The Role of Open Source in New Business Formation: Innovations for Development

Full Paper

Georg J.P. Link
University of Nebraska at Omaha
glink@unomaha.edu

Sajda Qureshi
University of Nebraska at Omaha
squreshi@unomaha.edu

Abstract

Innovative uses of ICTs can bring about development. The open source software movement offers new opportunities for innovation. In particular, the use of such platforms can enable entrepreneurs in low resource environments to access and use needed software to support their new businesses. This paper investigates the role of open source software for development. This research shows that participation in open source communities is significantly correlated with new business formation. Through an analysis of datasets from the World Bank and GitHub, the largest open source platform, this paper finds a relationship between open source participation, new business formation and their effects on development, through unemployment rates. There is a strong, positive correlation between new business registrations and active GitHub users, which was statistically significant. The implications for development are in the effect of a positive relationship in job creation based on business formation and open source participation.

Keywords

Open source software, new business formation, innovation, entrepreneurship, development, ICT4D.

Introduction

Microenterprises are an important driver for development (Grosh and Somolekae 1996). Entrepreneurs who create microenterprises solve societal issues and create business models to support their activities. Without the use of information and communication technology (ICT), entrepreneurs tend to be disadvantaged and less effective in bringing about development (Duncombe and Heeks 2002). The use of ICT in business has repeatedly been connected to positive outcomes such as business growth, increased productivity, administrative efficiencies, increased revenues, improved marketing strategies, better access to customers, and cost saving (Qureshi et al. 2009). With the advent of more widely available broadband internet, new forms of doing business emerged and new innovations for low resource environments improve the lives of people (Qureshi 2010). Innovations and development initiatives are most effective when rooted in local communities that know locals' needs and contextual constraints (Nanne et al. 2015).

Open source communities create an environment for collaboration and innovation around the development of open source software which can support rapid development (Garzarelli et al. 2008). Innovations in open source communities are freely accessible and can be monetized by anyone (von Hippel and von Krogh 2003). One of the benefits of this innovation model is that users can directly influence software development and ensure that desired and needed features are implemented, thus improving the usefulness (von Hippel 2002). As more cities and villages have internet access, more people can participate in open source communities and entrepreneurs can use open source software innovations to spark business ideas, reduce up-front sunk cost, lower entry barriers, and gain visibility with customers (Gruber and Henkel 2006). These benefits for entrepreneurs make it easier to start new businesses, which is a desirable development outcome. Additionally, entrepreneurs find open source software to be suitable solutions to support their business ideas (Mitra 2009). Consequently, new businesses hire more employees and we expect the unemployment rate to decrease. This leads to our research questions:

RQ1: How is open source participation correlated with the registration of new businesses?

RQ2: How are open source participation and the registration of new businesses together correlated to development in terms of unemployment rate changes?

These research questions are investigated through an analysis of open source participation data collected through GitHub, the largest open source platform in the world, and data from World Bank on the number of new businesses registered in 81 countries for the year 2014. An index was created of the two variables to denote an open source business innovation measure. This was then tested against the unemployment rate for the countries in our sample. The theoretical background, methodology, findings, contributions and implications for development are described in the following sections.

Theoretical Background

Development is "a process of expanding real freedoms that people enjoy" (Sen, 1999, p. 3). Development outcomes can be grouped into three dimensions: economic, social, and human (Malaquias et al. 2017). Economic development can be observed in indicators such as economic growth, growth in per capita income, registration of new businesses, reduction in poverty, stimulated financial market liquidity, or unemployment rate. Social development can be observed in indicators such as reduced inequalities, social exclusion, (digital-) inclusion, access to government services, crime levels, and level of corruption. Human development is about enlarging human choices and can be observed in non-material indicators related to a long and happy life, education, and a decent standard of living (Malaquias et al. 2017). This paper explores economic development as it manifests in the registration of new businesses and job creation.

Information and communication technology (ICT) and development have been subject to research for over thirty years (Walsham 2017). ICT includes "high-speed computing, Internet, mobile telephony, geography positioning systems, and Wi-Fi" (Roztocki and Weistroffer 2016, p. 543) and enables government, business, and personal activities. The body of literature on ICT and development can be classified in a variety of ways. Brown and Grant (2010) identified two streams of research: (1) the study of *ICT for development* (ICT4D) with an interest in how ICT impacts development and (2) the study of *ICT in development* with an interest of how ICT is engaged with in low resource environment. In another classification, Avgerou (2008) identified three research streams. The first stream assumes that developing countries are catching up to the technologically advanced economics and theories of technology adoption dominate the discourse. The second stream assumes that ICT4D is about constructing new solutions for developing countries and focuses on local social context, exploring local meanings, and striving towards locally appropriate solutions. The third stream goes beyond the local concerns to consider the implications of dynamics resulting from the deployment of ICT on macro-level political and economic concerns. The context of this paper is ICT for development with a macro-level perspective.

