Investigating open source software creators through the lens of an entrepreneur

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Abstract: The purpose of our research is to explore the characteristics of the creators of open source software (OSS) and to determine if there is a connection between OSS creators and entrepreneurs. We begin with a review of the literature on OSS and entrepreneurship, and then develop a conceptual model that seeks to define what it means to be an entrepreneur. We use the conceptual model as a lens to examine if OSS creators can be classified as entrepreneurs via an exploratory multiple-case research approach based on OSS projects found in the SourceForge repository. Our study establishes an association between the characteristics of an OSS creator and an entrepreneur.

Keywords: innovation; case study; open source software; OSS; open innovation.


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1 Introduction

Open source software (OSS) has emerged as an innovative and creative force in the global software industry. Once considered a hobby or an underground activity for ‘programming geeks’, OSS has emerged as a successful approach for developing rigorous and commercially viable software products challenging the basic ground rules associated with proprietary software development (Fitzgerald, 2006). The Gartner Group estimates that by the end of 2015 at least 85% of all commercial software products will include OSS (Driver, 2013) and that by 2016 at least 95% of all IT organisations will include OSS in their mission critical portfolios (Driver, 2012).

The rise and acceptance of OSS development has sparked a stream of research that has investigated the factors that determine why people dedicate their time and expertise in developing software that can be freely used, changed, and shared. As of 2012, no fewer than 40 papers had been published on the factors that motivate OSS developers (von Krogh et al., 2012). Interestingly, the prior literature has focused little on the characteristics associated with the creators of OSS projects. This is surprising because there is a substantial history of OSS software creators achieving notable success. For example, Linus Torvalds, the creator of Linux, is well paid by the Linux Foundation to oversee Linux development and has reportedly received approximately $1 million in stock from Red Hat (McMillan, 2012), and in 2004 was named by Time Magazine as one of the most influential people in the world (Lessig, 2004). Michael Widenius, the primary creator of MySQL, profited significantly from the 2008 sale of MySQL to Sun Microsystems for a reported $1 billion, has since created MariaDB (Ricknas, 2009) and sits on the Board of Directors for SkySQL. Marc Andreessen, co-author of the first widely used web browser (Mosaic now the open source browser Mozilla Firefox), which in 1995 was worth $2.9 billion, has become a successful Silicon Valley entrepreneur who has backed successful companies such as Twitter, Skype, Groupon, Instagram and Airbnb (Anderson, 2012). In light of these examples, the economic and professional success of Torvalds, Widenius and Andreessen raises many intriguing questions about the characteristics of OSS creators and sparked our interest in exploring the relationship between OSS creators and entrepreneurs.
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Today entrepreneurs are viewed as catalysts for the modern economy through job creation and business growth (Shane et al., 2003). The information technology (IT) industry is a major area where economic growth and entrepreneurship remain vital to the success of the global economy. Global output from IT more than doubled from $1.2 trillion in 1995 to $2.8 trillion in 2010 accounting for 6% of the global gross domestic product (National Science Board, 2012). The software industry is noteworthy for its ability to promote individual innovation and entrepreneurship. For example, Google has created initiatives to encourage an entrepreneurial atmosphere and a ‘20% time’ policy which allows technologists to pursue innovative pet projects (Savoia and Copeland, 2011). Rackspace, an IT hosting company with a large application development division, launched a program to support new technology start-ups through free hosting and business mentoring (Lee, 2012). As a result, scholars studying the software industry have identified the importance of the ‘software creation industry’ (Messerschmitt and Szyperski, 2005) and the significance of effective business models in sustaining software firms (Popp and Meyer, 2010).

While many studies exist that examine OSS developers and communities (Elliott and Scacchi, 2008; Iivari, 2009), the relationship between entrepreneurs and individual OSS creators has received little attention. On one end of the spectrum, some research suggests that the people who devote their time and expertise to creating OSS software are altruists primarily motivated by a desire to help the greater good of society (Baytiyeh and Pfaffman, 2010) and by the need for “scratching a developer’s personal itch” [Raymond, (1999), p.32]. Although we are interested in these assertions, we are led to posit that at the core of an individual OSS creator lies an entrepreneur. Thus, this paper examines the OSS creator through the lens of an entrepreneur as a first effort to identify relationships and constructs for further research. Establishing such a link would certainly add value to the notion that OSS development plays a critical role in the fulfilment of the demand for reliable, rapidly available software necessary to support an organisation’s ability to agility respond to business opportunities.

