Economic Impact of Free and Open Source Software Usage in Government
Final Report

June 2015

Principal Investigator	Rahul De' *Hewlett-Packard Chair Professor*, IIM Bangalore
Co-Investigators	Lewin Sivamalai, Ravi A. Rao (IIM Bangalore) Sharmila Chakravarty, Supriya Dey, Uma Bharath (Independent Researchers)

Acknowledgement

This report was prepared with a grant from the International Centre for Free and Open Source Software (ICFOSS), Thiruvananthapuram, Kerala. The authors would like to thank Satish Babu, Director of ICFOSS, for all the help and cooperation extended to the project team.

License

Contents

Executive Summary 1

1 Introduction **3**

2 Method **6**

3 FOSS Adoption Around the World **9**
3.1 Reasons for Adoption of FOSS 9
3.2 Case Study: FOSS in Brazil 11
3.3 FOSS Policies of Governments 12

4 Analysis of Field Data **14**
4.1 Analysis of Eduction Department Responses 14
4.1.1 Kerala 14
4.1.2 Karnataka 16
4.1.3 Goa 18
4.1.4 Maharashtra 18
4.1.5 Assam 19
4.2 Analysis of Police Department Responses 20

5 Summary & Conclusions **24**
5.1 Summary and Key Findings 24
5.2 Conclusions 25
5.2.1 Tangible and Intangible Benefits 25
5.2.2 Hurdles to FOSS Adoption 28
5.2.3 Policy Implications for FOSS 28

Executive Summary

Use of free and open source software (FOSS) in government departments around the world has increased significantly over the years. This policy-driven phenomena has benefits both for the departments and the economy at large. The objective of this report is to examine whether there are any tangible or intangible benefits (or losses) associated with use of FOSS, with a focus on state departments in India.

Two departments, Education and Police, were studied in seven states in India. These departments had considered FOSS use and several were actively using FOSS. These departments were researched through an extensive field study that involved visits to department offices, schools, police stations, central offices, and affiliated institutions, in all seven states. The field data were analysed with extensive secondary data obtained from online and offline published sources.

By its very nature FOSS promotes sharing, experimentation and carefree use. These properties have strong intangible impacts on those who adopt and use FOSS. The study shows that schools in Kerala that had adopted FOSS, benefited from a do-it-yourself and experimentation culture that was fostered by the technology. Compared to other states, where schools adopted proprietary software, teachers and administrators in Kerala were more adept at addressing and solving their technology-related problems, were open to sharing their knowledge about IT, participated actively in setting the IT syllabi and examinations, and depended very little on vendors.

Teachers and administrators in states that had adopted proprietary software in schools depended heavily on vendors for ICT use and teaching in schools. Setting syllabi and examinations were also outsourced to vendors. There was very little evidence of self-reliance and sharing in IT problem-solving related issues.

Tangible benefits of adopting FOSS include significant cost savings, mainly from avoiding buying proprietary licences for operating systems and application software, their upgrades and for anti-virus software. At a rough estimate, the tangible savings from using FOSS in schools across India can be to the tune of Rs 8254 crores (USD 1.3 billion).

Despite the advantages, FOSS adoption in the two departments across states was not widespread. There were significant hurdles to state departments considering FOSS, despite having, in some cases, an inclination to do so. A major hurdle was the dependence on vendors, through the use of the build-own-operate-transfer (BOOT) models, who then dominated the decisions regarding software choice. This dependence also led to lack of

confidence amongst officers and departments in their own decision-making abilities vis-a-vis FOSS choice.

Another significant hurdle was misinformation regarding FOSS. Respondents were largely aware of FOSS, but many held negative views regarding this class of software. As compared to proprietary software, many held the following views: FOSS was more expensive; FOSS created a lock-in to vendors (and monopoly proprietary software did not); FOSS was not reliable; FOSS was prone to virus attacks; FOSS did not have vendor support; and FOSS was not stable.

A clear policy implication from this study is that any further development of FOSS adoption in government has to focus on clearing the misinformation and highly negative views that have been spread.

Another clear policy implication for FOSS adoption in schools is that this can be strongly encouraged, as this study found that all concepts of ICT taught in schools can be taught using FOSS; there is no need to consider proprietary software at all.

Further, FOSS policy has to promote the do-it-yourself and self-reliant nature of FOSS, and even when there is need for vendors to be involved, to ensure that key decision making is not outsourced to them.

1 | Introduction

Free and Open Source Software (FOSS) is increasingly being used by government departments around the world. This choice is driven by the increased adoption of information technology by governments, often referred to as electronic government (egov), and also by the value proposition that FOSS provides. FOSS provides access to high-quality software, with licenses to use and modify freely, and is usually available free of cost. When government departments consider developing egov applications to improve their services and reach to citizens, FOSS is often a powerful alternative to consider.

FOSS advantages, however, are not always readily understood by all decision makers. There are many complexities in decision making in government departments, driven by aspects of funding, hierarchy of administration, policy conflicts, impoverished understanding of technology and influence of powerful vendors. When it comes to making clear and rational choices with regard to adoption of technology, many government departments experience considerable difficulty. Information technology is constantly evolving and changing in both scope and form, and this further confounds clear and rational decision making.

This study began with the premise that FOSS represents a strong and viable alternative to proprietary software, and as such has strong economic implications when adopted. This premise is founded on a prior study, conducted in 2010[1], which concluded that if proprietary desktop and laptop software is substituted by FOSS, even partly, the savings for India could add up to $2 billion annually.

The economic contribution of FOSS is not restricted to the aspect of substitution of paid, proprietary sotware alone. It is also based on other aspects such as costs of experimenting and exploring, costs of training and familiarization, costs associated with developing complementary products, cost of servicing the software, recurring costs associated with upgrades, and so on. Costs associated with the total life cycle of a software application are

[1]De', R. (2009) "Economic Impact of Free and Open Source Software - A Study in India.

usually known as the total cost of ownership (TCO) that is written up quite extensively in the literature. However, it is also well known that TCO is highly contextual in nature and there are no standard measures of TCO that can be applied across departments and organisations. TCO computations require factoring costs of licensing, maintenance, integration, support and training. The latter three costs are directly dependent on labour costs (as they are labour intensive activities). In developed countries, where labour costs are higher, the licensing costs do not figure prominently in the TCO computations. However, in less developed countries and developing countries, where labour costs are lower, the software license costs play a significant role in the TCO computations[2].

