Measuring the Scope and Impact of Open Source Software

Government Advancement of Statistical Programming (GASP) Workshop 20

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UNIVERSITY of VIRGINIA
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NSF NCSES National Center for Science and Engineering Statistics

The NCSES and UVA
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Open Source Software (OSS)

“A computer software, with its source code made available with a license, in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose.” (Open Source Initiative)

It is developed *within and outside* of the private sector

- *universities* (e.g., Stanford, MIT, UC Berkeley),
- *businesses* (e.g., Microsoft, Google),
- *government research institutions* (e.g., Sandia National Lab),
- *nonprofits*, and
- *individuals*

Current NCSES and other economic indicators do not measure the *value of open source software* outside the business sector.

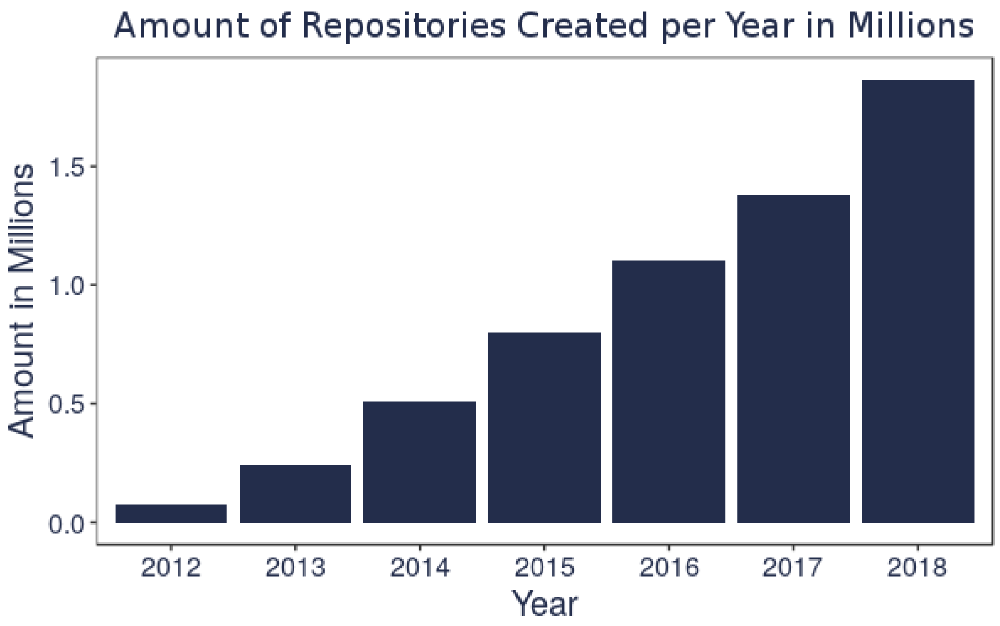
Research Questions

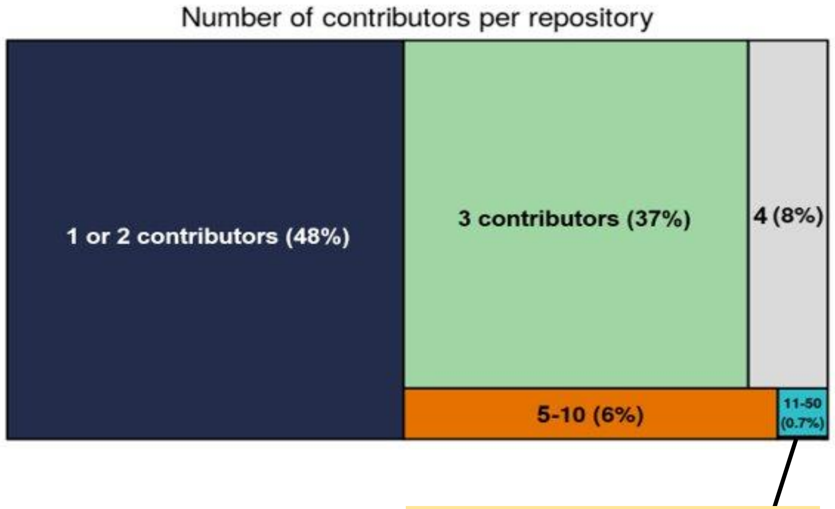
- How much open source software is in use? (*stock measure*)
- How much is created each year? (*flow measure*)
- What types can be identified?
- Who creates it? (*Sectors:* Business, Government, Academia, Households, Nonprofits, Foreign)
- What *sources of data and variables* could serve as proxies for measuring attributes and economic value of open source software?
  - Counts of OSS, by sector (e.g., university, government), by technology
  - Attributes, e.g., # citations, #downloaded,

OSS Universe: Projects on GitHub

- **55.1M** repositories with commits 2012-2018
- **7M** repositories with OSI-approved licenses on GitHub as of July 2019.