Extant literature informs how ICT impacts development. Roztocki and Weistroffer (2016) proposed a conceptual framework, in which business activities and services are enabled by ICT, supported by human and social capital, and generated in an environment of governmental policies, business culture, and existing infrastructure. The business activities and services lead to socioeconomic development at the individual (e.g. education, health, income, quality of life, social liberty, and occupation), organization (e.g. global competitiveness, business opportunity, consumer demand, reputation, and assets), and country level (e.g. national product, political freedom, national wealth, international esteem, and labor market) which all together affect business activities by providing the environment for doing business (Roztocki and Weistroffer 2016). In this paper, we argue that open source communities are beneficial to business activities because they are a place for innovations and entrepreneurs.

We further position open source communities as a response to a criticism that the ICT may be implemented with intentions that are not aligned with development goals (Sahay 2016). While ICT is often framed as a silver bullet for development or is used synonymously with development, it is the livelihood of people and their neighborhoods that matter. Sahay makes the argument, that development does not always require ICT but might be achieved by alternative means, that simplicity and aesthetics are important, and that ultimately development should provide a joy of living (Sahay 2016). Both criticisms can be responded to by involving local community members in the development projects and respecting their specific needs and local knowledge (Nanne et al. 2015). Open source communities provide such a space where anyone can contribute to the software development and innovation occurs quickly to address real problems and needs.

Use of ICT in Business and the Open Innovation Model

Micro- and small enterprises (MSE) are the foundation of economic development (Grosh and Somolekae 1996). MSE without ICT rely on localized, informal social networks for information and knowledge which are often of poor quality and thus limit MSE's influence on social and economic development (Duncombe and Heeks 2002). ICT has been reported to cause positive outcomes such as business growth, increased productivity, administrative efficiencies, increased revenues, improved marketing strategies, better access to customers, and cost saving (Bharati and Chaudhury 2009; Qureshi et al. 2009). Further, the use of ICT in MSE has been known to increase their growth by a factor of 3.8% (Qiang et al. 2006). However, several barriers for ICT use in MSE exist. For some time, existing MSE did not see the benefit of bringing ICT into their firm and only adopted ICT because of social pressure (Riemenschneider et al. 2003). MSE that want to adopt ICT might lack technical skills or cannot afford the investment in technology (Qureshi et al. 2009). Nevertheless, many entrepreneurs are seeking to upgrade their ICT because they see the benefits of being better connected with customers and having access to timely information (Donner 2006).

The increasing access to broadband internet and adoption of ICT increase the chance that entrepreneurs start new businesses with ICT support from the inception. Open source software (OSS) is a technology that allows entrepreneurs to innovate very quickly, use existing solutions, build an agile and scalable business (Castelluccio 2008). OSS is marked by license terms that allow anyone to use the software for any purpose, share the software freely, make changes to the software, and share those changes while still allowing businesses to make money with it (Kelty 2008). The OSS licensing model avoids monopolies and democratizes access to software innovations (von Hippel and von Krogh 2003). This licensing is especially important in low resource environments that might otherwise face detrimental effects from intellectual property laws that can make access prohibitively expensive (Owoeye 2016). The quality and stability of OSS have reached enterprise grade which makes it a viable building block for successful businesses (Feller et al. 2008; Fitzgerald 2006). Entrepreneurs can use OSS to build on existing solutions, customize or extend them, and create unique solutions for their customers (Gerber 2016). OSS innovations can spark business ideas, reduce up-front sunk cost for development, lower entry barriers, and gain visibility with potential customers (Gruber and Henkel 2006). Users of OSS can recommend changes, report bugs, and help improve the software, which entrepreneurs benefit from without having to pay employees to do all the work (von Hippel 2002). Similarly, when entrepreneurs solve customers' needs by modifying OSS, they can contribute those changes back to the OSS community and allow everyone to benefit. Other motivations to participate in open source include altruism, fun, sense of community, the goal to build a reputation, to learn, and to advance one's career (von Krogh et al. 2012). OSS supports rapid economic growth in low resource environments because the development model allows for a division of labor, increases knowledge, fosters sharing, and can scale (Garzarelli et al. 2008). The following vignette illustrates how open source and business formation can relate and impact development.

Vignette: Micro Finance Open Source Community-Driven Development

Micro-loans are an innovation for the development of small businesses operating in low resource environments. The Grameen Bank received the Nobel Peace Prize 2006 for its efforts to help people in low-resource environments through micro-loans ("The Nobel Peace Prize 2006" 2006). Grameen Bank open sourced its banking software Fineract to create a community of entrepreneurs that want to replicate the micro-loans business model (Mifos Initiative 2017a). A global open source community emerged with specialists and volunteers that collaborate online and across multiple time-zones. The core technology (Fineract) is developed under the umbrella of the Apache Software Foundation, which is a long-standing and respected open source community, recognized as a non-profit organization.