FOSS has many implications for the economic development of an economy. When seen as a public good it acts as a lever that enables many forms of development, for example, as a low-cost driver of innovation in public processes, as a platform for entrepreneurs to develop products, and as an enabler for public knowledge products such as Wikipedia. Governments around the globe have understood these implications of FOSS and have adopted policies to promote the same.

However, there is also a counter argument that FOSS is a free and public alternative for revenue generating products, and hence drives away entrepreneurship and closes down options for further economic development. Those who make this argument rely on an assumption that FOSS and proprietary software can be compared as rival products, with roughly the same utilities.

Objectives of Study

The objective of this report is to examine the impact of FOSS adoption in government departments.

Tangible and Intangible Benefits When an organisation adopts a powerful technology, such as FOSS, there are both tangible benefits - such as cost savings, increase in efficiency, increase in accuracy, etc - and intangible benefits - such as increase in transparency, improvement in decision making etc. The objective of this report is to examine both the tangible and intangible benefits (or challenges) of FOSS adoption.

Hurdles to FOSS Adoption Though government departments are not averse to adoption of information technology as such, there appear to be some

[2]Ghosh, R. A. (2003). "Licence fees and GDP per capita: The case for open source in developing countries." *First Monday, 8(12).*

hurdles to FOSS adoption. A priori, such hurdles may assume different forms, such as lack of information, low awareness, mis-information about security and cost issues, etc. The objective here is to uncover these hurdles and understand why they exist.

Policy Implications for FOSS Governments may create regulations and policies to favour FOSS adoption. There exist arguments exploring various hues of regulations. The objective of this report is to identify key policy issues for Indian government departments with regard to FOSS adoption.

2 | Method

This study was carried out in three distinct phases - desk research, RTI applications, and field visits. Each phase had specific objectives and steps that had to be carried out. In the following sections the phases are explained.

Desk Research The objectives of this phase of the study were to:

1. Identify the main issues of FOSS use that had to be examined further.
2. Develop a set of questions to be answered through the field study.
3. Identify sources of data for the secondary study.
4. Identify the departments to be issued RTI applications, and also the departments that had to be studied through direct field visits.

An extensive desk research was carried out by the team to explore the published literature on FOSS use by government departments. Well over 300 articles published in academic journals, as industry reports and online were examined and analysed. Sources of secondary data for the direct research questions were identified and collated.

The output from this phase was a detailed assessment of the state of electronic government in India, with a particular emphasis on state government departments. The study also helped identify and delineate a set of issues relevant for the study of FOSS in government departments. These issues were obtained from academic papers that reported on use of FOSS in governments around the world. The issues were varied and directly related to the context of the country and department involved. To focus the research, issues pertaining to developing countries were highlighted and selected.

The desk research phase also helped identify the government departments that would be best suited for primary data collection. The criteria for selection of the departments was that they should have considered the use of FOSS, and preferably have ongoing FOSS use in some states. The two selected departments were: Education and Police.

State	Region	Size
Karnataka	South	Large
Kerala	South	Large
Goa	South	Small
Uttar Pradesh	North	Large
Maharashtra	West	Large
Assam	East	Small
Jharkhand	East	Small

Table 2.1: States covered for data collection.

Following this, the states in which the primary data would be collected were chosen. The criteria for selection of the states were - whether there were reports of FOSS usage, the extent of electronic government use, and size of the state. Further, geographical spread was also included as a criteria. The states selected are listed in Table 2.1.

RTI Applications In an attempt to obtain data on spending on information technology, the Right to Information Act (RTI) of India was used to approach Education departments of 13 states and Union Territories. RTI applications were mailed to them, which included a detailed questionnaire requesting information on various aspects related to the study. All the departments responded, mostly by rejecting the applications on technical grounds. Three departments stated some cursory facts, without any details. In one state the RTI application was re-directed to all government colleges in the state - which resulted in 32 responses from colleges. Of these responses, some did mention details about their IT use.

Field Visits Field visits to Education and Police departments in the seven states were made by various members of the research team in the period October, 2013 - April, 2014. Respondents were selected carefully and each one was asked questions based on a questionnaire that had been prepared in advance. The interviews were unstructured in nature, with the intention of enabling the respondents to express their views freely. The questions were designed to initiate a conversation, and follow up questions were asked based on the views expressed.

For most cases respondents gave their views freely, however, there were instances in which the interviewees held back their responses, stating that they would have to seek permission to reveal some data or policy matter.

State	Interviews for Education	Interviews for Police
Karnataka	5 schools; 4 officers in the Department of State Education Research and Training (DSERT); one NGO; one private IT vendor; one officer in the Centre for Public Instruction	3 Officers; one Technical Manager; one private IT provider
Kerala	7 schools; 4 officers from the Education deparment; one officer from CDAC	2 Officers; 4 employees from the Keralal State IT Mission; one private vendor
Goa	4 schools; 6 Officers from the Education department	2 Officers
Uttar Pradesh	1 school; 1 Officer from the Education departmeht	3 Officers
Maharashtra	5 schools; 5 Officers from Education department	2 Officers
Assam	6 schools; 4 Officers of state Education department; 1 IT vendor	3 Officers
Jharkhand	none	2 Officers; 1 IT vendor

Table 2.2: Details of data collection.

To study FOSS use in the Education department, visits were made to schools, education department offices, non-governmental organisations (NGOs), and to private firms that provided IT services to schools. For the Police department study, field visits were made to police stations, police department offices (including training centres and IT offfices) and to National Informatics Centre (NIC) offices (a central organisation that supports IT deployment in different government departments). Details of the field visits are provided in the Table 2.2. Names of some individuals and organisations are not disclosed as they requested anonymity.