  Of those, we analyzed **4.9M** repos that have at least one commit.
- There are **2.8M** unique OSS contributors

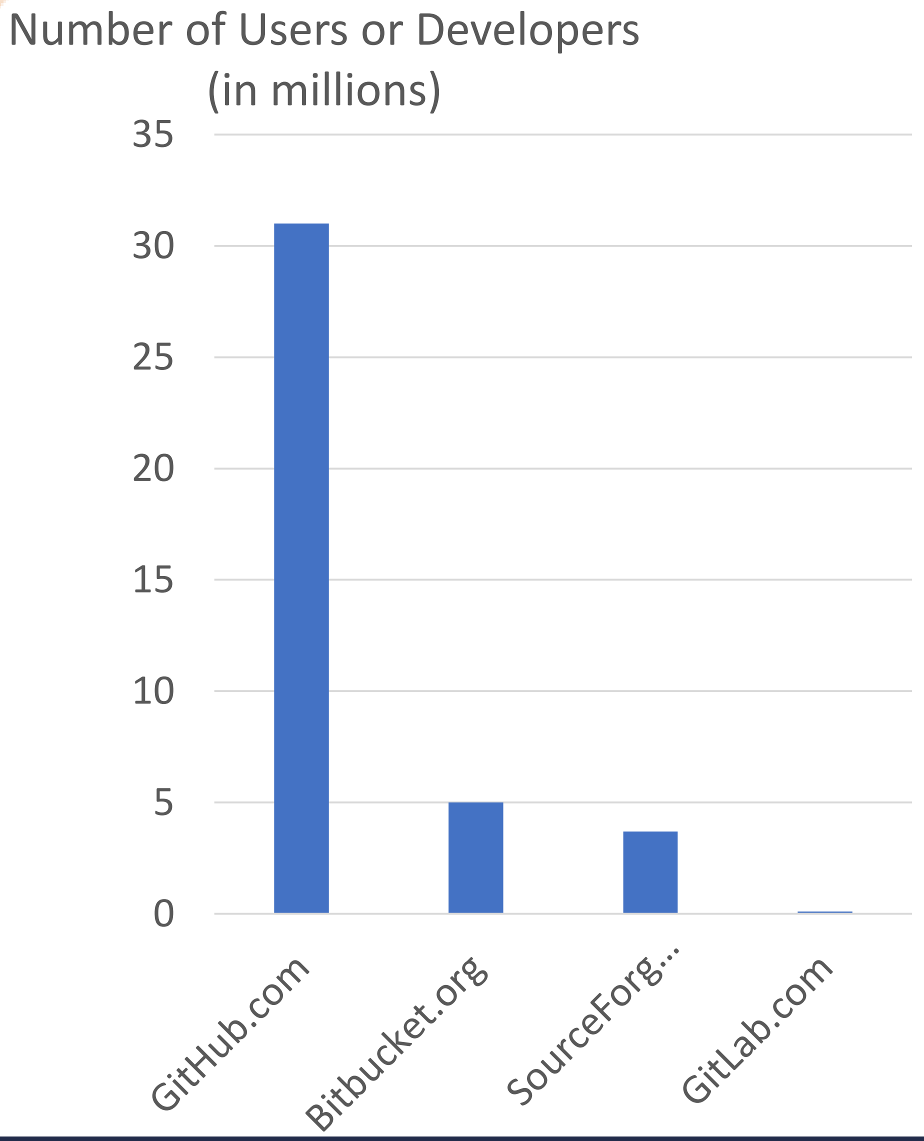

Amount of Repositories Created per Year in Millions


Number of contributors per repository

> 50 contributors (0.3%)

Most repositories have fewer than 5 contributors.