To properly investigate possible linkages between OSS creators and entrepreneurs, we begin with a review of the literature on OSS and entrepreneurship, and then develop a conceptual model that seeks to define what it means to be an entrepreneur. We then use this model as a conceptual lens to examine OSS creators via an exploratory study of popular OSS projects found in the SourceForge repository. We conclude with a discussion of the purpose and meaning of our findings from both a practical and theoretical stance.

2 Literature review

The conceptual marriage of entrepreneurship and OSS is not new. A classic example would be the partnership between Sun Microsystems and Java which promotes institutional entrepreneurship through the sponsorship of common technological standards (Garud et al., 2002). Additionally, a number of research efforts have been conducted that study OSS and entrepreneurship together. For example, Piva et al. (2012) explored whether or not entrepreneurial ventures gain innovative value from working with various OSS communities. Savoia and Copeland (2011) studied the innovative value gained at Google by fostering an entrepreneurial spirit. Riehle (2007) studied the economic motivation of OSS stakeholders. Piva and Rossi-Lamastra (2012) studied
whether or not the OSS movement has created new forms of entrepreneurship. However, none of these efforts study the role of the individual OSS creator nor do they address whether or not an OSS developer at the individual-level has any relationship to that of an entrepreneur.

To provide a proper basis to address our study, this literature review will first examine the OSS research stream in more detail. We then examine the entrepreneurship literature and create a conceptual model that we will use as an instrument for discovery.

2.1 Open source software

Open source is a software development method that provides participants the ability to ‘freely’ read, modify, and redistribute the source code. The Open Source Initiative (OSI) provides an updated open source definition that includes information about: source code guidelines, distribution guidelines, derived works, integrity of the author’s source code, anti-discriminatory policies, and licensing issues (Open Source Initiative, 2014). According to OSI, the promise of open source is better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in.

The open source phenomenon has been widely investigated by researchers from varying disciplines using several different methodologies. To organise this research, von Krogh and von Hippel (2006) proposed a framework that consisted of three areas of research. These research areas included:

1. governance, organisation and the innovation process
2. competitive dynamics
3. motivations of contributors.

The first area provides research that includes: governance of project architecture to prevent ‘forking’; functioning of various organisations in open source projects; and coordination of innovation. The second area provides research that includes: impact of OSS on competition; hybrid strategies for melding commercial and open source platforms; and relationships between firms and OSS projects. Finally, the third area provides research that includes: individual incentives, impact of enterprise and community participation on individual motives; and relationships between incentives and technical design.

2.2 OSS creators

While the prior literature on OSS developers and contributors is extensive (Fosfuri et al., 2008; von Krogh et al., 2012), we found a very small amount of literature that directly considers the OSS creator. von Hippel and von Krogh (2003) describe the role of the person(s) who create an OSS project, but largely ignore the importance of the creator in the development of their innovation model. Bonaccorsi et al. (2006) and Kogut and Metiu
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(2001) examine the business and innovation models associated with OSS start-ups but ignore the OSS project creators. Rizk (2012) sees OSS creators as a catalyst for the development of human capital through the creation of business value. In fact, only Piva and Rossi-Lamastra (2012) explicitly consider the characteristics of the OSS creator (average age of firm founders) in their study of OSS firm success. Hence, we posit that a greater focus on the OSS creator as an actor is needed in the literature stream. Past research provides little or no evidence that entrepreneurship is a motivating factor for OSS developers. However, prior studies are based on OSS development communities and do not specifically look at the individual creators of specific OSS projects. Thus, we concluded that rather than concentrating on intrinsic factors that tend to generalise to the community-level, our research should focus on studying the external characteristics of the OSS creator as an individual.

2.3 What is an entrepreneur?

Shane and Venkataraman (2000) state that entrepreneurship involves the nexus of two phenomena that include the presence of lucrative opportunities and the presence of enterprising individuals. In their attempt to provide a conceptual framework, they define the field of entrepreneurship as “the scholarly examination of how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and exploited.” They go on to state that the field “involves the study of sources of opportunities; the processes of discovery, evaluation, and exploitation of opportunities; and the set of individuals who discover, evaluate, and exploit them”.