3 | FOSS Adoption Around the World

Over the years, governments worldwide have been veering towards adopting FOSS, notwithstanding their motivations or triggers, which often times are different. The number of government departments and countries that have adopted FOSS has increased significantly from 2006 to 2010, as depicted in Figure 3.1.

3.1 Reasons for Adoption of FOSS

While some governments (eg. Venezuela) have actively pursued FOSS options, with a strong focus on its democracy enhancing attributes (for free as in libre), others have remained 'technology neutral' (eg. many departments in India) while there are also governments, like Chinese Taipei, which have adopted FOSS for its immediately apparent benefits (cost savings or superior technical attributes).

Different countries, and within countries, different governmental agencies have been found to be at varying levels of adoption - from just emerging web presence to fully integrated, and running the whole spectrum in between. Though governmental FOSS adoptions have been varied (soft, staggered, voluntary migrations to hard, coercive migrations), in most cases the investments in FOSS are justified, not only from cost and security perspectives, but also in being participative and being pro-democratic, though the latter benefits may be more incidental than envisaged.

It is evident that government departments adopt FOSS for tangible and intangible reasons. The published literature has examples of both these reasons for adoption of FOSS, and some of these are discussed below.

Cost saving is probably the most widely cited tangible rationale for the adoption of FOSS, however there are other reasons too.

1. Import substitution of expensive proprietary licences; to conserve for-

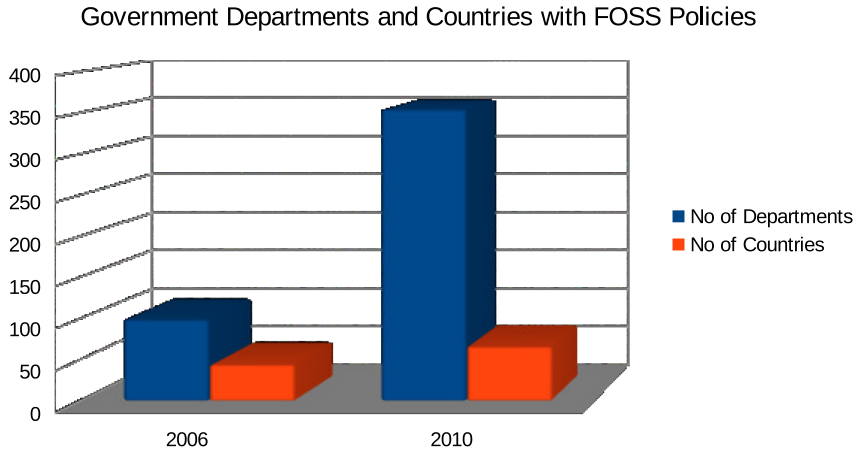

Figure 3.1: FOSS Adoption in Government (Source: Centre for Strategic and International Studies).

eign exchange; cost savings that results from using zero-cost-licence software (Camara & Fonseca, 2007[1]; Cook & Horobin, 2006[2])

2. To improve e-government capacity and access (Cassell, 2008[3]; Mengesha, 2010[4]; Shaw, 2011[5]); and for inter-departmental cooperation (Oram, 2011[6])

3. To avoid lock-in to vendors, promote indigenous companies; for national

[1]Camara, Gilberto, and Frederico Fonseca. (2007) "Information policies and open source software in developing countries." *Journal of the American Society for Information Science and Technology* 58(1): 121-132.

[2]Cook, Ian, and Gavin Horobin. (2006) "Implementing eGovernment without promoting dependence: Open source software in developing countries in Southeast Asia." *Public Administration and Development* 26(4): 279-289.

[3]Cassell, Mark. (2008) "Why governments innovate: Adoption and implementation of open source software by four European cities." *International Public Management Journal* 11(2): 193-213.

[4]Mengesha, Nigussie Tadesse. (2010) "The Role of Technological Frames of Key Groups in Open Source Software Implementation in a Developing Country Context." *The Electronic Journal of Information Systems in Developing Countries* 43.

[5]Shaw, Aaron. (2011) "Insurgent expertise: The politics of free/livre and open source software in Brazil." *Journal of Information Technology & Politics* 8(3): 253-272.

[6]Oram, Andrew. (2011) "Promoting Open Source Software in Government: The Challenges of Motivation and Follow-Through." *Journal of Information Technology & Politics* 8(3): 240-252.

security (tOSSAD Report, 2007[7]; UNCTAD Report, 2012[8])

The intangible reasons for adoptin of FOSS by government departments are varied.

1. According to Waring and Maddocks (2005) "OSS has to some extent revived the enterprise spirit of the programming community and has started to bring competitive choice and freedom back to the software marketplace"[9] Thus, FOSS helps to restore IT competencies that are lost to the overwhelming presence of imported, proprietary software.

2. FOSS helps to foster democracy and socio-technical alliances (Berry & Moss, 2006[10]).

3. FOSS enables the transfer of ICT skills to unserved populations and promotes technological change (Tapia and Maldonado, 2009[11]).

3.2 Case Study: FOSS in Brazil

Brazil is an interesting case study for FOSS adoption, as it took the matter of free software very seriously, even at the highest levels of government.

In the year 2000, a province in Brazil was one of the first in the world to make FOSS mandatory. Later, Brazil's government, in 2003, took a clear decision to promote FOSS in the country, by first shifting to FOSS in government agencies. A nodal agency was identified to help with this transition.[12],[13] The objective of this move was to convert Brazil to a 'producer' of IT rather than remain as a mere consumer of imported software. Brazil

[7]tOSSAD. (2007) "Current Status of F/OSS. Towards Open Source Software adoption and dissemination," D18, Version 2.3.

[8]UNCTAD. "Information Economy Report 2012: The Software Industry and Developing Countries."

[9]Waring, Teresa, and Philip Maddocks. (2005) "Open Source Software implementation in the UK public sector: Evidence from the field and implications for the future." *International Journal of Information Management* 25(5): 411-428.

[10]Berry, David M., and Giles Moss. (2006) "Free and open-source software: Opening and democratising e-government's black box." *Information Polity* 11(1): 21-34.

