The Impact of Open Source Software Regulations on Productivity, Entrepreneurship, and Social Welfare

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NBER Productivity, Innovation and Entrepreneurship Program
Digitization Research Proposal Submission
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Overview

Continual advances in information and communication technology (ICT) are influencing the nature of production, the prominence of entrepreneurship, and the level of social welfare across the globe. Despite the impact of ICT use, considerable differences exist in the adoption of these technologies across countries. This is particularly alarming to policy makers since disparities in ICT use between countries are thought to contribute to the divergence in aggregate productivity growth (Van Ark, O'Mahony, and Timmer, 2008). It is therefore not surprising that governments around the world are enacting policies to encourage firms to implement emerging technologies. For example, a recent survey by the OECD (2015) found that 27 out of 34 surveyed countries had or were enhancing an overarching digital strategy which included product and labor regulations, access to credit, broadband infrastructure and so on.[1]

While firms continue to rely on corporate vendors for their ICT investment needs, increasingly a number of software applications are becoming readily available for free as Open Source Software (OSS). Those outside of the information technology community tend to think narrowly of OSS as simply Linux operating systems. However there are increasingly greater varieties of free software which offer similar functionality to a host of purchased products, including database software (MySQL and PostgreSQL), web servers (Apache) computer aided design software (FreeCAD and LibreCAD) and so on. In fact, in recent years businesses have begun to embrace OSS as opposed to more traditional providers (e.g., Finely, 2015). Even Microsoft, long the standard bearer of proprietary software, has embraced Linux and OSS in a large way (Microsoft, 2016). This shift from traditional investments in proprietary software to open source suggests new opportunities for policy makers to augment traditional policy levers.

In fact, as open source software (OSS) becomes an increasingly important building block of the digital economy, governments have employed various regulations to encourage its use. However, to this point, there have been no rigorous studies to examine the impact of such regulations on national, firm, and individual productivity.[2] As such, this study seeks to answer the following related research questions:

1) What is the impact of OSS-related regulation on firm usage of OSS and how does this, in turn, impact firm productivity?
2) What is the impact of OSS usage-related regulation on individual contributions to OSS and what is the value of these contributions?
3) Do OSS-related regulations have spillover impacts on a) the size of the ICT labor force, b) the amount of ICT innovation within the country, and c) the amount of ICT entrepreneurship in the country?

In aggregate, answering these three questions will allow for a better understanding of how OSS-related regulations may be able to enhance firm productivity and national competitiveness while simultaneously increasing global social welfare by providing incentives to develop an important public digital good.

Methodology and Preliminary Results

To answer all of these questions, data on OSS regulations in European Union member countries will be used as an exogenous shock to shift the likelihood of firms using OSS and individuals contributing to OSS. In particular, France and The Netherlands introduced legislation related to federal use of OSS at varying points during the 2000's. Other EU countries that did not introduce such legislation will be used to construct synthetic controls based on various economic measures. Then a standard differences-in-differences analysis will be applied.

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[1] Available from: http://www.oecd-ilibrary.org/science-and-technology/oecd-digital-economy-outlook-2015_9789264232440-en

[2] Although Lerner and Schankerman (2010) use survey data to construct suggestions for how OSS related policies should be created, they do not analyze the impact of any existing policies.

Preliminary results show that the introduction of such legislation does indeed increase the levels of individual contributions to the creation of OSS (as measured by contributions to the GitHub OSS repository) and that these contributions have a large economic value (answering Question 2 above). Publicly available data from the Organization for Economic Co-operation and Development (OECD) will be used to answer Question 3. In particular, the OECD collects data on the percentage of individuals within a country that have written computer code within the last 12 months, which will answer Question 3a, and information on the number of ICT related patents within a country, which will answer Question 3b. Question 3c will be answered by gathering data from governmental organizations that track within-country entrepreneurial entry into ICT industries.

Obtaining data to answer Question 1 is the primary purpose of the funding requested in this proposal. Data on ICT usage at the firm level is available for purchase via the Aberdeen Corp. (formerly Harte Hanks) and its Ci Technology Database (CiTDB). This data has been used for many prior studies of IT (e.g., Bloom, Sadun, and Van Reenen. 2012; Forman, Goldfarb, and Greenstein, 2012; Tambe, Hitt, and Brynjolfsson, 2013) and I have previously used the North American CiTDB to examine the impact of OSS usage on firm productivity (Nagle, 2016). However, OSS regulations in North America do not offer enough variation to answer the research questions posed above. Therefore, I am seeking funding to purchase the EU CiTDB, which will allow for Question 1 above to be properly explored. The CiTDB includes measures of OSS usage at the firm and establishment level allowing for a granular analysis of the impact of OSS regulation on the use of OSS by firms. In particular, multi-national firms that have establishments in both treated and control countries will allow for firm-fixed effect analysis in addition to the differences-in-differences. Answering Question 1 will add additional insights into the effects and mechanisms at play in Questions 2 and 3. By better understanding the impact of existing regulations related to OSS, our results will be able to guide future policies related to OSS and the broader class of public digital goods (e.g., Wikipedia, 3D printing blueprints).