Bruyat and Julien (2001) define entrepreneurship as the “dialogic between individual and new value creation, within an ongoing process and within an environment that has specific characteristics”. They indicate that the phenomenon of entrepreneurship cannot be understood if we are unable to define what an entrepreneur is, the types of opportunities that lead to value and the back and forth influence of the individual and resulting environment. Dobni (2012) contributes to the discussion by stating that an entrepreneur is “an individual or group of people who are risk takers and employ their own (or leveraged) capital to develop new ventures”.

Because this research is focused on individual OSS creators, our focus is on defining the term entrepreneur. Bygrave and Hofer (1991) define an entrepreneur as “someone who perceives an opportunity and creates an organization to pursue it”. Churchill (1992) defines an entrepreneur as someone who “uncovers and develops an opportunity to create value through innovation”. And Shane et al. (2003) indicate that this value creation is developed via rearranging and organising resources (creating a business model) and sustained through market-making and product-development activities.

Figure 1 provides a conceptual lens grounded from our analysis of the entrepreneurship literature. As shown in Figure 1, an entrepreneur is someone who recognises an opportunity to create value through innovation, organises resources to pursue this opportunity and attempts to create and follow some type of strategy or business model to sustain this value over time.
3 Methodology

The study of OSS project creators through the lens of the entrepreneur is novel. Thus, we sought a research methodology where the OSS creator could be identified and where the characteristics associated with these creators and their associated projects could be collected and analysed. Bruyat and Julien (2001) stress the importance of considering the individual entrepreneur and their associated project when seeking to understand an entrepreneurial event. Our study is based on a comparative analysis of the OSS project creators that have met a baseline measure of success. We seek to identify key characteristics associated with these creators across multiple OSS projects and to lay a foundation for determining if the creator of an OSS project can correctly be classified as an entrepreneur. More specifically we view multiple OSS creators through three entrepreneurial dimensions as shown in Figure 1:

1. opportunity
2. organisation
3. business model.

An important starting point was a review of the literature on entrepreneurs and their role in software development and the open source movement. The scope of our review included research on the definition and characteristics of the entrepreneur and on the stakeholders that contribute to OSS projects. This helped us build the foundation needed to identify the characteristics of an entrepreneur and to understand how these
characteristics are manifested in OSS projects. Subsequently, we discussed the suitability of exploring multiple case studies as an appropriate research method. The purpose of the case study is to identify key characteristics associated with these creators across multiple OSS projects and to lay a foundation for determining if the creator of an OSS project can correctly be classified as an entrepreneur. Based on foundational material in the prior literature, we use both organisational and value-creation characteristics when comparing OSS creators. Comparative analysis of cases can be useful to generate new understanding of not yet well-understood topic (Miles and Huberman, 1994; Yin, 2012). Case-based research allows investigators to understand the nature and complexity of the entity being examined and serves as a basis for theory building. We adopted the general principles of theory building through case study research (Eisenhardt, 1989; Yin, 2012). Hence, we adopted an exploratory multiple-case research strategy as elaborated in Yin (2012).

Online documentation and archival records were the primary source of data in this study. Following the principles of case study research, a protocol was developed that included not only the research question but also the procedures to be used by the investigators and overview of the case study project (Yin, 2012). Each data collection session started with a review of the purpose of the research and a checklist of procedures and documentation methods. The checklist of procedures and documentation methods contained steps for identifying and documenting the characteristics of the OSS project and next, steps for determining and documenting the OSS project creator(s).

A data source was required that would provide a reliable, diverse set of OSS projects from different industries, user groups and nations. In addition, these project characteristics included data about the developer community needed to be readily available. As a result, SourceForge, a web-based OSS repository, was selected as the primary data source. In SourceForge software developers are able to access centralised tools for managing OSS projects in a global, online environment. SourceForge exposes projects to a large pool of potential users and developers. As of March 2014 SourceForge enabled over 3.7 million developers create over 430,000 OSS projects. SourceForge estimates that over 46 million users of their open source projects and there are typically more than 4,000,000 downloads from their site each day. It should be noted that identifying OSS projects and their characteristics in SourceForge is a relatively simple task that required relatively little knowledge or skill. However, the steps in identifying the OSS creator required a bit of detective work. For example, the SourceForge repository lists the current project administrators (leaders) and the date that the project was initially registered in SourceForge. However, SourceForge does not identify the original person(s) that created the project and does not indicate if the OSS project was created at the time it was initially registered in SourceForge. Thus, a systematic protocol was created for the investigator to identify the project creator.