OSS Universe: Programming Languages

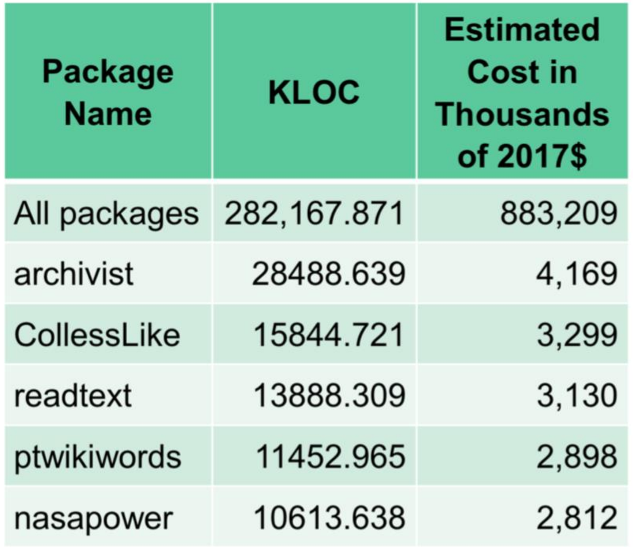


Language	R	Python
Package manager	CRAN	PyPI
Number of packages	13,719	164,836
OSI-approved & production ready	13,143	15,043
Packages on GitHub	4,407	11,016
Packages on GitHub (analysis)	4,358	9,773

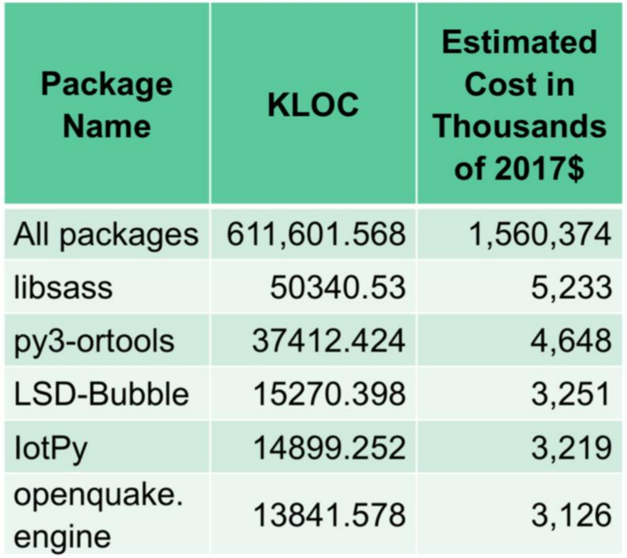
Value of OSS: Cost of Software Package Creation

- Identify number of people involved each package’s development
- Estimate time spent on software development using **Kilo-lines of code (KLOC)**
- Estimate **resource cost** with wage equivalent for 2017
  - Using average compensation for **computer programmers**
  - Occupation Employment Survey, Bureau of Labor Statistics
- Estimate **non-wage costs**
  - Adapting BEA (Bureau Economic Analysis) and OECD (Organisation for Economic Co-operation and Development) methodologies

Cost of R and Python Packages developed on GitHub



Package Name	KLOC	Estimated Cost in Thousands of 2017$
All packages	282,167.871	883,209
archivist	28488.639	4,169
CollessLike	15844.721	3,299
readtext	13888.309	3,130
ptwikiwords	11452.965	2,898
nasapower	10613.638	2,812

