Duo: The Economic Impact of Open Source

The EU Dimension

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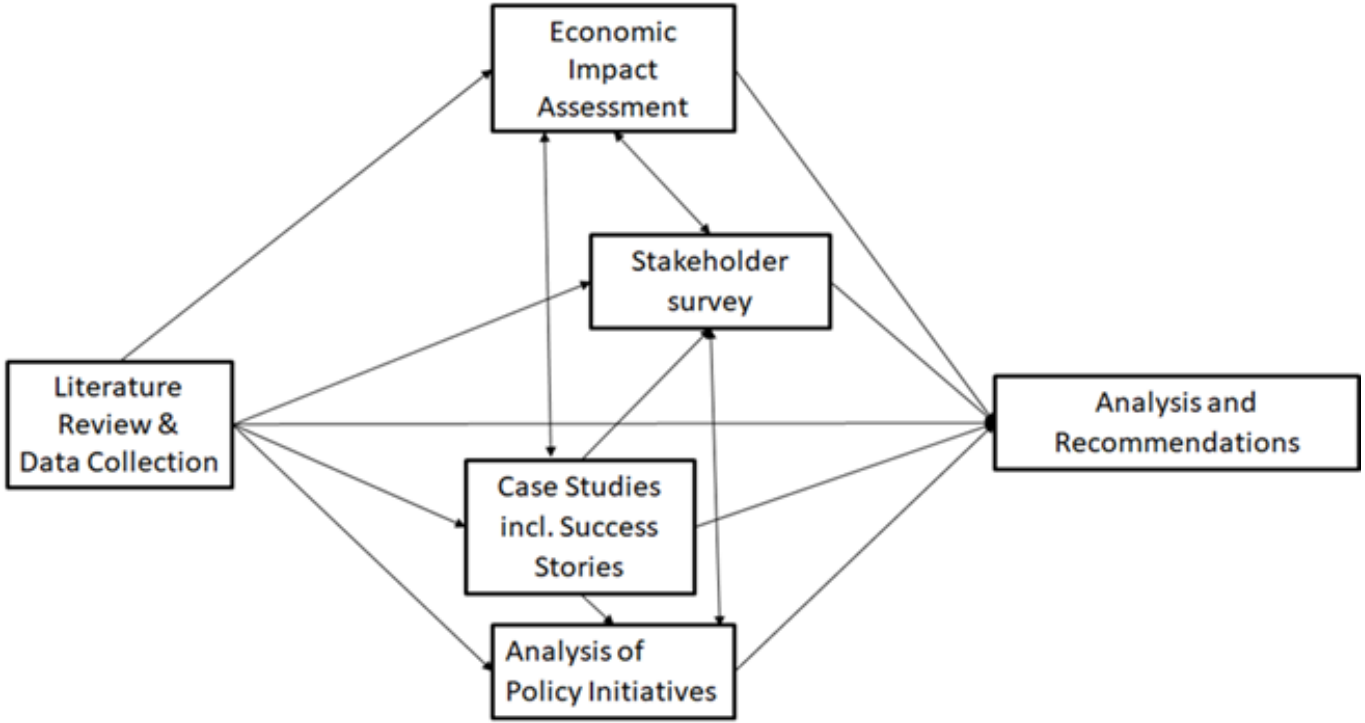
Relation of methodological approaches