[11]Tapia, Andrea, and Edgar Maldonado. (2009) "An ICT skills cascade: Government-mandated open source policy as a potential driver for ICT skills transfer." *Information Technologies & International Development* 5(2): pp-31.

[12]Shaw, A. (2011). "Insurgent expertise: The politics of free/livre and open source software in Brazil." *Journal of Information Technology & Politics*, 8(3), 253-272.

[13]Oram, A. (2011). "Promoting Open Source Software in Government: The Challenges of Motivation and Follow-Through." *Journal of Information Technology & Politics*, 8(3), 240-252.

had spent about $1.1 billion in software licences in 2002. Microsoft corporation, which dominated the Brazilian market with 60% servers running on Windows, countered the move by arguing that technology selection should be based on merit (of the technology) rather than on political considerations.

Arguments in favour of FOSS stated were: better access to the latest technology, better use of limited budgets, and growth of software as a public good. State departments and agencies not only adopted existing FOSS, but also developed software on their own, for education and telecommunications etc, and released the code on FOSS licences. Many large private, and multi-national, firms too made the decision to shift to FOSS and this included retailers, banks, and telecommunications companies. Carrefour, a large multi-national retail chain, first tested FOSS on a hundred cash registers and later moved 7000 of them to open source.

Brazil's shift to FOSS contributed to its overall national development as it reduced payments and royalties on imported software, enhanced the security of systems of national importance, reduced technological dependence and enhanced autonomy, and enhanced the ability to create cultural goods, such as photographs, music, films, design and published artifacts (Schoonmaker, 2007[14]).

3.3 FOSS Policies of Governments

There is some dispersion of opinion amongst academics about the role and use of FOSS policies by governments. At the extreme ends of these are opinions that oppose any explicit policy and those that mandate strong FOSS policies.

Should governments promote FOSS as policy?

Schmidt and Schnitzer (2003) argue that governments **should not** favour FOSS, either as a requirement for government technology purchases, or through subsidies. Their argument is based on the premise that governments should not favour any particular 'product' as this would reduce competition, impact innovation and increase overall prices as products become uncompetitive[15].

There are market failures in software production and use - in many countries there are not enough software engineers and coders, there is strong lock-in to some proprietary products with very high switching costs, and incompatibility of standards prevents free choice of software. Such failures

[14]Schoonmaker, Sara. (2007) "Globalization from below: Free software and alternatives to neoliberalism." *Development and Change* 38(6): 999-1020.

[15]Schmidt, Klaus M. and Schnitzer, Monika, (2003) "Public Subsidies for Open Source? Some Economic Policy Issues of the Software Market." CEPR Discussion Paper No. 3793. Available at SSRN: http://ssrn.com/abstract=395461.

imply that governments **should** intervene to correct the failures, and ensure that software of all types, particularly FOSS is available for users. This also promotes competition (Lee, 2006[16]; Forge, 2006[17]).

Comino and Manenti (2005) show that governments should support policies that encourage FOSS adoption and also inform potential and current users of IT about the value of FOSS, however, governments should not subsidise consumers to use FOSS. The authors base their arguments on a model that settles these decisions by the government, based on social welfare. The research argues that governments should level the playing field for competition, through information provision, rather than through subsidies (Comino & Manenti, 2005[18]) - maybe certain policies (informing and mandating) will help, but not subsidies.

The literature is thus inconclusive about government intervention in terms of policies and support for FOSS.

[16]Lee, Jyh-An. (2006) "New Perspectives on Public Goods Production: Policy Implications of Open Source Software." New Perspectives on Public Goods Production: Policy Implications of Open Source Software. *Vanderbilt Journal of Entertainment and Technology Law* 9(1).

[17]Forge, Simon. (2006) "The rain forest and the rock garden: the economic impacts of open source software." *Info* 8(3): 12-31.

[18]Comino, Stefano, and Fabio M. Manenti. (2005) "Government policies supporting open source software for the mass market." *Review of Industrial Organization* 26(2): 217-240.

4 | Analysis of Field Data

The field data from the interviews conducted in the different states and departments are now analysed. The responses from the Education department and schools is analysed first. The intent of the analysis is to show the key insights that were obtained from the field interviews.

4.1 Analysis of Eduction Department Responses

4.1.1 Kerala

The Education department of Kerala adopted FOSS in the year 2001, for all government schools in Kerala. This was a policy of the state government that recommended FOSS for all government departments and offices. The department chose to implement FOSS in schools using its own resources, by training teachers and school staff on FOSS and related technologies.

The impact of FOSS implementation in schools is deep and strong in Kerala. The field data shows considerable tangible and intangible impacts.

Adoption of FOSS led to re-thinking on the entire chain of bringing IT to schools - including procuring and implementing hardware and software, designing the syllabus, imparting skills training, and conducting exams. Each of these aspects is discussed below.

Hardware and software procurement Since Kerala had already adopted a FOSS policy for schools, the central education department, called IT@School, prepared a distribution, which was initially based on Debian, and later on Ubuntu, that was the basic operating system that could be installed on computers. This distribution included other FOSS packages, such as Geogebra, Kalzium, etc that are used by schools to teach subjects such as geometry and chemistry.

Hardware procurement was centralised, where IT@School allocated a budget for each school, who could then select their hardware from a web-