Budget and Timeline Estimate

I have obtained a quote from Aberdeen of $25,000 for purchasing access to the EU CiTDB data. Therefore, the NBER Digitization research grant funding would be combined with my own existing funds to allow for the purchase of the data and payment to a research assistant to help clean and organize the data. All other data required to complete the project is publicly available and has already been obtained. As mentioned above, the initial analysis for Question 2 has already occurred. Therefore, the proposed timeline for the remaining activities would be as follows:

Summer 2017 – Obtain CiTDB data and complete data analysis for Questions 1 and 3
Fall 2017 – Write initial draft of paper to circulate and present for feedback
Spring 2018 – Integrate feedback and submit paper to a journal for review

References

Bloom, N., Sadun, R., & Van Reenen, J. (2012). Americans do IT better: US multinationals and the productivity miracle. *The American Economic Review*, *102*(1), 167-201.

Finley, K. (2015). Open Source Databases Keep Chipping Away at Oracle's Empire. *Wired*, Jan. 7, 2015. Retrieved from https://www.wired.com/2015/01/open-source-database/.

Forman, C., Goldfarb, A., & Greenstein, S. (2012). The Internet and local wages: A puzzle. *The American Economic Review*, *102*(1), 556-575.

Lerner, J. and Schankerman, M. (2013). The comingled code: Open source and economic development. *MIT Press*.

Microsoft (2016). Microsoft contributes to open ecosystem by joining Linux Foundation and welcoming Google to the .NET community. Microsoft News Center, Nov. 16, 2016. Retrieved from https://news.microsoft.com/2016/11/16/microsoft-contributes-to-open-ecosystem-by-joining-linux-foundation-and-welcoming-google-to-the-net-community/.

Nagle, F. (2016). Open Source Software and Firm Productivity. *Harvard Business School Working Paper 15-062*. Available from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2559957.

Tambe, P., Hitt, L. M., & Brynjolfsson, E. (2012). The extroverted firm: How external information practices affect innovation and productivity. *Management Science*, *58*(5), 843-859.

Van Ark, B., O'Mahony, M., & Timmer, M. P. (2008). The productivity gap between Europe and the United States: trends and causes. *The Journal of Economic Perspectives*, *22*(1), 25-44.

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Academic Positions

University of Southern California

- Assistant Professor, Management and Organization, Marshall School of Business — 2015 - Present
- Co-Director, Marshall Digitopolis — 2016 - Present
- Faculty Affiliate, Lloyd Greif Center for Entrepreneurial Studies — 2016 - Present
- Faculty Affiliate, Annenberg Research Network on International Communication — 2016 - Present

Education

Harvard Business School, Boston, MA, USA — May 2015

- Doctor of Business Administration in Technology and Operations Management
- Committee: Shane Greenstein (co-chair), Marco Iansiti (co-chair), Carliss Baldwin, Karim Lakhani, Feng Zhu
- Dissertation Title: The Digital Commons: Tragedy or Opportunity? The Effect of Crowdsourced Digital Goods on Innovation and Economic Growth
  - Harvard Business School Wyss Award for Excellence in Doctoral Research
  - INFORMS TIMES Doctoral Dissertation Award, 2016 Runner-Up
  - Grigor McClelland Doctoral Dissertation Award, 2016 Finalist[i]

Georgetown University, Washington, DC, USA — January 2011

- Master of Science in Computer Science, focus in Information Security
- Master's Thesis Title: Quantifying Privacy Breaches in Social Networks

City University, London, UK — September 2007

- Master of Science in International Business Economics, Graduated with Distinction
- Master's Thesis Title: High-Tech IPO's in the US and Europe Before, During, and After the Dot-Com Bubble

Georgetown University, Washington, DC, USA — May 2004

- Bachelor of Science in Computer Science, Cum Laude

Peer Reviewed Journal Publications

- S. Greenstein and F. Nagle. (2014). "Digital Dark Matter and the Economic Contribution of Apache." *Research Policy* 43 (4), pp. 623-631. **Lead Article.**

- F. Nagle and C. Riedl. (2014). "Online Word of Mouth and Product Quality Disagreement." *Academy of Management Best Paper Proceedings*.