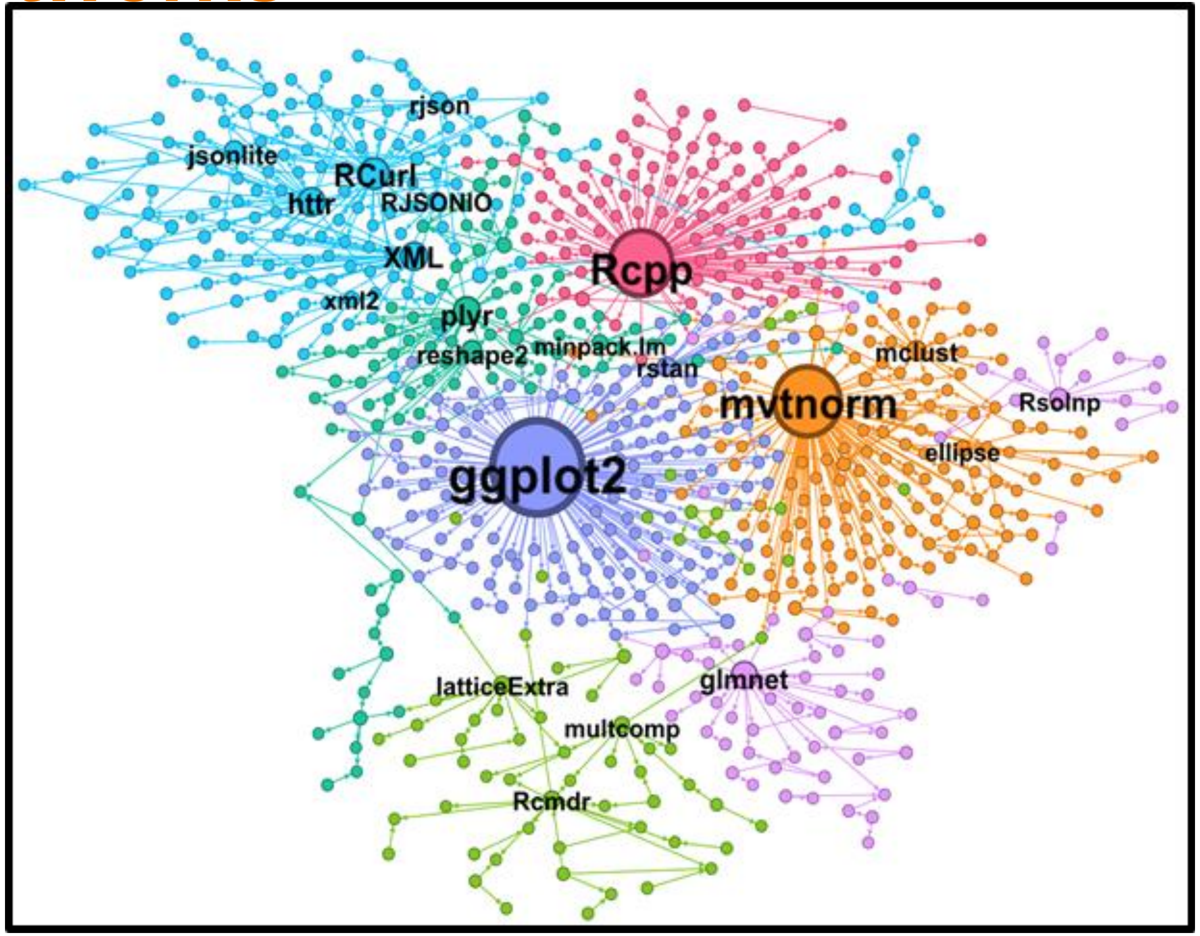


Package Name	KLOC	Estimated Cost in Thousands of 2017$
All packages	611,601.568	1,560,374
libsass	50340.53	5,233
py3-ortools	37412.424	4,648
LSD-Bubble	15270.398	3,251
IotPy	14899.252	3,219
openquake. engine	13841.578	3,126

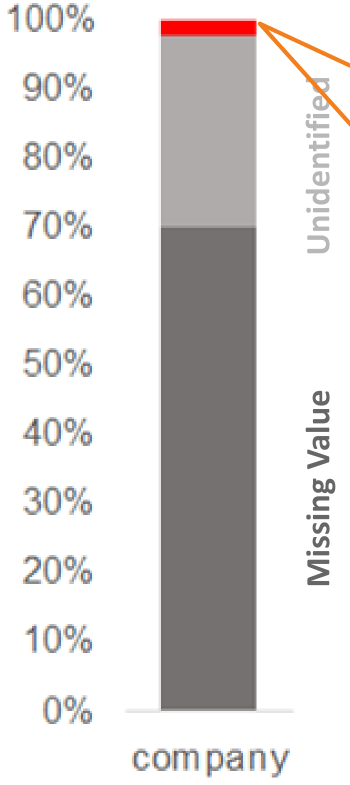
Impact of OSS: Downloads and Dependency Networks

Package	2018 Downloads
Rcpp	3,519,510
rlang	2,893,889
stringi	2,610,184
stringr	2,511,011
ggplot2	2,495,315