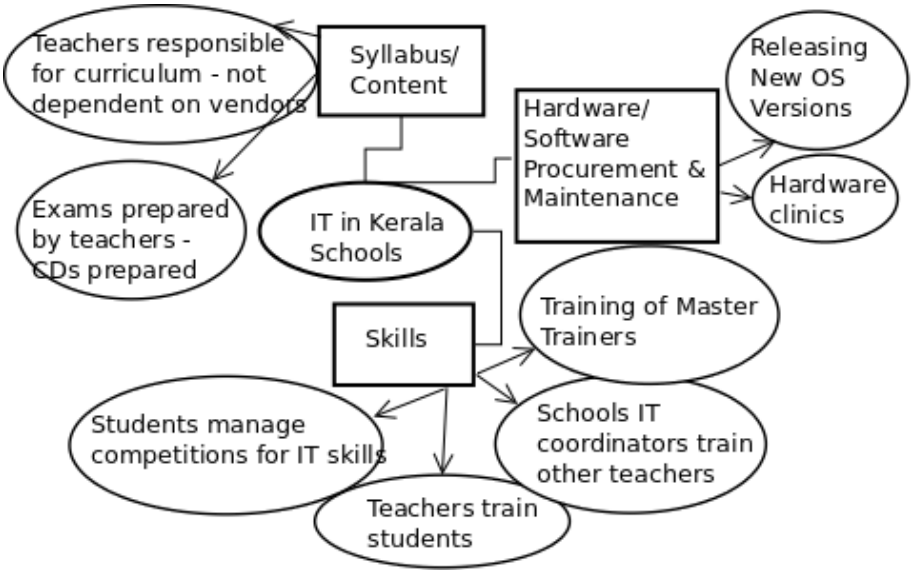

Figure 4.1: FOSS in Kerala Schools

site. This was delivered by a state agency - Keltron. This agency was also responsible for maintenance of the hardware for the duration of the warranty.

However, many respondents noted that they became quite proficient at maintaining the hardware themselves, if it was just an issue of upgrading the software or getting a new driver. Teachers and administrators could also log complaints to a centralized system, and receive help within a reasonable time.

After the warranty period was over, schools could attend hardware "clinics" where they could bring old hardware for repair, and also teachers could participate in the repairs themselves. This led to further development of skills and confidence in extending the life of the hardware.

IT@School initially provided the operating system and application software to the schools. This was a basic package, however, they were free to introduce and use other packages they needed. This latter practice was not common as teachers felt that they were overwhelmed by their teaching requirements and did not have time to experiment.

Skills and training Kerala has evolved an elaborate system of training teachers on IT subjects and on basic IT skills. The system follows a snowball model where the department trains Master Trainers (MTs), who then train teachers in their districts. The trained teachers in schools then teach other teachers. They also train student IT coordinators, there are 4-5 in each school, who take the responsibility of involving other students and helping

with maintaining labs. The task of training is highly distributed in nature - teachers teach other teachers and students.

Many teachers mentioned that they took advanced training on IT subjects beyond the basic training. Many were comfortable with installing FOSS on their home computers also.

The advantage of FOSS is evident here as it is easily distributed and available without licensing constraints. Many teachers have self taught themselves software and basic educational tools. They were able to install basic software at home, on their personal computers, from what they had learned at work.

Syllabus and content Teachers are involved in the design and creation of the syllabus for the IT curriculum. Though IT@School controls the content and design, there are inputs from the MTs and teachers. Teachers also help with the design and execution of the tests.

This high level of participation is also a function of the use of FOSS, which has fostered a culture of involvement and sharing, thus creating a community. Teachers actively contribute to blogs and wikis on their subject. They feel involved and committed to their work, and don't leave it to vendors to design and structure the instructional material.

4.1.2 Karnataka

Karnataka initiated ICT education in the state through the "Mahiti Sindhu Project" introduced in 1000 government schools in the year 2000. This was a state funded project and involved training for teachers and free computer education for students. In 2005, this project was merged with a larger project called "ICT@Schools" project, which received funds from the central government also. The ICT@Schools project was implemented in three phases. The phases were designed to increase the reach of the ICT implementations in a gradual manner. Each phase built upon the previous phase. The first phase focused on 480 schools, the second on 1571 schools, and the third phase on 4396 schools.

Hardware and software procurement In each phase the Department of State Education Research and Training (DSERT) relied on private vendors to both procure the hardware and software for the schools and install them. Companies such as NIIT, Aptech, Educomp and Microsoft were enrolled. These firms took the responsibility of installing the hardware and software in the schools, which included building the facilities such as furniture, networks and power supply.

FOSS was not encouraged by either the state or the vendors. Some NGOs in Karnataka, such as IT for Change, worked extensively with schools and the education department to spread awareness and understanding of FOSS. However, the state relied on the vendors and did not permit use or installation of FOSS.

Some schools in and around Bangalore received computers from philanthropic grants with FOSS installed on them. For the most part these were later replaced with proprietary software.

Skills and Training Training of teachers was outsourced to private firms and NGOs. They trained teachers under various schemes, either on basic IT concepts or on advanced concepts related to a subject. One of the vendors, Microsoft, followed the ideas of training Master Trainers, who were teachers from different schools, and who then trained other teachers.

The engagements with firms were on the build, own, operate and transfer (BOOT) model encouraged by the central government. In this model firms entered into a limited period contract with the school, usually for 5 years, to implement the project, transfer it to the school and then leave (unless the contract was extended). The trained teachers then took over the maintenance and running of the systems. Often, young engineers who were trained especially to manage and maintain the systems, were hired by the schools, although many of them left for lucrative jobs in the private sector.

There was no involvement of students in the skills training and in imparting training to other students.

The field interviews showed that there was no attempt to train or inform teachers or department personnel about FOSS. The vendors actively discouraged use of FOSS, and downplayed its value and usefulness. One of the department officals remarked:

> When we procured the systems, we paid for Windows. If we go for Open Source, then everything we paid for is waste.

Syllabus and Content The syllabus for computer subjects was developed by the vendors according to the guidelines provided by the Department of Education. For the most part, the syllabus and the content was tailored by the vendors. The syllabii for other subjects, such as Science and Mathematics, was left to the schools and teachers, to develop lesson plans using the software already installed by the vendors.

4.1.3 Goa

In the year 2000, an NGO in Goa, called the Goa Schools Computer Project, undertook an effort to procure old computers from corporations and distribute them in schools. The NGO was able to give computers to 380 schools, in which FOSS had been preloaded. The costs of such a deployment were very low, and the main challenge they faced was that of training teachers. However, initial training was provided and teachers felt comfortable using FOSS and teaching with the available software. This attempt did not survive, as the government stepped in later to provide computers to schools and the task was outsourced.

Hardware and software procurement Goa state government, through the Directorate of Education, gave the hardware and software procurement task to three vendors, for the three zones in Goa, who would operate on a BOOT model. The vendors selected and installed the hardware and software. In all cases, they chose the Windows operating system and Office tools, along with utility software such as anti-virus. At the end of the contract period of five years, the computers were transferred to the schools.