- F. Nagle. (2016). "Learning By Contributing: Gaining Competitive Advantage Through Cooperative Contribution to Public Goods." *Academy of Management Best Paper Proceedings*

Working Papers

- F. Nagle. "Open Source Software and Firm Productivity." *Harvard Business School Working Paper 15-062*.
  - Under 3rd round review
  - **Strategic Management Society (SMS) Best Conference Paper, 2014 Finalist**

- F. Nagle. "Learning By Contributing: Gaining Competitive Advantage Through Cooperative Contribution to Public Goods."
  - 2nd Revise and Resubmit requested
  - **Strategic Management Society (SMS) Best Conference Paper, 2017 Nominated**
  - **AOM TIM Best Paper, 2016 Finalist**
  - **Selected for AOM Best Paper Proceedings, 2016**

- F. Nagle and C. Riedl. "Online Word of Mouth and Product Review Disagreement."
  - Under review
  - **Selected for AOM Best Paper Proceedings, 2014**

- F. Nagle. "Stock Market Prediction via Social Media: The Importance of Competitors.
  - Under review

Work In Progress

- E. Altman, F. Nagle, and M. Tushman. "Engaging Communities for Problem Solving and Innovation: Shifting Institutional Logics."

- F. Nagle, S. Ransbotham, and G. Westerman. "Security Investment as a Strategic Response."

- H. Lifshitz-Assaf and F. Nagle. "Goldilocks and the Three Programmers: Unpacking the Relationship Between Online Contributions and Productivity at Work."

- F. Nagle. "The Impact of Open Source Software Regulations on Productivity, Entrepreneurship, and Social Welfare."

- F. Nagle. and F. Teodoridis. "How Technology Fuels Knowledge Creation: The Role of Diversity."

Book Chapters

- E. Altman, F. Nagle, and M. Tushman. (2015). "Innovating Without Information Constraints: Organizations, Communities, and Innovation When Information Costs Approach Zero." In Oxford Handbook of Creativity, Innovation and Entrepreneurship, edited by Michael A. Hitt, Christina Shalley, and Jing Zhou. Oxford University Press.

- E. Altman, F. Nagle, and M. Tushman. (2013). "Technology and Innovation Management." In Oxford Bibliographies in Management, edited by Ricky W. Griffin. New York: Oxford University Press.

Computer Science Publications

- F. Nagle. (2013). "Privacy Breach Analysis in Social Networks." In Studies in Mining Social Networks and Security Information, edited by Zeki Erdem, Tansel Ozyer, Suheil Khoury and Jon Rokne. Springer Verlag.

- F. Nagle, L. Singh, and A. Gkoulalas-Divanis. (2012). "EWNI: Efficient Anonymization of Vulnerable Individuals in Social Networks", *Proceedings of The 16th Pacific - Asia Conference on Knowledge Discovery and Data Mining (PAKDD 2012)*. Republished in *Lecture Notes in Computer Science: Vol. 7302. Advances in Knowledge Discovery and Data Mining* (pp. 359-370).

- A. Ramachandran, L. Singh, E. Porter, and F. Nagle. (2012). "Exploring Re-Identification Risks in Public Domains", *Proceedings of the Tenth Annual International Conference on Privacy, Security, and Trust (PST 2012)*. **(Best Student Paper)**

- F. Nagle, L. Singh. (2009). "Privacy in Online Social Networks: Empirical Evidence from Facebook", *Proceedings of the 2009 International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, Hellenic American University, Greece, July 2009.

- F. Nagle, M. Sutton. (2006). "Emerging Economic Models for Vulnerability Research", *Proceedings of The Fifth Workshop on the Economics of Information Security (WEIS 2006)*, University of Cambridge, England, June 2006. Republished as Chapter 1 in Cyber Fraud: Tactics, Techniques, and Procedures, edited by James Graham, Rick Howard, Ralph Thomas, and Steve Winterfield, 2nd Edition. (2010). CRC Press, Auerbach Publications.