The protocol for identifying the OSS project creator consisted of three steps. First, the username of each current OSS project maintainer was identified in SourceForge. Whenever possible, personal identities were determined and personal web pages were discovered and recorded. Evidence for linking the OSS project maintainer to OSS project creation was then collected. Second, non-SourceForge websites associated with the OSS project were identified and searched for evidence of the individuals responsible for the creation of the OSS project. These websites included both the .com and .org websites directly associated with the OSS project. In addition, they included a search of journalistic sites affiliated with the computer industry. Finally, the search included online
encyclopedia resources such as Wikipedia and Webopedia. In other words, exhaustive attempts were made to verify OSS project creators through multiple sources.

Due to the relatively ad-hoc nature of the protocol for identifying the OSS project creator, two independent investigators were deployed. Specifically, two student workers were independently given the search protocol and asked to collect OSS project data and identify the OSS project creator(s) for 50 SourceForge projects. Consistent results were found for 45 out of the 50 projects. A third investigator, one of the project authors, researched the five inconsistences and resolved any data collection issues.

The data collected consisted of:

1. creator characteristics
   a. current association with project
   b. current administration of project
   c. current employment by organisation associated with project

2. opportunity characteristics
   a. product description
   b. year made open source
   c. year created
   d. project type
   e. multi-lingual support

3. organisational mechanisms to engage external participants
   a. bug tracking enabled
   b. project wiki enabled

4. business model attributes
   a. profit or non-profit
   b. domain type for project website
   c. revenue model.

Our protocol required that each OSS project meet a minimum baseline of success. As a result we wanted a representative sample of projects with

1. high development activity
2. high user activity
3. at least three years of activity in SourceForge
4. a recognised OSS license.

Considering only highly ranked projects eliminates the possibility of considering rogue projects with little traction in the OSS community. Ultimately data was collected on the 50 highest ranked OSS software projects on Sourceforge.net where ‘project rank’ is
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assessed directly by Sourceforge.net based on traffic, communication, and development statistics collected for each project. It should be noted that this ranking is not meant to be an indicator of the quality, maintenance, or stability of any particular project. Additionally, high ranking projects benefit by being included in the SourceForge.net ‘top projects’ listing and are moved toward the top of the listings for project searches on SourceForge.net.

Two independent examiners were used in the data collection phase. Determining the OSS project creator(s) and their relationship to the OSS project during data collection sometimes resulted in an interpretative scenario. The investigators approached the data collection with an open mind and attempted to maintain an unbiased view so that any contradictory evidence would not be missed. Following Eisenhardt’s (1989) recommendations to improve validity of the results, one of the investigators remained independent of the original data collection efforts in order to assess the initial findings of the interviewing team. At the conclusion of the data collection phase, one of the authors was responsible for cross-examining and triangulating the data from the two data collectors. When inconsistencies were detected between the two data collectors, a third review was made and inconsistencies were resolved. The goal was to treat all the evidence fairly with adequate considerations for alternative interpretations and to produce analytic conclusions consistent with an exploratory research project. The details of the analysis of evidence are presented in the subsequent sections.

4 Findings

The purpose of our research is to explore the characteristics of OSS creators through the lens of an entrepreneur. Via a substantial literature review, a grounded conceptual framework was established and provided insight on the data required for this exploration. Thus, this section will provide the findings that identify creators and the attributes of an entrepreneur on three dimensions (opportunity, organisation, business model).

4.1 Creator

Elliott and Scacchi (2008) distinguish between core maintainer, module owner, software developer, project leader, lead programmer and contributor. In our case the OSS creator is defined as the person or persons who developed the original code that initiated the software project. Our analysis of 50 successful OSS projects revealed 56 individuals who could be positively identified as a project creator (see Table 1). In four instances, the creators could only be identified as a team of individuals with no individual attribution. In addition, one creator could only be identified through an alias and in another case the creator was unidentifiable.