In a subsequent plan, the state government directly procured computer equipment and supplied it to schools. This was an attempt to create state-of-the-art computing facilities. All the computers used proprietary software. The contractors who provided the computers were retained for maintenance for one year.

An official stated that many schools were starved of funds and much of the money meant for computing education was diverted to other things such as buying textbooks.

Skills and Training All the vendors provided one trained teacher to each school, who was later hired by the school and whose task it was to be mainly responsible for computer use and continued maintenance of the systems.

Training was provided directly to teachers, including headmasters, through another state sponsored scheme. They were trained only on Windows software and related office tools.

4.1.4 Maharashtra

Hardware and software procurement For the most part hardware procurement and installation was done by vendors appointed by the government. One of the vendors, NIIT, got a five year contract to install and maintain

all the hardware. They mainly deployed Windows and other proprietary software.

Once the contract period was over, the schools were left to maintain computers on their own. Some teachers had been hired from NIIT and they could help with fixing things, but they mostly relied on local technicians. Students did not participate in maintenance.

Some donors, such as the Rotary club, provided computers to local schools, however these were gifts with no significant program of training teachers and staff.

Skills and Training Most teachers received training. All government new hires were required to take a six month course on information technology. This was necessary for teachers also. The training was outsourced and the vendors taught only Windows and proprietary software. Some teachers mentioned using Geogebra in class, but they learnt this on their own. They were not aware that Geogebra is open source.

Of the vendors, NIIT, did teach Linux to some of the teachers. NIIT also organised meetings of teachers, related to computer use and teaching. Students were not involved in the training as teachers felt that a majority of the students were not familiar with computers.

Syllabus and Content The syllabus for ICT education was determined by the State Board of Secondary and Higher Education. Here the exact software to be used was not specified. The choice was left to the schools and vendors. It was noted that schools did not exercise this choice affirmatively, leaving the selection of software to vendors.

A convener on the board of studies for ICT stated that he was worried about recommending open source for fear of being questioned. He had no such worries about recommending proprietary software.

4.1.5 Assam

Assam introduced computers in schools through the Rajiv Gandhi Computer Literacy Programme for schools in 2004. This programme was later extended via the 'Computer in School' project in 2009, which had similar goals. The overall charge of implementing the computers in schools project was handed to the Assam Electronics Development Corporation (AMTRON). AMTRON was responsible for selecting vendors for the schools and for distributing the funds.

Hardware and software procurement AMTRON specified the hardware that had to be provided to each school and these were procured and installed by the vendors. The two main vendors were NIIT and Educomp. The contracts were assigned based on the BOOT model, and were for five years, after which they were extended for another five.

The software used by the vendors was entirely proprietary. In 2009, Assam government did recommend use of FOSS in the curriculum but this was not implemented. In part this was because the state government had already signed a 'partners in learning' memorandum with Microsoft corporation, who would provide software and learning tools under the scheme, at special prices.

Skills and Training The vendors hired and trained one ICT teacher in each school. This teacher had prior knowledge of computing, along with a diploma in a relevant discipline. Teachers of each school were also trained for 3-4 days in basic computing skills. All the ICT teachers also helped in training other teachers in schools. All the training material, documents and books were provided by the vendor.

In some instances, when teachers became very skilled at using computers and software, they often left the school for private and better paying jobs. Retention of competent, computing-savvy teachers was a problem.

Syllabus and Content For the ICT subjects, the entire syllabus, teaching materials and also the exams were prepared by the vendors. The materials were designed with approval from the competent authority in the state (the education department).

AMTRON has actively followed a policy of promoting and highlighting FOSS in the syllabus and for training. However, the vendors followed this only reluctantly. Linux training was provided in a few schools.

4.2 Analysis of Police Department Responses

The Crime and Criminal Tracking Network and System (CCTNS) is an effort of the National Crime Records Bureau (NCRB) of the Government of India. The objective of the CCTNS is to create a nationwide network of crime records that will help with tracking crime and criminals in real time. The project aims to connect over 20,000 police stations across the country, across all states and union territories. The CCTNS would also connect all the state crime record bureaus with the NCRB.

The CCTNS project succeeds two other projects that had similar goals. The first was the Crime Criminal Information System (CCIS) that was initi-

ated in 2002 and was functional till 2007, when the later system, the Common Integrated Police Application (CIPA) was implemented. The CCIS was designed for sharing information across state departments whereas the CIPA focused on workflows within departments. Both systems were inspirational in creation of the CCTNS that takes aspects of design from them. The CIPA system was built on Linux, with Java and PostgreSQL, whereas the CCIS was implemented on Windows.

CCTNS was commissioned by the NCRB and the contract was granted to Wipro Corporation to build the core solution. Wipro collected requirements from all the states and built the core application server (CAS) in two different versions: one using Java and another with .Net. This was to address the concerns of states that wanted open source (Java) or proprietary (.Net) software. The plan was that states could adopt one or another of these versions to blend with their existing applications, and could also select a vendor on their own, known as a system integrator (SI), who could help with the implementation of CCTNS. Different states chose different SIs, some hired Wipro for the task. The choices made by the states are shown in Table 4.1.

The CCTNS architecture was designed to have a central server at the state headquarters that would receive data from servers from different police stations, police district headquarters and from state crime record bureaus. The state server would then update the national server located at the NCRB in Delhi. State data could be configured and used in the language of the state and all files would then be translated and then uploaded to the centre.

Police stations had to set up 3-4 desktops or laptops that were used for retrieval of forms and data entry. Each police station usually has one computer that acts as a server that connects to the state server either in online or batch mode. The other desktops or laptops have an operating system, office tools and a browser, which could be either open source or proprietary. These systems had to connect with the state CAS, which could either be in the Java or .Net stack. This enabled considerable flexibility in the choice of software for states.

In **Karnataka**, a PoliceIT system had already been implemented when the CCTNS plan was announced by the central government. The state's police IT team found that their existing system had almost all the functionality that CCTNS required. Hence, for Karnataka it was a matter of adapting and merging their existing system. There was resistance to implementation of the PoliceIT system within the department, mainly because a system was already in place.