Honors and Awards

- Best Conference Paper, Strategic Management Society Conference, 2017 Nominated
- Academy of Management – Technology and Innovation Management Division Best Paper, 2016 Finalist
- INFORMS TIMES Doctoral Dissertation Award, 2016 Runner-Up
- Grigor McClelland Doctoral Dissertation Award, 2016 Finalist[1]
- Selected for Best Paper Proceedings, Academy of Management, 2016
- Selected for participation in Academy of Management Conference Technology and Innovation Management Junior Faculty Consortium, 2016
- Selected for participation in Strategic Management Society Conference Competitive Strategy Junior Faculty Paper Development Workshop, 2015
- Wyss Award for Excellence in Doctoral Research, Harvard Business School, 2014
- Best Conference Paper, Strategic Management Society Conference, 2014 Finalist
- Selected for Best Paper Proceedings, Academy of Management, 2014
- Selected for participation in Academy of Management BPS Dissertation and Doctoral Consortium, 2014
- Selected for participation in Atlanta Competitive Advantage Conference Doctoral Consortium, 2014
- Selected for participation in the Consortium on Competitiveness and Cooperation Conference, 2014
- Selected for participation in Academy of Management TIM Doctoral Consortium, 2013
- Received Excellent / High Pass on HBS Doctoral Qualifying Exam, 2013

Invited Presentations

- 2017 – Real Colegio Complutense at Harvard University (scheduled)

- 2016 – Annenberg School for Communication (USC), INFORMS TIMES Emerging Scholars

- 2015 – University of California – Los Angeles, University of Maryland, Harvard Business School, University of Pennsylvania, University of Southern California, Carnegie Mellon University, McGill University

- 2014 – Columbia University, Bocconi University, IESE Business School, Temple University, University College London, Boston College, NBER Productivity Seminar

Conference Presentations

- "Goldilocks and the Three Programmers: Unpacking the Relationship Between Online Contributions and Productivity at Work."

- Academy of Management Annual Conference, Atlanta, GA, August 2017 (scheduled)
- Collective Intelligence Conference, New York University, June 2017 (scheduled)

- "Learning By Contributing: Gaining Competitive Advantage Via Cooperative Contribution to Public Goods"
  - Strategic Management Society Conference, Houston, TX, October 2017 (scheduled)
    - **Best Conference Paper, Nominated**
  - DRUID Society Conference on Entrepreneurship, Organization, and Innovation, New York University, June 2017 (scheduled)
  - Collective Intelligence Conference, New York University, June 2017 (scheduled)
  - Workshop on Information Systems and Economics (WISE), Dublin, IE, December 2016
  - Academy of Management Annual Conference, Los Angeles, CA, August 2016
    - **Technology and Innovation Management Division Best Paper, Finalist**
    - **Selected for Best Paper Proceedings**
  - Open and User Innovation Conference, Harvard Business School, August, 2016
  - Strategic Management Society Special Conference, Rome, IT, June 2016
  - Organization Science Winter Conference, Park City, Utah, February 2016

- "Engaging Communities for Problem Solving and Innovation: Shifting Institutional Logics"
  - Strategic Management Society Conference, Houston, TX, October 2017 (scheduled)
  - Academy of Management Annual Conference, Los Angeles, CA, August 2016
  - Open and User Innovation Conference, Harvard Business School, August, 2016
  - Collective Intelligence Conference, New York University, June 2016[ii]

- "Open Source Software and Firm Productivity"
  - National Bureau of Economic Research (NBER) Summer Institute, Boston, MA, July 2016
  - American Economic Association (AEA) Annual Meeting, Boston, MA, January 2015
  - INFORMS Annual Meeting, San Francisco, CA, November 2014
  - INFORMS Conference on Information Systems and Technology (CIST), November 2014
  - Strategic Management Society Conference, Madrid, Spain, September 2014
    - **Best Conference Paper, Finalist**
  - 2nd Conference on Knowledge Commons, NYU Engelberg Center on Innovation Law & Policy, September 2014
  - Academy of Management Annual Conference, Philadelphia, PA, August 2014
  - Harvard Business School TOM Alumni Research Workshop, August 2014
  - Open and User Innovation Conference, Harvard Business School, July 2014
  - DRUID Society Conference on Entrepreneurship, Organization, and Innovation, Copenhagen Business School, June 2014
  - ZEW Conference on the Economics of Information and Communication Technologies, Centre for European Economic Research, Mannheim, Germany, June 2014
  - Charles River Conference, Harvard Business School, May 2014
  - Consortium on Competitiveness and Cooperation (CCC), Boston University, April 2014

- "Innovating without Information Constraints: Organizations, Communities, and Innovation When Information Costs Approach Zero"
  - 2nd Conference on Knowledge Commons, NYU Engelberg Center on Innovation Law & Policy, September 2014

- "Online Word of Mouth and Product Quality Disagreement"
  - Academy of Management Annual Conference, Philadelphia, PA, August 2014
    - **Selected for Best Paper Proceedings**
  - Workshop on Information Systems and Economics (WISE), Orlando, FL, December 2012[2]

- Workshop on Information in Networks (WIN), NYU Stern, September 2012[2]