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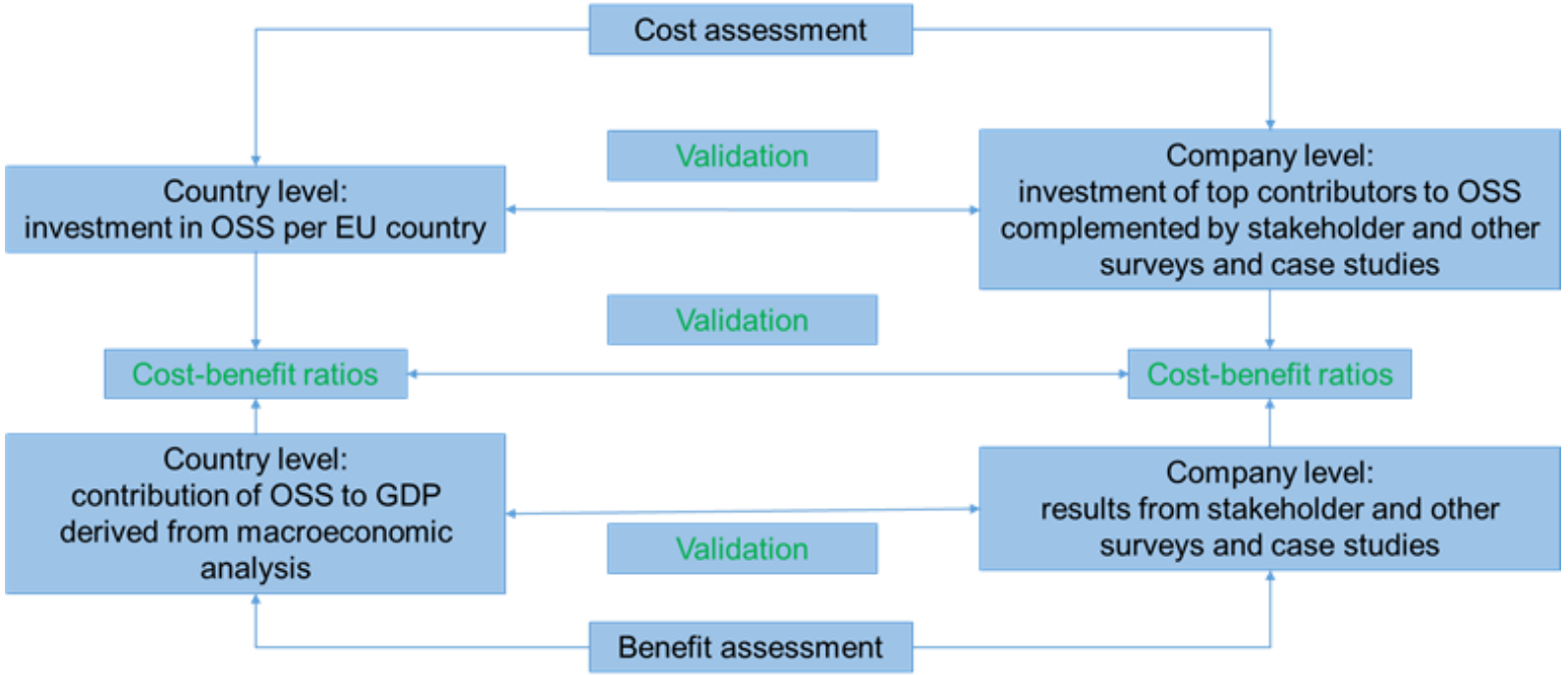
Overall approach of Economic Impact Assessment



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Data sources

- Open Source Software
  - 1.3 billion commits at GitHub
  - 32 million users at GitHub with 1.5 million organisational affiliations and 2.5 million country codes
  - almost 700,000 organizations
- Economic Data
  - OECD
  - Eurostat
  - European Patent Office
  - Crunchbase, Amadeus, Worldbank, ILO, ...