Around the core technology in the Apache Fineract open source community, the non-profit Mifos Initiative facilitates a user community, supports an ecosystem, and fosters the volunteer network (Mifos Initiative 2017b). The Mifos Initiative and Fineract open source software are used by 245 businesses to serve a total of 6,083,974 clients. One client, Marie-Claire Ayurwanda of Rwanda, survived HIV, the death of two husbands, built a house for herself and her four children, and started a second business in her village to employ others. Marie's triumphant escape from poverty is what motivates this open source community to continue supporting micro-loan finance institutions and their borrowers (Mifos Initiative 2017c).

The user community includes bank customers that are using the Fineract software of a micro-loan financial institution. The community shares knowledge, provides support, and influences the development of the software. The Mifos Initiative certifies reliable partners that help entrepreneurs and financial institutions adopt the Fineract technology. The Mifos Initiative states: "Our open source community-driven development and distribution promotes new business models that create and share value across our community rather than capture and contain it within one organization" (Mifos Initiative 2017b).

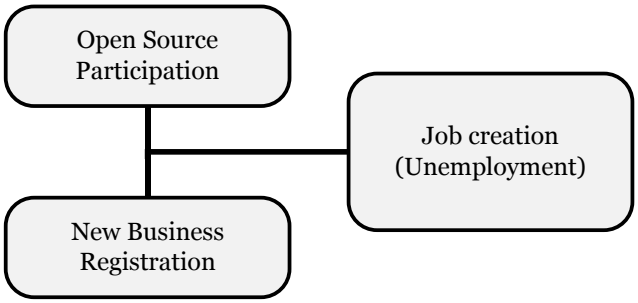

Figure 1. Open Source Participation and New Business Registration are correlated. Together, they are correlated with job creation and unemployment rate reduction.

Theoretical Model

This study investigates the research question how open source participation is correlated with the registration of new businesses (RQ1). Open source participation occurs when people help develop OSS. This does not include the use of OSS, which is a passive consumption. The active participation in open source communities is where we conjecture new business ideas and efficiencies for MSE can come from. We relate this to the development outcome of new business registrations. Entrepreneurs get the most value out of OSS when they participate (Bonaccorsi et al. 2006) and can innovate faster through OSS participation and customization of existing OSS solutions to provide unique customer value. Therefore, we expect that entrepreneurs using OSS would likely be participating in OSS. Further entrepreneurs are expected to create jobs in their new businesses. This study investigates how new business registration and open source participation together are correlated with job creation and unemployment reduction (RQ2). Figure 1 depicts the relationship between open source participation and new business registration, and their shared relationship with job creation and unemployment reduction.

Method

A quantitative analysis was carried out to identify the correlations between the two variables: open source participation and new business formation. Both these variables were then tested against a third variable, unemployment rate, to identify the effect on development. Secondary data from World Bank and GitHub was used. The number of new businesses registered in a country is part of the World Development Indicators (WDI) dataset (The World Bank 2016). The newest data is from 2014 for 85 countries. Where possible, data from 2013 data was used (5 countries). Countries with no data in 2014 or 2013 are excluded.

Open source participation was estimated by the number of unique active GitHub users per capita. GitHub is the largest OSS development platform with more than 53 million OSS projects. Several issues with using GitHub data for inferring knowledge about OSS development have been raised (Kalliamvakou et al. 2014) but do not affect our study because we are interested users' locations. The dataset has the limitation that only ~9% of users voluntarily declared a country in their GitHub profile (Hoffa 2016). Inspired by Hoffa (2016), we used Google BigQuery to query public datasets from GHTorrent and GitHub Archive, both providing log data from the GitHub platform (See Appendix A). Taiwan users were combined with Chinese users because the WDI did not list Taiwan separately. As a filter for active contribution to open source projects, we considered users with push events which signify changes to an open source project. Because the new business registered data is from 2014, we queried the unique active GitHub users for each month of 2014. We used the month with the highest number for each country to avoid giving too much weight to one-time users throughout the year. We excluded countries with less than 10 active GitHub users.

We normalized the data by the working population aged 15-64 in 2014 (WDI dataset) because we assume that this is the population most likely to start a new business or participate in open source. The new business density is the number of new businesses registered per 1,000 population. Open source participation is the number of GitHub users per 10,000 population. The unemployment rate change is the difference between the unemployment rate (in percentage) from year 2013 to year 2014 (WDI dataset). A positive unemployment rate change indicates a higher unemployment in 2014 than the prior year. Therefore, a negative unemployment rate change indicates job creation and lower unemployment in 2014. Our final dataset contains 81 countries (see Appendix B).