- "Stock Market Prediction via Social Media: The Importance of Competitors"
  - Workshop on Information in Networks (WIN), NYU Stern, September 2013
  - Academy of Management Annual Conference, Orlando, FL, August 2013
  - 11th ZEW Conference on the Economics of Information and Communication Technologies, Center for European Economic Research, Mannheim, Germany, June 2013
  - London Business School Trans-Atlantic Doctoral Conference, London, UK, May 2013

- "Supply-Chain Based Network Effects in In Information Technology Adoption"
  - Academy of Management Annual Conference, Orlando, FL, August 2013[2]

Media Coverage and Interviews

- "Stock Market Prediction via Social Media: The Importance of Competitors"
  - Guarda, Dinis. "Social Investing and Considerations about the Stock Market Going Social." *The Motley Fool*, August 20, 2012.
  - Copeland, Dave. "Harvard Researcher Uses Social Media to Predict Stock Market Volume." *ReadWrite*, February 8, 2012.

Teaching Experience

- **University of Southern California – Marshall School of Business**
  - BUAD 497 - Strategic Management, 2016-2017.
- **Harvard Business School**
  - Analytics – Teaching Fellow for pre-MBA program, 2011 - 2014. Head Teaching Fellow, 2013, 2014.
  - Technology & Operations Management – Teaching Fellow for core MBA course, Fall 2013.
  - Managing Innovation - Teaching Fellow for elective MBA course, Spring 2012.
  - Leading Change and Organizational Renewal – Facilitator for Executive Education course, 2011.
- **Federal Bureau of Investigation (FBI)**
  - Network Investigation Techniques for Agents – Developer and lead instructor for a required course for all new FBI cyber agents, 2009 – 2010.
  - Wireless Security – Lead instructor, 2008 –2009.
- **Georgetown University**
  - Computer Hardware Fundamentals – Teaching Assistant, Spring 2004.
  - Computer Science I – Teaching Assistant, Spring 2002 and Fall 2003.
  - Computer Science II – Teaching Assistant, Spring 2003.
  - Introduction to Computer Science I – Teaching Assistant, Fall 2002.

Professional Service

- Ad-Hoc reviewer for Management Science, Organization Science, Strategic Management Journal, Information Systems Research, and Telecommunications Policy.
- Program Committee for INFORMS Conference on Information Systems and Technology (CIST 2014 - 2017).
- Symposium Session Organizer for Academy of Management (2016, 2017)
- Session chair for Academy of Management (2016) and Strategic Management Society (2016)
- Reviewer for Strategic Management Society Conference (2017).
- Grant reviewer for Social Sciences and Humanities Research Council (Canadian equivalent of the NSF).
- Discussant for LBS TADC 2013, ZEW ICT 2013, DRUID 2014, ZEW ICT 2014.
- Reviewer for Academy of Management Annual Conference for TIM and OCIS divisions (2013, 2014).
- Reviewer for Social Network Mining, Analysis and Research Trends: Techniques and Applications, ed. I-Hsien Ting.

- Reviewer for Studies in Mining Social Networks and Security Information, edited by Zeki Erdem, Tansel Ozyer, Suheil Khoury and Jon Rokne.

Institutional Service

Marshall School of Business, University of Southern California

- Marshall Digitopolis, school wide initiative supporting research on digital business, co-founder 2016 - present
- Strategy Faculty Recruiting Committee, member 2015-2016
- Strategy Seminar Series, coordinator 2016-2017
- Qualifying Exam Committee Member: Jihoon Hong (Marketing)

Harvard Business School

- Student Advisory Group – Member of committee that advises the doctoral office on student policies, 2012-2015
- Wyss Mentoring Award Committee – Member of selection committee for faculty mentoring award, 2013-2015
- Student Mentor for incoming doctoral students in the TOM unit, 2013-2015
- Panel member for various presentations to incoming and accepted doctoral students at HBS

Professional Experience

Multiple Big Data Analytics Startups	Various Locations
Technical Advisor	April 2012 - Present
Mandiant Inc. (acquired by FireEye)	Alexandria, VA
Senior Security Consultant	October 2008 – July 2010
Deloitte & Touche LLP	Washington, DC
Senior Consultant, Federal Security and Privacy	September 2007 – October 2008
iDefense, A VeriSign Company	Dulles, VA & London, UK
Assistant Director of Vulnerability Intelligence	September 2005–September 2007
iDefense, Inc.	Reston, VA
Security Analyst	May 2003 – September 2005
Nokia Mobile Phones	Burlington, MA
Software Engineer Intern	June 2002- August 2002

[i] Unable to attend award ceremony, therefore not included on published list of finalists
[ii] Presented by a co-author