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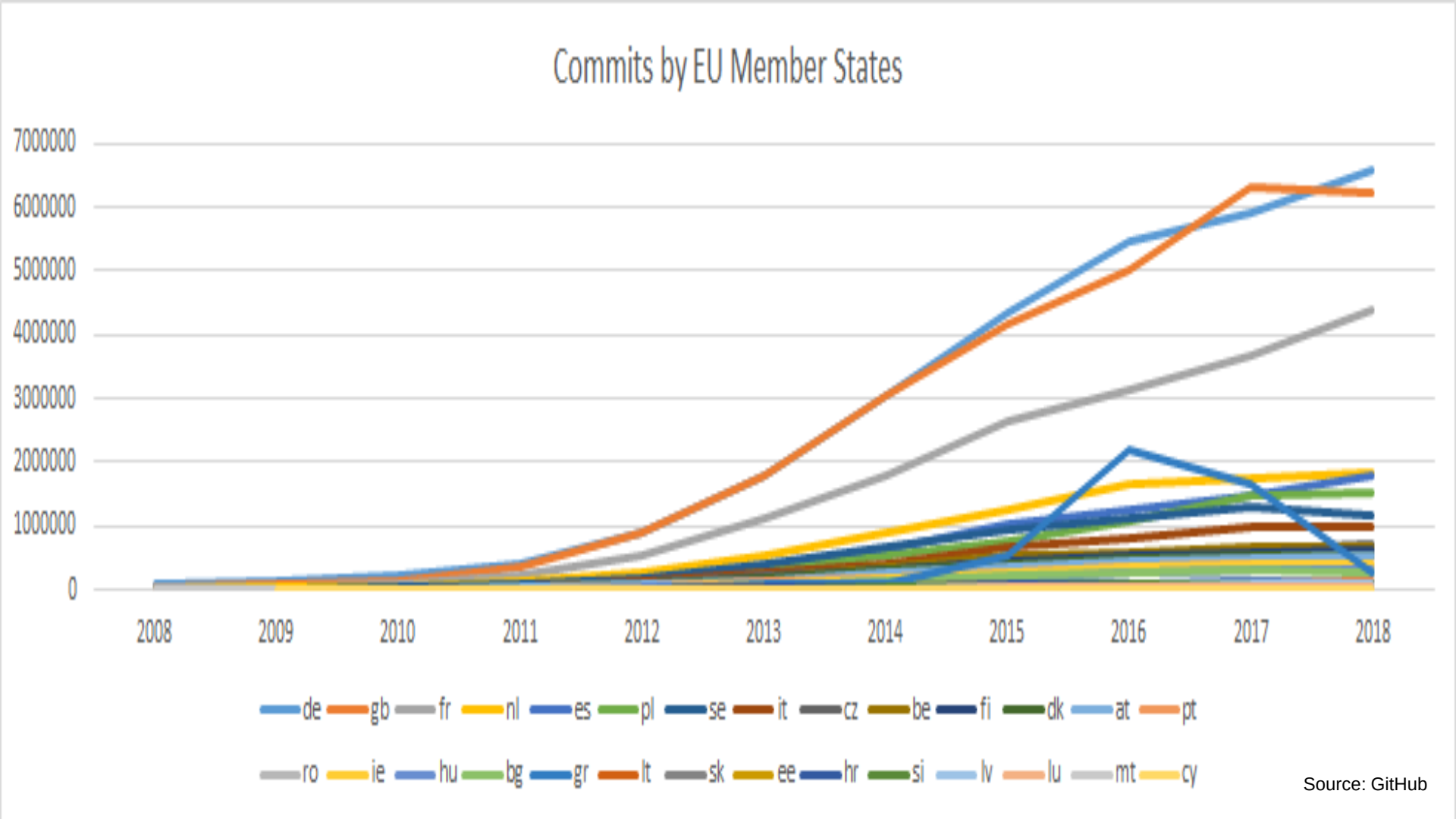
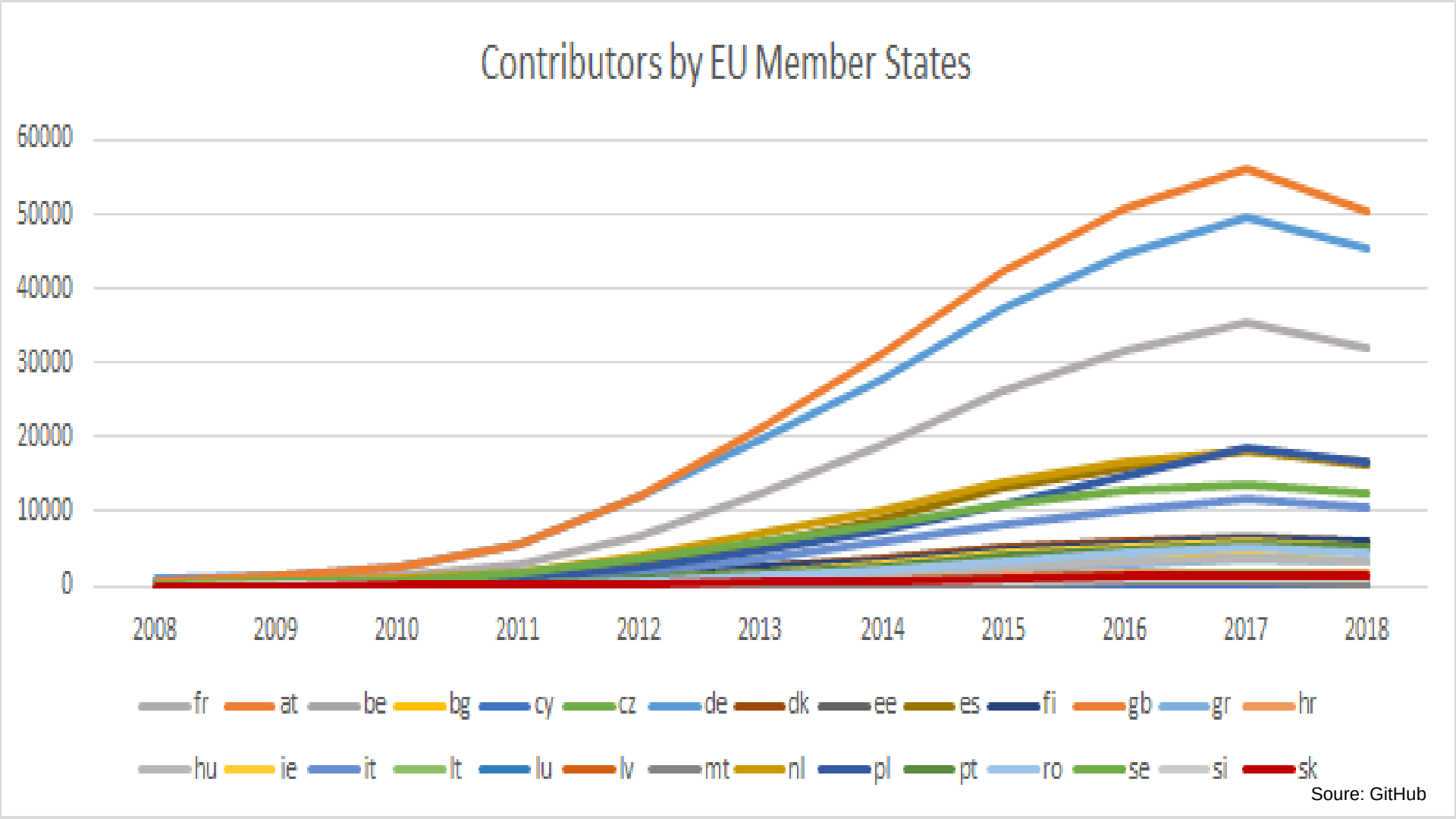