The relationship of the OSS creator to the OSS project was varied. In 78% of the cases at least one OSS creator was still associated with the OSS project at the time of the study. In 70% of the cases at least one creator was still serving as project administrator at the time of the study. However, in only 28% of the cases at least one creator currently had employment connected to the OSS project that they created.
<table>
<thead>
<tr>
<th>OSS project name</th>
<th>Description</th>
<th>Creator(s)</th>
<th>Year created</th>
<th>Profit/non-profit</th>
<th>Business model</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZK – Simply Ajax and Mobile</td>
<td>Web application framework for creation of GUI for web applications</td>
<td>Tom Yeh, Henri Chen</td>
<td>2005 (early 1990s)</td>
<td>Profit</td>
<td>Product-enhanced</td>
</tr>
<tr>
<td>xVideoServiceThief</td>
<td>Tool for downloading video and converting to new formats</td>
<td>Unknown</td>
<td>2007</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>webERP web-based ERP</td>
<td>Open source ERP system for small and medium-sized enterprises</td>
<td>Phil Daintree</td>
<td>2003</td>
<td>Profit</td>
<td>Services-partners</td>
</tr>
<tr>
<td>DeSmuME</td>
<td>Nintendo DS emulator</td>
<td>YopYop156 (alias)</td>
<td>2006</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Mumble</td>
<td>Allows users to talk to each other via the same server</td>
<td>Thorvald Natvig</td>
<td>2005</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>OrangeHRM</td>
<td>Human resource management (HRIS) software</td>
<td>D. Saparamadu, S. Saparamadu</td>
<td>2005</td>
<td>Profit</td>
<td>Services-commercial</td>
</tr>
<tr>
<td>Bochs x86 PC emulator</td>
<td>x86 and x86-64 IBM PC compatible emulator and debugger</td>
<td>Kevin Lawton</td>
<td>2000 (1994)</td>
<td>Non-profit</td>
<td>Product-sold</td>
</tr>
<tr>
<td>FreeCol</td>
<td>Turn-based strategy game based on PC game colonisation</td>
<td>Lars Willemsens</td>
<td>2003</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>OSS project name</td>
<td>Description</td>
<td>Creator(s)</td>
<td>Year created</td>
<td>Profit/non-profit</td>
<td>Business model</td>
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<tr>
<td>Audacity</td>
<td>Cross-platform software for recording and editing sounds.</td>
<td>Dominic Mazzoni, Roger Dannenberg</td>
<td>2000</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Fink</td>
<td>Software to port and package open-source Unix programs to Mac OS X</td>
<td>Christoph Pfisterer</td>
<td>2001 (2000)</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>ffdshow tryouts</td>
<td>Codec mainly used for decoding video and audio files</td>
<td>Milan Curka, Peter Ross</td>
<td>2006 (2002)</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>aTunes</td>
<td>Audio player</td>
<td>Alex Aranda</td>
<td>2006</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>KeePass Password Safe</td>
<td>Light-weight password management utility software</td>
<td>Dominik Reichl</td>
<td>2003</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>SW Test Automation</td>
<td>Create and manage automated testcases and test environments</td>
<td>Team of developers (IBM)</td>
<td>2001 (1998)</td>
<td>Non-profit</td>
<td>Services-partners</td>
</tr>
<tr>
<td>TinyMCE</td>
<td>Web-based JavaScript/HTML WYSIWYG editor control</td>
<td>Team of developers (MoxieCode)</td>
<td>2004</td>
<td>Product-enhanced</td>
<td></td>
</tr>
<tr>
<td>phpGEDView</td>
<td>Web application for working with genealogy data on the internet</td>
<td>John Finlay</td>
<td>2002</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>XBMC Media Center</td>
<td>Software to play and view media from network storage media</td>
<td>Team of developers (Xbox – Microsoft)</td>
<td>2002 (2000)</td>
<td>Non-profit</td>
<td>Product-sold</td>
</tr>
<tr>
<td>Gallery</td>
<td>Software for the management and publication of digital media</td>
<td>Bharat Mediratta</td>
<td>2003</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Ariane RPG</td>
<td>Multiplayer online engine to develop turn-based and real time games</td>
<td>Miguel Angel Lardin</td>
<td>2000</td>
<td>Non-profit</td>
<td>None</td>
</tr>
<tr>
<td>devkitPro</td>
<td>Console development tools based on the gnu compiler collection</td>
<td>Dave J. Murphy</td>
<td>2004</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>OSS project name</td>
<td>Description</td>
<td>Creator(s)</td>
<td>Year created</td>
<td>Profit/non-profit</td>
<td>Business model</td>
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</tr>
<tr>
<td>Windows Installer XML (WiX) toolset</td>
<td>Set of tools that builds Windows installation packages</td>
<td>Rob Mensching</td>
<td>2004</td>
<td>Non-profit</td>
<td>Services-partners</td>
</tr>
<tr>
<td>TCPDF-PHP class for PDF</td>
<td>Software for generating PDF documents</td>
<td>Nicola Asuni</td>
<td>2005</td>
<td>Profit</td>
<td>Services-commercial</td>
</tr>
<tr>
<td>FileZilla</td>
<td>Cross-platform FTP application software</td>
<td>Tim Kosse</td>
<td>2001</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Password Safe</td>
<td>Password manager program</td>
<td>Bruce Schneider</td>
<td>2002</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Sweet Home 3D</td>
<td>Architectural design software</td>
<td>Emmanuel Puybaret</td>
<td>2006</td>
<td>Profit</td>
<td>Services-commercial</td>
</tr>
<tr>
<td>Vuze (Azureus)</td>
<td>Client used to transfer files via the BitTorrent protocol</td>
<td>Oliver Chalouhi, Tyler Pitchford</td>
<td>2003</td>
<td>Non-profit</td>
<td>None</td>
</tr>
<tr>
<td>MindTouch Deki</td>
<td>Web platform for collaboration and customer support documentation</td>
<td>Steve Bjorg, Aaron Falkerson</td>
<td>2006</td>
<td>Profit</td>
<td>Product-enhanced</td>
</tr>
<tr>
<td>hugin</td>
<td>Panorama photo stitching and HDR merging program</td>
<td>Pablo d'Angelo</td>
<td>2003</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>OCS Inventory</td>
<td>Software to inventory IT assets</td>
<td>Pascal Danek</td>
<td>2002</td>
<td>Profit</td>
<td>Services-partners</td>
</tr>
<tr>
<td>Linux MultiMedia Studio (LMMS)</td>
<td>Software to produce music</td>
<td>Tobias Doerflie</td>
<td>2004</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
<tr>
<td>Firebird</td>
<td>Relational database management system</td>
<td>Team of developers (Firebird)</td>
<td>2000</td>
<td>(1981)</td>
<td>Services-partners</td>
</tr>
<tr>
<td>Inkscape</td>
<td>Software vector graphics editor</td>
<td>Raph Levien</td>
<td>2003</td>
<td>(1999)</td>
<td>Services-partners</td>
</tr>
<tr>
<td>Process Hacker</td>
<td>Software debugging, malware detection and system monitoring</td>
<td>Wen Jia Liu</td>
<td>2008</td>
<td>Non-profit</td>
<td>Donations</td>
</tr>
</tbody>
</table>
4.2 Opportunity