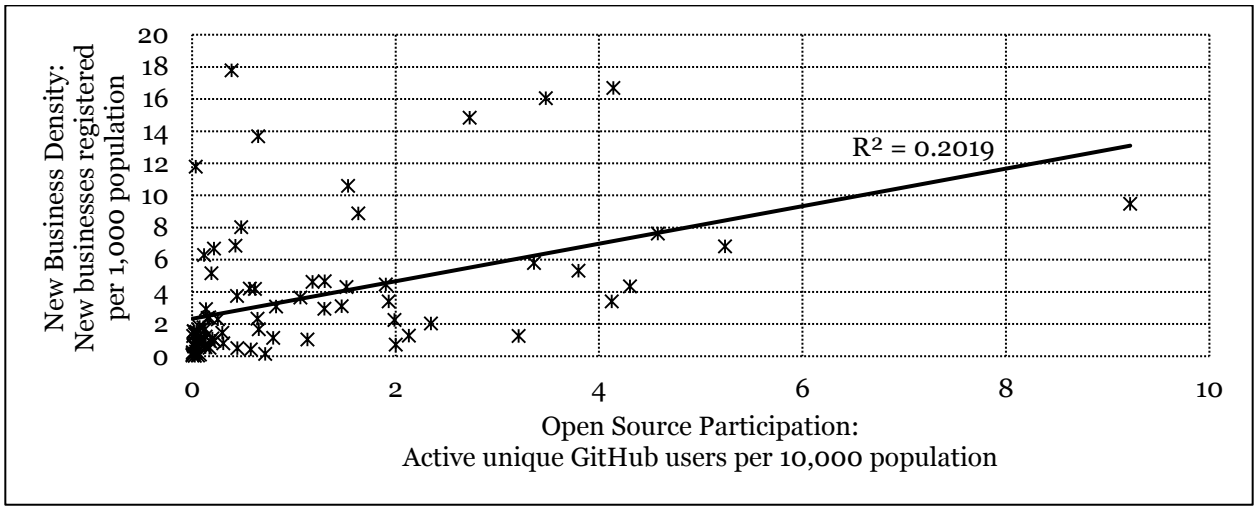

Figure 2: New business density and open source participation at the country level in 2014 are positively correlated, which is statistically significant.

Findings

In this section, we illustrate the results of our analysis and findings from investigating the theoretical model. Figure 2 shows the country level data for new business density and open source participation. The figure shows that countries with more open source participation tend to have a higher new business density. The data fails the normality assumptions. We, therefore, ran a nonparametric correlation analysis using Spearman's rank-order correlation using IBM® SPSS® Statistics software version 24 to determine the relationship between 81 countries' new business registrations and active GitHub users. There was a strong, positive correlation between new business registrations and active GitHub users, which was statistically significant at the .01 level (2-tailed, $r_s = .602$, $p = .000$). We repeated the analysis for countries that had open source participation of at least .1 or .5 (59 and 35 countries) and, in both cases, confirmed a positive correlation which was statistically significant ($r_s = .442$, $p = .000$ and $r_s = .441$, $p = .008$). Because we have two variables, we calculated a simple linear regression (see Neter et al. 1996). We found a significant regression equation ($F(1, 80)=19.985$, $p < .000$), with R^2 of .202). New business registration increased by 1.168 for each open source participant. Similarly, open source participation increased .173 for each additional new business registered.

After demonstrating that open source participation and new business registrations are significantly correlated, a composite index (mean of new business density and open source participation) is calculated to assess the impact on the unemployment rate change. A Spearman's rank order correlation determined the relationship between 81 countries' unemployment rate change and the composite index. There was a negative correlation between the unemployment rate change and the composite index, which was significant at the .01 level (2-tailed, $r_s = -.372$, $p = .001$). A simple linear regression was calculated to predict the change in unemployment rate based on open source participation and new business registrations. A significant regression equation was found ($F(1, 80)=6.397$, $p < .013$), with an R^2 of .075 (see Figure 3). The unemployment rate in percentage dropped by -.078 for every one point increase in the composite index of open source participation and new business registration.

These findings have important implications for development. Our research question of how open source participation is correlated with the registration of new businesses (RQ1) can be answered by the findings. We found a strong positive correlation, which was statistically significant. We further found a statistically significant correlation of open source participation and new business registrations together with an inverse change in unemployment rate (RQ2). This means that countries with higher levels of open source participation and more new business registrations are also reducing unemployment or creating jobs.