Source: GitHub



Soure: GitHub

Cost-based impact assessment

- Two cost-based impact assessments to generate baseline of economic impact of OSS based on two pillars:
  - efforts by the Member States of the EU
  - efforts by the most active companies located in the EU Member States
- Findings only present lower bound of economic impact
- Basic assumption beyond this approach is that benefits, i.e. OSS in the public domain, derived from these investments will at least outweigh invested costs

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The cost of investing in OSS in the EU: the Member State level

- more than **3 millions employees** in computer programming in the EU
- in 2018 more than **260,000 contributors to GitHub**, i.e. on EU average **8.2%** of employees in computer programming
- average personnel cost of all contributors based on full time equivalents of more than **Euro 14 billion** in 2018
- in 2018 more than **30 million commits** to GitHub representing an effort of more than **16,000 FTEs** based on Constructive Cost Model
- **almost Euro 1 billion** invested personnel cost in the EU in 2018

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The cost of investing in OSS in the EU: the company perspective

- **most active companies** in GitHub in 2018 responsible for >12% of contributors and one third of commits **employing > 1 million employees**
- high share of **small companies among most active companies participating in OSS,** i.e. > 75% have < 100 employees
- **the smaller the companies, the more contributors** are listed**, the more commits they provide,** i.e. almost 50% by companies < 50 employees, **and the more efforts they invest,** e.g. those between 11 and 100 employees invest > 5% of their FTEs
- **validity of company and Member State based cost-based approach confirmed**

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Basic Model following Botazzi & Peri (2007)