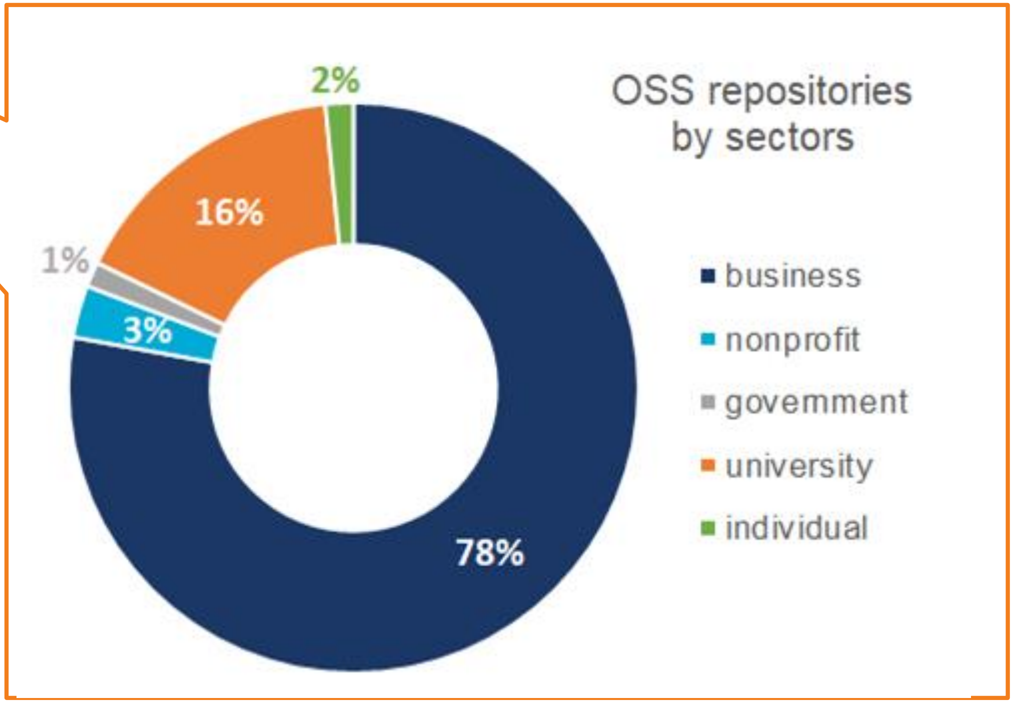
Package	Reuse
ggplot2	105,774
plyr	101,596
digest	99,774
stringr	98,086
colorspace	93,590



Limitations: Sectors of OSS



In the data, only ~2% of the users' sectors can be identified



- We use the self-reported company field in contributors profile.
- Only 2% of the contributors can be identified.
- OSS is becoming more permissive as businesses contribute more code.

Next Steps

- Get more detailed data on the OSS repositories, including additions and deletions to estimate the development cost using the lines of code
- Obtain contributor emails to improve the sector analysis
- Conduct network analysis to study interactions between contributors and OSS projects, and diffusion of OSS innovation.

Products

Peer-Reviewed Publications

Keller, S.A.; G. Korkmaz; C. Robbins; and S. Shipp. 2018. “Opportunities to Observe and Measure Intangible Inputs to Innovation: Definitions, operationalization, and examples.” *Proceedings of the National Academy of Sciences (PNAS)*. 115 (50), 12638-12645.

Korkmaz, G.; C. Kelling; C. Robbins; and S. Keller. 2018. “Modeling the Impact of R Packages Using Dependency and Contributor Networks.” *Proceedings of the 2018 IEEE/ACM International Conference on Advances in Social Network Analysis and Mining* (ASONAM), pp. 511-514. IEEE.

Conference Presentations/Papers

- National Bureau of Economic Research (NBER) Conference on Research in Income and Wealth (CRIW) Conference: Big Data for 21st Century Economic Statistics, Bethesda, MD, Mar. 2019.
- 2019 Women in Data Science Conference, Charlottesville, VA, Mar. 2019.
- International Association for Research in Income and Wealth (IARIW) 35th General Conference: Innovation and the Digital Economy, Copenhagen, Denmark, Aug. 2018.
- IEEE/ACM International Conference on Advances in Social Network Analysis and Mining (ASONAM), Barcelona, Spain, Aug. 2018.
- International Monetary Fund (IMF) Statistical Forum on Measuring Economic Welfare in the Digital Age: What and How? Washington D.C., Nov. 2018.
- NBER Conference on Research in Income and Wealth (CRIW) Pre-Conference: Big Data for 21st Century Economic Statistics, Cambridge, MA, Jul. 2018.
- Interagency Council on Statistical Policy (ICSP) Big Data Day, Committee on National Statistics (CNSTAT), Washington, DC, May 2018.
- Federal Committee on Statistical Methodology (FCSM) 2018 Research and Policy Conference, Washington DC, Mar. 2018.
- Arthur M. Sackler Colloquia of Sciences: Modeling and Visualizing Science and Technology Developments, Irvine, CA, Dec