The entrepreneur is responsible for the process of uncovering and developing an opportunity to create value. For this research the entrepreneur would create such value through the OSS product that they created and freely shared with others. Our analysis revealed the creation of software products in nine different types with the greatest percentage being in programming (24%), media (18%) and networks (14%). Multilingual support was developed for 56% of the projects. Interestingly, 18% of the projects were initiated prior to the launch of SourceForge in 1999 suggesting that sometimes placing software into the open source domain was not an original intent of the creator. An exploratory analysis showed little correlation between age of the project, multi-lingual support and the software type.

4.3 Organisation

In his seminal paper, Gartner (1988) states that organisation creation separates entrepreneurship from other disciplines. Bygrave and Hofer (1991) define an entrepreneur as someone who “perceives an opportunity and creates an organization to pursue it”. De Massis et al. (2012) study the ability of an entrepreneurial organisation to learn through ongoing experimentation. The OSS creator’s organisation is the community of like-minded participants that support the software. Scacchi (2004) describes how community participants (core developers, module owners, administrators, reviewers and end-users) are organised using online collaboration tools such as bug-tracking databases, code repositories, discussion forums, newsgroup postings, and how-to-guides. The OSS creator can then deploy these collaboration tools in different arrangements to facilitate the software development process. We collected data on three mechanisms used to engage and organise external resources (project contributors). First, we determined if the OSS project was using a bugtrack database and then determined this database’s domain. Second, we determined if the OSS project was using a wiki for community collaboration and its associated domain. The domain of the bugtrack database and the wiki give us some indication of the commercial or non-commercial nature of the OSS project.