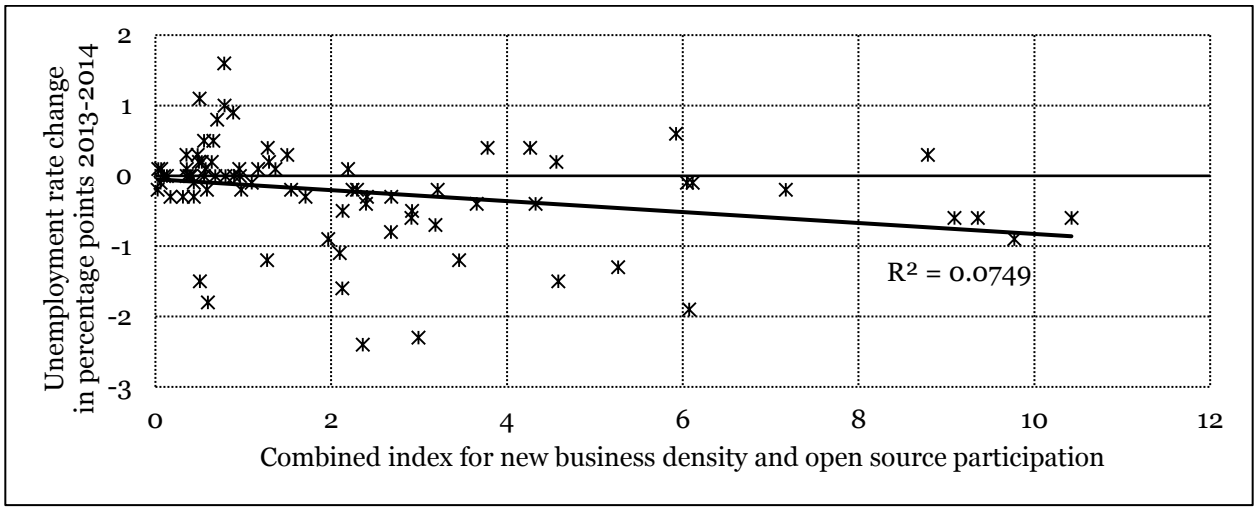

Figure 3. Higher open source participation and new business registrations are negatively correlated with changes in unemployment, which is statistically significant. A negative unemployment rate change indicates that jobs were created.

Contributions and Implications for Development

Given that open source participation is positively correlated with new business registrations and together they are correlated with a reduction in unemployment, we infer that open source participation has a positive effect on development. Our research has several contributions and implications for development.

First, following the framework of Roztocki and Weistroffer (2016), policy makers should create an environment that fosters open source participation. This can be achieved by making broadband internet access more widely available or by fostering a legal environment that supports open source communities. Some countries are passing laws that require software developed for government agencies to be released as open source (e.g. http://www.opensource.gov). Our data suggests that an environment that fosters open source participation is also fostering new business creation and job creation.

Second, open source is important to business formation. The vignette provided anecdotal evidence of the causations. We argued that open source provides basic software resources that would otherwise be unavailable to entrepreneurs in low resource communities. Entrepreneurs can jumpstart their business with the use of freely available OSS that they can customize to their individual needs. By establishing successful businesses, entrepreneurs can hire employees and thereby reduce the unemployment rate. People are further able to participate in open source communities to learn skills that will make them more valuable to employers. In summary, our analysis supports that there is a positive correlation between open source and entrepreneurship.

Third, open source helps create effective solutions in low resource environments. The open innovation model has been known to be effective for competitors to agree on non-differentiating technology that mutual benefit is derived from (Germonprez et al. 2013). No one person, entrepreneur, or business can develop the best software solution to complex problems. Open source communities provide a space to innovate collectively, engage local knowledge, respond to individual needs, and ultimately create solutions to pressing issues. Our data cannot prove causality, but the correlation is supported.

Conclusion

This study investigated the question whether open source participation and the registration of new businesses was correlated. At a country level, we found a significant positive correlation between open source participation and the registration of new businesses. This confirms prior theorized positive impact that open source should have on economic development (Garzarelli et al. 2008). This study further found that open source participation and new business registration have a significant impact on development, specifically job creation and unemployment reduction.

A limitation of this study is the use of secondary data that was not collected for the purpose of this study. The GitHub data, while being the best data available, remains spotty with ~9% known locations for users. Another limitation is the macro-level analysis that does not account for regional or contextual differences. The final limitation is that we lack detailed knowledge about the hypothesized complexities of open source engagement of small and micro enterprises in low resource environments.

Several questions remain for future research. First, the effects between open source participation and new business registrations have been theorized in this research but the actual mechanisms at play need further investigation. Second, a more comprehensive model can consider additional factors and their influence on open source participation and new business registrations. Third, open source participation requires access to ICT and broadband internet which, in the past, resulted in often homogeneous open source communities with members from rich resource environments. In recent years, open source is becoming more diverse and future research should replicate this study with newer data, once available. Fourth, a qualitative study of microenterprises that participate in open source communities can uncover complexities relating to our findings. Last, open source may have an impact on social and human development outcomes, which future research can investigate.