The respondents in Karnataka did not participate in the decisions regarding choice of software. Even the senior officers responsible for the implementation of the PoliceIT and CCTNS systems stated that the choice of .Net

State	Software Used
Karnataka	Core implementation based on .Net stack. Clients use proprietary software.
Kerala	Core based on Java/Solaris. Clients use Ubuntu.
Goa	Core based on Java/Solaris. Clients use proprietary software.
Maharashtra	Core on .Net stack. Clients use Ubuntu/Mozilla.
UP	Core based on .Net stack. Clients also use proprietary software.
Assam	Core based on .Net. Clients use Linux.
Jharkhand	Core on JAVA/Solaris. Clients use Windows with Open Office.

Table 4.1: Choice of open source or proprietary software by states for implementation of CCTNS

stack of CCTNS was not their choice and they also did not have a say in the desktop systems installed in police stations across the state. These decisions were "handed" to them.

The respondents in Karnataka were aware of the implications and value of open source. However, they did not comment on how or why the proprietary stack of the CAS was selected over the open source version. There were no cost considerations, as the entire cost was being borne by the central government.

Maharashtra too had legacy systems such as the CCIS and the CIPA, and when they selected the SI, Wipro, the selection of the CAS stack was left to them. The SI selected the proprietary (.Net) stack. This choice was supported by the leaders of the implementation team, based on the rationale that after the term of the SI expired, other vendors could be hired to maintain the system. However, for the desktops and client systems open source was used. The rationale for this choice was cost, as the operating system had to be deployed on 6400 desktops in 1600 police stations.

Kerala selected the FOSS stack for CCTNS implementation. This decision was by a high-level committee. However, Kerala has had a long history of promoting and using FOSS. The implementation was given to the state agency, Keltron, that hired TCS as the SI. The client computers at the police stations use Ubuntu and open source software. One respondent estimated that the saving in costs in not using Windows software, plus anti-virus software, was substantial - at about Rs 4500 per computer.

The **Jharkhand** police department too implemented the FOSS stack of

CCTNS with the help of NIIT (as the SI). One respondent estimated that the choice of FOSS saved the state an amount of Rs 5-7 crores that would have been spent on database and server licences. The 385 police stations opted for the Windows operating system with Open Office. This choice was dictated by the personnel's familiarity with proprietary software.

Jharkhand police department had some committed FOSS enthusiasts who had learnt programming on their own and had created a team that was skilled in developing applications. They used their knowledge to make extensions to the CAS, based on their local needs. The application was called OCCIS (Organised CCIS) that was built using the LAMP stack. The tool helped with data visualization and analysis of crime data.

5 | Summary & Conclusions

5.1 Summary and Key Findings

- This study examines the impact of FOSS use in government departments in different states in India. The focus is on tangible and intangible impacts of FOSS. The study identifies barriers to adoption of FOSS and policy implications.
- Desk research revealed FOSS use around the world. This also provided a view on the state of egov in India and the pertinent issues that had to be examined. This was followed by an RTI application effort, where many departments were sent information requests. This approach largely failed to elicit any meaningful information as almost all the RTI applications were rejected on technicalities.
- A detailed field study was conducted over a period of seven months where team members visited government departments in seven states - Karnataka, Kerala, Goa, Maharashtra, Uttar Pradesh, Assam and Jharkhand. The study involved interviews of officials, IT managers, IT vendors and NGOs.
- Two main departments were covered in the study - Education and Police. These departments were chosen because they had actively considered FOSS use and, in some cases, were using FOSS.
- Around the world governments have adopted FOSS for tangible and intangible reasons. Tangible reasons for using FOSS are - for import substitution and to conserve foreign exchange; to improve egov capacity and to avoid vendor lock-in. Intangible reasons include - to revive entrepreneurship; to foster democracy and socio-technical alliances; and to transfer ICT skills to unserved populations.
- Academic literature is ambiguous on policy implications of FOSS. Studies, alternatively, show that under certain conditions FOSS should be

advocated, should not be advocated, and may be advocated with reservations.

- Kerala stands out, amongst the states, for its adoption of FOSS for schools and the tangible and intangible benefits it has realized. Tangible benefits include massive cost savings, and intangible benefits include inculcation of a do-it-yourself culture amongst teachers and students and massive participation in the ICT education process.

- The other states did not adopt FOSS and incurred tangible and intangible costs. Tangible costs were directly linked to the price paid for proprietary licenses and training and maintenance. The intangible costs include - overwhelming dependence on vendors; disconnet of teachers in the ICT education process, including setting syllabii and exams.

- The police department at the centre had created the CCTNS system, for states to adopt to create a national crime records database. The system was implemented in two stacks - one on a FOSS platform (Java) and another on a proprietary platform (.Net). Different states chose different stacks, mainly based on their existing systems. Respondents in all the states felt that the choice of the stack was not theirs, and they had simply worked with what was given.

- There were no strong benefits or costs of using either stack for the CCTNS. The costs were being paid by the centre, hence the issue was not strong. In the state of Jharkhand there were some committed FOSS enthusiasts in the department who built additional products using FOSS.

5.2 Conclusions

5.2.1 Tangible and Intangible Benefits

Intangible benefits

The experience of schools in Kerala, as contrasted against schools of other states, shows a clear pattern of the impact of FOSS. The snowball method of training creates a do-it-yourself or maker culture and encourages users to experiment and try new things

Item	Karnataka	Goa
Hardware: computers, printers, scanners, furniture, routers, consumables, connectivity, maintenance	81.3%	88%
Software: Operating system, educational software, office software, anti-virus	9.7%	10.4%
Teacher training	9.0%	1.6%

Table 5.1: Data on spending categories for ICT in Schools.

In schools, FOSS stimulated a culture of shared understanding, engaging with technology, problem-solving and participation in all aspects of ICT in education.

