666	.780	-.54	-.02	.56
	(0.863)	(0.729)	(0.205)			
Commitment	1.144*	1.011	.884	-.43	-.02	.46
	(0.0825)	(0.118)	(0.100)			
l(Market Interest)	1.110	0.358	.322	-.02	-.08	.103
	(0.694)	(0.264)	(0.253)			
Games	5.382	0	0	-.21	-.22	.44
	(5.936)	(0.00)	(0.00)			
Banned	1.444	7.481**	5.18**	-.11	.08	.03
	(1.295)	(6.233)	(4.223)			
Donationware	0.322	0.436	1.355	.27	-.01	-.27
	(0.288)	(0.484)	(1.65)			
Constant	0.224	62.82	280			
	(0.761)	(240.3)	(1150.28)			
N		88				
chi2		37.35				
p		0.000				
Pseudo R^2		0.201				

Notes: Models at the developer level, where commercializing any application is coded as Commercial, updating at least one app while keeping all apps free of charge coded as Free, and abandoning all apps is coded as Abandon.

† Top entries are exponentiated multinomial logit coefficients (Relative Risk Ratios) comparing odds of the first outcome to that of the second. Standard errors in parentheses.

‡ Change in the predicted probability of each outcome from an increase of the minimum to the maximum of each independent variable, while holding all other variables constant at their means.

*, ** and *** refer to significance at the 10%, 5% and 1% respectively.

Table 4: Likelihood of commercialization by app, for individuals who commercialized at least one app

Commitment	1.393***
	(0.156)
l(Market Interest)	6.910***
	(4.543)
Opensource	0.263*
	(0.187)
Games	0.520
	(0.467)
N	47
chi2	14.35
p	0.006
Pseudo R^2	0.224

Notes: Results are exponentiated multinomial logit coefficients predicting the chance of an app being commercialized. The sample is limited to apps created by those developers who commercialized at least one app. Errors are clustered by developer. *, ** and *** refer to significance at the 10%, 5% and 1% respectively.

Table 5: Summary Statistics and Correlations for Longitudinal Survey

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1 Commercialized	0.32	0.47	1										
2 Disutility: Time1	1.7	0.7	0	1									
3 Disutility: Time2	2.66	1.15	0.05	0.17	1								
4 OSS Identity	3.02	0.91	-0.15	-0.13	-0.02	1							
5 IP: Hard to make money	2.33	1	-0.17	0.05	0.05	-0.02	1						
6 IP: Easy to copy OSS	2.62	0.88	-0.21	-0.06	0.06	0.04	0.4	1					
7 IP: Worry about legal	2.46	1.1	-0.07	0.09	-0.14	-0.06	0.26	0.2	1				
8 Previous Entrepreneur	0.64	0.48	0.41	0.03	-0.03	0.04	-0.04	-0.02	0.06	1			
9 Female	0.04	0.2	0.12	0.03	0.1	0.03	0.1	0.04	-0.24	-0.02	1		
10 Worked in Tech	0.58	0.49	-0.05	-0.07	-0.06	-0.17	0.02	-0.04	0.02	0.04	0.01	1	
11 Student at T1	0.09	0.28	0.03	0.14	0.19	0.15	0.15	-0.06	-0.05	0	0.08	-0.37	1
12 Self Employed Propensity	3.82	1.92	0.16	-0.02	-0.06	-0.16	-0.1	0.11	0.15	0.08	0.04	0.14	-0.07

Table 6. Longitudinal Survey Regression Results

VARIABLES	(1)	(2)	(3)	(4)
	Commercialized			
Disutility: Time1		-0.16		-0.24
		(0.377)		(0.385)
Disutility: Time2		0.22		0.34
		(0.244)		(0.265)
OSS Identity			-0.71**	-0.72**
			(0.280)	(0.296)
IP: Hard to make money	-0.09	-0.26	-0.24	-0.06
	(0.318)	(0.297)	(0.319)	(0.377)
IP: Easy to copy OSS	-0.88**	-0.69**	-0.69**	-1.05***
	(0.352)	(0.327)	(0.324)	(0.376)
IP: Worry about legal	-0.21	0.04	-0.08	-0.20
	(0.236)	(0.230)	(0.231)	(0.266)
Previous Entrepreneur	3.37***	3.07***	3.22***	3.85***
	(0.756)	(0.615)	(0.630)	(0.836)
Female	1.88	2.15**	2.68**	2.21*
	(1.173)	(0.969)	(1.056)	(1.151)
Worked in Tech	-0.82	-0.34	-0.50	-1.11*
	(0.559)	(0.542)	(0.589)	(0.599)
Student at T1	-0.95	-0.69	-0.40	-0.94
	(1.078)	(0.892)	(0.968)	(0.950)
Self Employed Propens.	0.35**			0.39**
	(0.157)			(0.160)
Year FE	-0.09	YES	YES	YES
Education FE	(0.318)	YES	YES	YES
Constant	-0.59	-0.22	2.34	0.93
	(1.405)	(1.538)	(1.730)	(1.976)
Observations	125	125	125	125
(Pseudo)R-squared	0.303	0.275	0.304	0.348
chi2	38.08	40.19	40.63	33.39
p	0.00	0.00	0.00	0.02

Notes: Models 1-4 are the results of logistic regressions, where the dependent variable is an indicator variable that takes the value of 1 if survey participant has engaged in an entrepreneurial venture or independent contracting since the first wave of the survey. All models include year and education level fixed effects. Robust standard errors are given in parentheses. *, ** and *** refer to significance at 10%, 5% and 1% respectively.