ORCID

Georg J.P. Link https://orcid.org/0000-0001-6769-7867

REFERENCES

Avgerou, C. 2008. "Information systems in developing countries: A critical research review," *Journal of Information Technology*, (23:3), pp. 133–146 (doi: 10.1057/palgrave.jit.2000136).

Bharati, P., and Chaudhury, A. 2009. "SMEs and competitiveness: The role of information systems," *International Journal of E-Business Research; Hershey*, (5:1), pp. I–IX.

Bonaccorsi, A., Giannangeli, S., and Rossi, C. 2006. "Entry strategies under competing standards: Hybrid business models in the open source software industry," *Management Science*, (52:7), pp. 1085–1098 (doi: 10.1287/mnsc.1060.0547).

Brown, A. E., and Grant, G. G. 2010. "Highlighting the duality of the ICT and development research agenda," *Information Technology for Development*, (16:2), pp. 96–111 (doi: 10.1080/02681101003687793).

Castelluccio, M. (Ed.). 2008. "Enterprise open source adoption," *Strategic Finance*, (90:5), pp. 57–58.

Donner, J. 2006. "Internet use (and non-use) among urban microenterprises in the developing world: An update from India," in *Conference of the Association of Internet Researchers (AoIR)*, pp. 28–30 (available at http://ai2-s2-pdfs.s3.amazonaws.com/5bde/3073c35e6a7a1b292e9461a6da643881627f.pdf; retrieved February 2, 2017).

Duncombe, R., and Heeks, R. 2002. "Enterprise across the digital divide: information systems and rural microenterprise in Botswana," *Journal of International Development*, (14:1), pp. 61–74 (doi: 10.1002/jid.869).

Feller, J., Finnegan, P., Fitzgerald, B., and Hayes, J. 2008. "From peer production to productization: A study of socially enabled business exchanges in open source service networks.," *Information Systems Research*, (19:4), pp. 475–493 (doi: 10.1287/isre.1080.0207).

Fitzgerald, B. 2006. "The transformation of open source software," *MIS Quarterly*, (30:3), pp. 587–598.

Garzarelli, G., Limam, Y. R., and Thomassen, B. 2008. "Open source software and economic growth: A classical division of labor perspective," *Information Technology for Development*, (14:2), pp. 116–135 (doi: 10.1002/itdj.20092).

Gerber, S. 2016. "How startups can use open source software to compete against the big guys," *The Next Web*, October 3 (available at https://thenextweb.com/entrepreneur/2016/10/03/how-startups-can-use-open-source-software/; retrieved February 26, 2017).
Germonprez, M., Allen, J. P., Warner, B., Hill, J., and McClements, G. 2013. "Open source communities of competitors," *ACM Interactions*, (20:6), pp. 54–59 (doi: 10.1145/2527191).
Grosh, B., and Somolekae, G. 1996. "Mighty oaks from little acorns: Can microenterprise serve as the seedbed of industrialization?," *World Development*, (24:12), pp. 1879–1890 (doi: 10.1016/S0305-750X(96)00082-4).
Gruber, M., and Henkel, J. 2006. "New ventures based on open innovation – an empirical analysis of start-up firms in embedded Linux," *International Journal of Technology Management*, (33:4), pp. 356–372 (doi: 10.1504/IJTM.2006.009249).
von Hippel, E. 2002. "Working paper 4366-02: Open source projects as horizontal innovation networks - by and for users," MIT Sloan School of Management (available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=328900).
von Hippel, E., and von Krogh, G. 2003. "Open source software and the 'private-collective' innovation model: Issues for organization science," *Organization Science*, (14:2), pp. 209–223.
Hoffa, F. 2016. "What countries have more open source developers per capita than the US?," *Medium*, September 8 (available at https://medium.com/@hoffa/github-top-countries-201608-13f642493773; retrieved February 23, 2017).
Kalliamvakou, E., Gousios, G., Blincoe, K., Singer, L., German, D. M., and Damian, D. 2014. "The promises and perils of mining GitHub," in *Proceedings of the 11th working conference on mining software repositories*, ACM, pp. 92–101.
Kelty, C. M. 2008. *Two bits: The cultural significance of free software*, Durham: Duke University Press.
von Krogh, G., Haefliger, S., Spaeth, S., and Wallin, M. W. 2012. "Carrots and rainbows: Motivation and social practice in open source software development," *MIS Quarterly*, (36:2), pp. 649–676.
Malaquias, R. F., Malaquias, F. F. de O., and Hwang, Y. 2017. "The role of information and communication technology for development in Brazil," *Information Technology for Development*, (0:0), pp. 1–15 (doi: 10.1080/02681102.2016.1233854).
Mifos Initiative. 2017a. "Our Story," *Mifos Initiative* (available at http://mifos.org/about-us/our-story/; retrieved February 28, 2017).
Mifos Initiative. 2017b. "Global Community," *Mifos Initiative* (available at http://mifos.org/mifos-initiative/global-community/; retrieved February 28, 2017).
Mifos Initiative. 2017c. "3 Billion Maries," *Mifos Initiative* (available at http://mifos.org/impact/social-mission-success/; retrieved February 28, 2017).
Mitra, S. 2009. "Open source means business," *Forbes*, February 6 (available at https://www.forbes.com/2009/02/04/open-source-entrepreneur-technology-enterprise-tech_0206_mitra.html; retrieved February 6, 2017).
Nanne, I., Moshabela, M., Huynh, U., and Diop, P. M. 2015. "When development breeds contempt: Case examples of community-driven health systems initiatives," *Development in Practice*, (25:8), pp. 1120–1130 (doi: 10.1080/09614524.2015.1082534).
Neter, J., Kutner, M. H., Nachtsheim, C. J., and Wasserman, W. 1996. *Applied linear statistical models*, (Vol. 4), Irwin Chicago.
Owoeye, O. 2016. "Intellectual property, health, regionalism and development: A third world's perspective," *European Journal of Sustainable Development; Rome*, (5:4), pp. 225–232.
Qiang, C. Z.-W., Clarke, G. R., and Halewood, N. 2006. "The role of ICT in doing business," in *Information and communications for development - Global trends and policies*, Washington, DC: The World Bank.
Qureshi, S. 2010. "Driving development through innovations in information technology and its applications," *Information Technology for Development*, (16:4), pp. 241–243 (doi: 10.1080/02681102.2010.522040).
Qureshi, S., Kamal, M., and Wolcott, P. 2009. "Information technology interventions for growth and competitiveness in micro-enterprises," *International Journal of E-Business Research; Hershey*, (5:1), pp. 117–140 (doi: 10.4018/978-1-61520-627-8.ch015).
Riemenschneider, C. K., Harrison, D. A., and Mykytyn, P. P. 2003. "Understanding it adoption decisions in small business: Integrating current theories," *Information & Management*, (40:4), pp. 269–285 (doi: 10.1016/S0378-7206(02)00010-1).