Our analysis revealed that 94% of the OSS projects organised external resources by using bugtrack databases and 62% of the OSS projects organised external resources by project wikis. Not surprisingly, a high percentage (72%) of the OSS projects used the bugtracking database provided by SourceForge in the .net domain. It should also be noted that many projects did not use a project wiki, but many compensated by creating FAQs and online forums to communicate with end users.

4.4 Business model

Classic economists Robert Turgot and Jean-Bapitiste Say were among the first to distinguish between the entrepreneur and the capitalist (Bruyat and Julien, 2001). Both Turgot and Say were clear in making the connection between the entrepreneur and the development of a new for-profit business. More recent research distinguishes between the ‘business entrepreneur’ and the ‘non-profit entrepreneur’ (Austin et al., 2006). Entrepreneurs seek to sustain their opportunity through planning, deal making and resource mobilisation (von Krogh et al., 2012). In other words, according to some, entrepreneurs must develop a business model.
The notion of a business model in the OSS industry is not new. Bonaccorsi et al. (2006) analyse different entry strategies for OSS software firms through the examination of hybrid business models that deployed various mixes of products, licenses and sources of revenue. Other researchers examining a means to sustain OSS projects include the consideration of commercialisation of OSS (Fosfuri et al., 2008) and the protection of OSS intellectual property through patents (Cockburn and MacGarvie, 2009; Wen et al., 2012).

We define ‘business model’ as the strategy for sustaining value over time. Interestingly we discovered five different business models for OSS projects:

1. donations: gifts from product users
2. product-enhanced: enhanced version of software product for fee
3. product-sold: software product sold to commercial interest
4. services-commercial: firm directly overseeing OSS offers associated services for fee
5. services-partners: multiple firms participating in OSS development offer associated services for fee.

A listing of these business models with the OSS projects and OSS creators is shown in Table 1.

Our research found that donations (50%) were the most popular form of business model, while ‘services-partners’ (20%) was the most popular revenue model for the remainder of the projects. Furthermore, a large percentage (73%) of the for-profit OSS projects had associated .com websites. In addition, our research found that in 22% of the cases, the projects had creators that were in some way directly profiting from the OSS project.

4.5 Business model vs project type

Based on our data analysis, a few trends emerged when comparing revenue models to the type of OSS project. As shown in Table 2, personal software such as ‘media’ and ‘desktop’ tend to be driven by donations. On the other hand enterprise-level projects in ERP and application development (programming) tend to have more sophisticated revenue models.

4.6 Profit/non-profit vs project age

In our study, all OSS projects with one or more associated for-profit businesses were classified as ‘profit’ and all others were classified as ‘non-profit’ (see Table 1). There appears to be a relationship between the age of the project and the business model that sustains the project. In particular, as shown in Table 3, the creator of many of the younger OSS projects (eight years or less) have adopted some type of for-profit strategy to sustain value over time. 72% of the for-profit OSS projects are less than eight years old, while only 21% of the non-profit OSS projects are less than eight years old. This suggests that the consideration of for-profit sustainability models by OSS creators is a relatively new and growing phenomena.
Table 2  OSS business model vs type of OSS project

<table>
<thead>
<tr>
<th>Donations</th>
<th>Desktop</th>
<th>Education</th>
<th>ERP</th>
<th>Game</th>
<th>Mobile</th>
<th>Network</th>
<th>Programming</th>
<th>Security</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donations</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Product-enhanced</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Product-sold</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Services-commercial</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Services-partners</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>
Table 3 Profit/non-profit vs. project age

<table>
<thead>
<tr>
<th>Age of project</th>
<th>Profit (count)</th>
<th>Non-profit (count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 years</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>13 years</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>12 years</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>11 years</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10 years</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>9 years</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>8 years</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>7 years</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>6 years</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5 years</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11 (22%)</strong></td>
<td><strong>39 (78%)</strong></td>
</tr>
</tbody>
</table>

5 Conclusions

5.1 Is an OSS creator an entrepreneur?

Our study provides evidence that a connection exists between OSS creators and entrepreneurs. We demonstrate that the OSS creators in this study meet the mainstream definition of an entrepreneur established by Bygrave and Hofer (1991) where “an Entrepreneur is someone who perceives an opportunity and creates an organization to pursue it”. In other words, all of the OSS creators saw an opportunity to add value and organised resources to pursue this value. We then examined a third dimension of an entrepreneur which deals with establishing a business model to safeguard the sustainability of value. Our findings support the work of others that suggest that there are both economic (Piva et al., 2012; Riehle, 2007) and non-economic (Scacchi, 2004) means to sustain an OSS project. However, we found that less than half (42%) of the OSS creators developed revenue models built on either a product-centric or a services-centric approach. The remainder of this section will present and discuss additional findings that we considered to be interesting and could serve as a means for further research.