Tangible Benefits

As part of the study, we examined the curriculum and content of ICT education. A clear and unambiguous finding is that all ICT concepts can be taught using FOSS. There was no evidence of any concept or theory that required or mandated use of proprietary software. Though some state syllabii have mentioned knowing Microsoft Excel as a requirement, the underlying concepts that are being covered can be covered using FOSS spreadsheets also. This clearly shows that almost all schools can use FOSS effectively.

Table 5.1 shows data collected from two states, Karnataka and Goa, depicting the computerization funds spending categories for schools. It is clear that the spending on software stands at approximately 10% of the total ICT budget.

There is some variation across states on the amount of funds allocated for each school for computerization. For Karnataka, for Phase 3 of the ICT @ Schools programme, the average budget, including centre and state contribution, stood at Rs 13.39 lakhs[1] per school.

For the state of Karnataka, the spending in each school on software alone would be about Rs 1.3 lakhs. This figure is conservative, as it takes the bare minimum software costs and does not includes costs of maintenance and upgrades.

It is safe to say, then, that this figure can be used as a proxy for spending on software in schools across all states in India.

[1]Rs 440.76 crores was provided by the GOI, and Rs 148.36 was the state share. This totalled to Rs 589.06 crores for Phase 3 of the ICT @ Schools project. This amount was distributed across 4396 secondary schools in the state. Source: Department of State Education Research and Training Report, Bangalore, 2013.

Item	Cost
Windows Desktop licence	Rs 6400 per unit
MS Office licence	Rs 5200 per unit
Anti-virus licence	Rs 455 per unit

Table 5.2: Bulk licence costs of proprietary packages

There are 634924 upper primary and secondary schools in India[2]. If each school spends Rs 1.3 lakhs on software, the total spending will be Rs 8254 crores.

This study clearly shows, from the example of Kerala, that all the proprietary software can be entirely replaced by FOSS and just that could result in a potential saving of Rs 8254 crores for the country as a whole.

Police Police departments were equipped with computers and office productivity software under the CCTNS and, earlier, under the CIPA grant. Most states adopted proprietary software, however, there were exceptions such as Maharashtra, Assam and Kerala, which adopted FOSS. Respondents from Maharashtra and Assam stated that the choice of FOSS clients in offices was based on cost considerations.

Typically, each desktop with proprietary software used the Windows operating system, Microsoft Office and one anti-virus. Bulk prices for the licences of these packages - as obtained from field data - are shown in Table 5.2.

There are 14155 police stations in India[3]. There were approximately 6 desktops purchased for each police station under the CCTNS project.[4] The total number of desktops purchased for the entire CCTNS project is approximately 84930. Even if half this number of desktops were based on FOSS, the savings would amount to Rs 51.20 crores.[5]

Though a saving of Rs 51 crores is small compared to the overall budget of the CCTNS project (Rs 2000 crores), it is a tangible benefit.

[2]Source: "Educational Statistics at a Glance," Report of the Bureau of Planning, Monitoring and Statistics, Ministry of Human Resource Development, Government of India, 2014.

[3]Source: NCRB data for 2012.

[4]This figure was computed by dividing the total number of desktops purchased for all offices affiliated with the police department, under the CCTNS project, by the number of police stations in the state.

[5]This figure is computed by multiplying half the total number of computers, 42,465, times the total licensing costs of proprietary software, obtained from Table 5.2.1.

5.2.2 Hurdles to FOSS Adoption

State governments are encouraged to rely on vendors, either through the BOOT model or as SIs, in order to meet their implementation deadlines. This approach discourages the do-it-yourself approach as this would require more time and resources. This dependence on vendors leads to a choice of proprietary software even though FOSS is a viable choice.

Dependence on vendors also leads to lack of confidence in internal decision-making and internal resources. Both in the education and police departments, where vendors have a strong presence, the decision makers have low familiarity with FOSS and confidence in expressing their preference. As one respondent stated - he was worried about recommending FOSS, but had no fears about recommending proprietary software.

Many respondents in both departments knew about free software but were misinformed about many aspects of FOSS. Some felt that FOSS was more expensive than proprietary software, including the cost of licences. Some responded by saying that FOSS created a lock-in, because once they adopt FOSS, they would be unable to select any other (they also felt that proprietary and monopoly software like Windows did not create such a lock-in). The other doubts expressed about FOSS included - FOSS was not reliable; FOSS was prone to virus attacks; was unstable; did not have vendor support; and was harder to maintain. Most of these opinions about free software were not substantiated, but were a reservation that respondents had.

A consistent response that resonated across the study was that of helplessness with regard to choice of technology. Respondents in the police department expressed their inability to state why FOSS had or had not been chosen. They said that the decision had been made by "higher ups" and they were following that. This is in contrast to the CCTNS policy that states that software choice is decided by the state implementers along with the SI.

In the education department too, many respondents were unable to say why a certain kind of software was chosen. In most cases this choice was left to the vendor.

5.2.3 Policy Implications for FOSS

FOSS can be made mandatory for schools. This study shows that ICT concepts can be taught with FOSS tools, and FOSS can be used to teach other subjects also. There is no academic reason to use proprietary software at all.

The Government of India, in 2015, has adopted a FOSS preference policy that is in line with the key findings of this study, viz, FOSS has strong long-term tangible and intangible benefits for the economy. The reduced

dependence on product vendors, most of whom are from abroad, will give a boost to the indigenous software service providers. This policy has to be encouraged.

There is an urgent need to inform government employees and officials, at all levels, about the value of FOSS, and the benefits it can bring. This is mainly to counter the excessive mis-information that prevails in this population about the role and nature of FOSS.

Further, there is also a need to inform government officials about the nature of FOSS licences, and the manner in which they impact FOSS use and development. Government departments should also be encouraged to place under FOSS licences the software that they get developed internally. This will help other departments and offices to use the same software.

The do-it-yourself culture that FOSS promotes needs to be strengthened, and its value communicated to all users. This will further reduce dependence on imported proprietary products.

IT governance, which is the basis on which high-level decisions regarding IT are made, within government departments has to involve all stakeholders. There is no evident demarcation of input rights and decision rights, something that has to be established. With the prevailing scenario of top-down decision making, progressive IT policies are difficult to sustain.