Roztocki, N., and Weistroffer, H. R. 2016. "Conceptualizing and researching the adoption of ICT and the impact on socioeconomic development," *Information Technology for Development*, (22:4), pp. 541–549 (doi: 10.1080/02681102.2016.1196097).
Sahay, S. 2016. "Are we building a better world with ICTs? Empirically examining this question in the domain of public health in India," *Information Technology for Development*, (22:1), pp. 168–176 (doi: 10.1080/02681102.2014.933522).
Sen, A. K. (1999). *Development as freedom*, New York, NY: Anchor Books.
"The Nobel Peace Prize 2006.," 2006. *Nobelprize.org* (available at https://www.nobelprize.org/nobel_prizes/peace/laureates/2006/; retrieved February 28, 2017).
The World Bank. 2016. "World Development Indicators," (available at http://data.worldbank.org/products/wdi; retrieved February 23, 2017).
Walsham, G. 2017. "ICT4D research: Reflections on history and future agenda," *Information Technology for Development*, (0:0), pp. 1–24 (doi: 10.1080/02681102.2016.1246406).

Appendix A: Query for unique GitHub Users

```
SELECT b.country_code, COUNT(DISTINCT login) unique_login
FROM [githubarchive:month.201401] a
JOIN [fh-bigquery:ghtorrent.users] b
# http://ghtorrent.org/faq.html
ON a.actor.login=b.login
WHERE country_code != '\\N'
AND a.type='PushEvent'
GROUP BY 1
ORDER BY unique_login DESC
LIMIT 300
```

The query was executed on Google BigQuery (https://bigquery.cloud.google.com/) and was inspired by Hoffa (2016). The datasets are originally from GHTorrent (http://ghtorrent.org/) and GitHub Archive (https://www.githubarchive.org/).

The query has to be changed on line two for each month, e.g. 'month.201401' for January of 2014 and 'month.201412' for December of 2014.

Reference

Hoffa, F. 2016. "What countries have more open source developers per capita than the US?," Medium, September 8 (available at https://medium.com/@hoffa/github-top-countries-201608-13f642493773; retrieved February 23, 2017).

Appendix B: Data

Columns:
A (sorted in descending order): Index (Average of New Business Density and Open Source Participation).
B: New Business Density (New business registrations per 1.000 population ages 15-64 in 2014).
C: Open Source Participation (Active GitHub users per 10,000 population ages 15-64 in 2014).
D: Unemployment Rate Change (Percentage point difference of unemployment rates 2013-2014).