Building on prior research, we contribute to the literature in two ways. First, we clearly distinguish between the OSS creator and the OSS developer and show that the OSS creator is a distinct entity worthy of study separate from the OSS developer. Second, originating from the stories of high profile OSS creators such as Linus Torvalds, Michael Widnienius, and Marc Andreessen, we examined the association between an OSS creator and an entrepreneur. To examine this association, a grounded conceptual framework was developed and used to define the essential characteristics or dimensions of an entrepreneur. As shown in Figure 1, these dimensions were opportunity, organisation and business model. We then used this framework as a lens to examine OSS creators and their associated projects.
5.2 Managerial implications

Our findings suggest an association between the OSS creator and the entrepreneur on three dimensions: opportunity, organisation, and business model (see Figure 1). This suggests that when initiating an OSS project, the creator should simultaneously consider three questions:

1. How will my software best add value to the customer?
2. How should the project be organised to best support both the developer community and the end-user community?
3. What strategy (economic or non-economic) should be used to ensure the long-term sustainability of the project?

Strategically answering these questions would potentially lead to successful outcomes for the OSS project creator.

In addition, our research suggests a linkage between IT project management and the entrepreneur. The OSS creator can be viewed as both a project manager and, based on our findings, as an entrepreneur. Prior research on technical projects suggests that a combination of transformational and technical leadership behaviours augment the effectiveness of transactional leadership (Thite, 2000) and that personality profiles that more closely match the ideal project management profile for a particular project type were more successful in their impact on the customers, benefit to the organisation and overall success (Malach-Pines et al., 2009). Also, prior research suggests that personality plays a role in the emergence and success of entrepreneurs (Zhao et al., 2010). The possible implications are significant. For IT project leaders, what balance is required between project management and entrepreneurial characteristics? What types of IT projects are better suited for the leader with a strong entrepreneurial bent? Under what circumstances should the IT project be viewed as an entrepreneurial activity?

5.3 Limitations and future research

Our research focused exclusively on popular OSS projects found in a single development environment (SourceForge). The case of unpopular OSS projects was out of the scope of this research. In the future it may be worthwhile to investigate OSS creators who have been unsuccessful in creating a community to support and sustain their OSS project and what implications this may have on potential outcomes. In addition, the downside to a comparative analysis study with cases is increased difficulty in making systematic comparisons and drawing unambiguous conclusions.

Because this study examines only descriptive statistics associated with the OSS creators and their associated projects, it does not consider the perceived motivations of the OSS creators when creating their software. It would certainly be worthwhile studying the extrinsic and intrinsic motivations of OSS creators and comparing these findings with the many studies that have investigated the motivations of OSS developers.

Also, this research has spurred some original hypotheses that require further investigation. Some of these hypotheses include:
over time, OSS creators have increasingly engaged in for-profit business models
successful OSS projects are associated with well-grounded business models
the personality characteristics of successful OSS creators are similar to those of
successful entrepreneurs.

We believe that our research is a credible first effort in identifying these relationships and
constructs for further research.

Finally, we hope that this research will lead to more empirical research on the
connection between OSS and entrepreneurship. There is the suggestion that the open-
source entrepreneur may be able to respond to end-user needs in a faster and more
responsive manner than traditional entrepreneurs (Piva et al., 2012) and may have more
choices in selecting an appropriate business model (Bonaccorsi et al., 2006). Clearly,
entrepreneurship can be an informative lens that could help in determining the
motivations and behaviour of OSS creators.

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References

24 April.
same, different, or both’, Entrepreneurship Theory and Practice, Vol. 30, No. 1, pp.1–22.
hybrid business models in the open source software industry’, Management Science, Vol. 52,
No. 7, pp.1085–1098.
(Eds.): The State of the Art of Entrepreneurship, pp.579–596, PWS Kent, Boston.
firms: evidence from the software industry’, Journal of Economics and Management Strategy,
Dobni, C.B. (2012) ‘Organizational factors that promote entrepreneurship and innovation: an
Investigating OSS creators through the lens of an entrepreneur