- Cobb-Douglas production function:

- $Y_{it} = A_{it-1} K_{it}^{\alpha} L_{it}^{\beta}$ (1)

with Y = output, K = capital and L = labour, α, β = production elasticities and A_{it} = knowledge stock

- $log(\dot{A_{it}}) = \varepsilon_1 logRD_{it-1} + \varepsilon_1 logRD_{it-1}^{ROW} + \varepsilon_1 logA_{it-1}$ (2)
- $logY_{it} = \gamma_1 logRD_{it-1} + \gamma_2 logRD_{it-1}^{ROW} + \gamma_3 logPAT_{it} + \alpha logK_{it} + \beta logL_{it} + logF(.)$ (3)
- $logY_{it} = \gamma_1 logRD_{it-1} + \gamma_2 logRD_{it-1}^{ROW} + \gamma_3 logPAT_{it} + \alpha logK_{it} + \beta logL_{it} + \gamma_4 logOSS_{it-1} + \gamma_5 logOSS_{it-1}^{ROW} + logx_{it}\mu$ (4)

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European Growth Model

- $logY_{it} = \gamma_1 logRD_{it-1} + \gamma_2 logRD_{it-1}^{ROW} + \gamma_3 logPAT_{it} + \alpha logK_{it} + \beta logL_{it} + \gamma_4 logEU\_OSS_{it-1} + logx_{it}\mu$
- elasticity, i.e. the measurement of the percentage change of one economic variable in response to a change in another, of GDP in EU member states in response to their contributions to OSS

  0.04 (based on commits)

  0.06 (based on contributors)

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Quantification of economic benefit based on European growth model

- elasticity of 0.04, i.e. the **10% increase of commits** as from 2017 to 2018 to GitHub is **contributing 0.4% of GDP** in the EU
- in 2018, 0.4% of the total GDP of Euro 15,900 billion in the EU is a contribution of more than **Euro 63 billion** per year
- a **10% increase in the number of contributors** would raise EU GDP **by 0.6%**, i.e. **Euro 95 billion** per year
- in summary, EU economy is significantly benefiting from global pool of OSS
- if EU can increase in the future both of them by 10%, additional GDP of **> Euro 100 billion per year** in the EU is possible in the future

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Cost-benefit ratios

- Cost-benefit ratios based on the commits: 63:1,
  based on the number of contributors: 95:15
  Remark: we assume that the 260.000 software developers in the EU contributing to GitHub work full time on OSS, but studies report at maximum 10%, i.e. the effort has to be divided by 10 leading to a similar ratio of 60:1
- but contribution of OSS to the GDP in 2018 not only based on code developed in 2018, but also on the code in previous years
- Bernhardsson (2016) reveals for different OSS projects a half-time of 3.33 years, i.e. only 50% of the code is used after 3.33 years; Linux has even a half-time above six years; he shows that the half-time of OSS more recently released is significantly lower
- assuming a linear depreciation rate of 10% and the same effort per year, then the effort in 2018 has to be multiplied by five, which leads us to a cost-benefit ratio of 12:1

Cost-benefit ratio at the macro level

- Contributions of OSS to GDP based on cost for current and historical code
- Considering additionally hardware costs
- Overall, we derive **cost-benefit ratio of at least 1:4**
- Cost of one FTE to contributing to OSS generates additional GDP of four times the cost
- Result consistent with similar studies on ICT hardware and innovation expenditure

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Policy Recommendations

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Policy Recommendations

1. Building Institutional Capacity
2. Knowledge Creation
3. Knowledge Diffusion and Networking
4. Entrepreneurial Activities
5. Financial Capital Development
6. Regulatory Environment
7. Market Creation
8. Creation of Legitimacy
9. Human Capital Development
10. Strategic Intelligence
11. Domain-specific recommendations
    a. Open Source Hardware recommendations
    b. AI, HPC, software defined infrastructures, sustainability

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Summary

- Today, large economic impact of OSS and potential impact of emerging OSH
- Utilise public policy to further scale and incentivise production of OSS for the benefit of the European economy
- Comprehensive and coordinated policy approach needed based on institutional capacity in the various layers of the public sector

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