Country Name	A ▾	B	C	D
New Zealand	10.4215	16.7014	4.1417	-0.6
Estonia	9.7727	16.0689	3.4764	-0.9
Iceland	9.3575	9.4935	9.2215	-0.6
Malta	9.0889	17.7912	0.3866	-0.6
Australia	8.7885	14.8489	2.7281	0.3
Cyprus	7.1723	13.6948	0.6499	-0.2
Norway	6.1136	7.6480	4.5791	-0.1
Latvia	6.0735	10.6144	1.5325	-1.9
Sweden	6.0461	6.8528	5.2394	-0.1
Botswana	5.9228	11.8106	0.0350	0.6
Bulgaria	5.2656	8.8983	1.6329	-1.3
Ireland	4.5842	5.8067	3.3617	-1.5
Netherlands	4.5610	5.3244	3.7976	0.2
Denmark	4.3253	4.3468	4.3039	-0.4
Chile	4.2649	8.0480	0.4817	0.4
Finland	3.7772	3.4290	4.1253	0.4
Montenegro	3.6546	6.8823	0.4270	-0.4
Georgia	3.4551	6.6954	0.2149	-1.2
Mongolia	3.2092	6.3023	0.1160	-0.2
Slovenia	3.1842	4.4657	1.9027	-0.7
Portugal	2.9938	4.6836	1.3040	-2.3
Lithuania	2.9193	4.3205	1.5181	-0.5
Croatia	2.9131	4.6434	1.1828	-0.6
Mauritius	2.6815	5.1732	0.1898	-0.3
Czech Republic	2.6789	3.4241	1.9337	-0.8
Romania	2.4071	4.1958	0.6184	-0.3
Russian Federation	2.3940	4.2201	0.5679	-0.4
Hungary	2.3583	3.6527	1.0639	-2.4
Israel	2.2943	3.1188	1.4699	-0.2
Canada	2.2408	1.2735	3.2081	-0.2
Belgium	2.1920	2.0373	2.3467	0.1
France	2.1304	2.2723	1.9885	-0.5
Spain	2.1271	2.9534	1.3008	-1.6
Macedonia, FYR	2.0980	3.7539	0.4421	-1.1
Slovak Republic	1.9657	3.1051	0.8262	-0.9
Germany	1.7066	1.2830	2.1301	-0.3
Belize	1.5420	2.9490	0.1351	-0.2
Italy	1.4985	2.3536	0.6434	0.3
Austria	1.3649	0.7292	2.0006	0.1
Peru	1.2919	2.4178	0.1660	0.2
Korea, Rep.	1.2759	2.3000	0.2518	0.4
Malaysia	1.2698	2.3863	0.1533	-1.2
Serbia	1.1689	1.6816	0.6562	0.1
Belarus	1.0942	1.0536	1.1348	-0.1
Costa Rica	0.9757	1.1559	0.7955	-0.2
Qatar	0.9606	1.8111	0.1102	0.0
Kenya	0.9541	1.8346	0.0736	0.1
Tunisia	0.8948	1.6674	0.1222	0.0
Armenia	0.8860	1.4757	0.2962	0.9
Rwanda	0.7967	1.5777	0.0158	0.0
Morocco	0.7873	1.5343	0.0403	1.0
Lesotho	0.7816	1.5472	0.0159	1.6
Suriname	0.7030	1.3778	0.0281	0.8
Dominican Republic	0.6794	1.2251	0.1337	0.0
Turkey	0.6578	1.1176	0.1979	0.5
Zambia	0.6418	1.2723	0.0112	0.2
Jamaica	0.5976	0.9754	0.2198	-1.8
Kyrgyz Republic	0.5865	1.0856	0.0874	-0.2
Albania	0.5719	1.0587	0.0851	0.1
Bosnia and Herzegovina	0.5545	0.8044	0.3046	0.5
Mexico	0.5536	0.9290	0.1782	0.0
Azerbaijan	0.5260	0.9854	0.0666	0.2
Jordan	0.5073	0.9141	0.1005	-1.5
Argentina	0.5013	0.4254	0.5773	1.1
Thailand	0.4948	0.8946	0.0950	0.2
Brazil	0.4816	0.5185	0.4448	0.3
Oman	0.4359	0.8440	0.0278	-0.1
Japan	0.4358	0.1524	0.7192	-0.3
Nepal	0.4053	0.6915	0.1191	0.0
Nigeria	0.3873	0.7623	0.0124	0.0
Madagascar	0.3571	0.7003	0.0138	0.0
Bolivia	0.3555	0.5818	0.1293	0.1
El Salvador	0.3527	0.5350	0.1704	0.3
Algeria	0.3128	0.6062	0.0195	-0.3
Senegal	0.1712	0.3040	0.0384	-0.3
Togo	0.1314	0.2551	0.0077	0.0
India	0.0964	0.1159	0.0770	0.0
Guinea	0.0646	0.1261	0.0030	0.1
Bhutan	0.0580	0.0580	0.0580	-0.1
Pakistan	0.0340	0.0433	0.0247	0.1
Congo, Dem. Rep.	0.0249	0.0463	0.0034	-0.2