Building a Better World: Frugal Hospital Information Systems in an Indian State

Completed Research Paper

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Abstract

This paper draws on a case study of the development and use of hospital information systems in a particular state in India. The theoretical framework for the study conceptualises the systems as frugal IS and draws on theories of frugal innovation to analyse their innovative elements. The paper also asks in what way such systems claim to be making a better world, and this is theorized through the use of Amartya Sen's capability approach. It is argued that the systems enable wider choices for their beneficiaries. Particular outcomes in the case study included strengthening processes to include the disadvantaged, empowering the patient, and making voices count. A key contribution of this paper is the two-part theorization linking innovation to enhanced capabilities, and this could be used to address the value-added of IS innovations in other resource-constrained contexts.

Keywords: Development, Health Information Systems, Innovation, Capabilities

Introduction

A current theme which is receiving significant attention in the IS field is the question as to whether the widespread availability and use of information and communication technologies (ICTs) is making a better world. This is the conference theme for ICIS 2014 and MIS Quarterly has demonstrated interest in this wider topic of a better world through its special issue on 'ICT and societal challenges'. The IS field is not alone in addressing these broader global agenda and a wider range of stakeholder groups. For example, in the sphere of economics and development, traditional measures such as GDP have been augmented by a focus on human development through new measures such as the human development index and the millennium development goals. In the sphere of management and organizations, there is widespread interest in the so-called bottom of the pyramid model (Prahalad and Hammond 2002), relating to the interests and purchasing power of the four billion or so people in the world with incomes in the lowest category.

So how should the IS field respond to these global challenges of making a better world, with a particular focus on the role of ICTs? One broad approach to this was articulated by Walsham (2012). He argued

that the IS field needs to widen its traditional agenda if it is to retain an important role in contemporary and future global debates on the role of ICTs in society. He put forward an outline future-oriented agenda for the IS field emphasizing a focus on ethical goals, increased use of critical approaches, welcoming other disciplines with open arms, widening fields of study to many non-traditional settings and rejecting a dominant methodological paradigm. This wider approach is a useful starting point for debate but does not answer the question as to how to operationalize this agenda in specific research domains, or what theoretical concepts can help us in this endeavour.

We aim in this paper to do precisely that, namely to address a specific research domain and to develop some theoretical constructs to help us in analyzing that domain. The chosen research domain is the non-traditional setting of hospital information systems in India and the ethical questions concern how to develop and use such systems for the general benefit of those using public health services in that context. Health is development (Sen 1999), and initiatives to improve health of the population through the vehicle of information contribute directly to social development and the making of a better world. The theoretical approach which we bring to bear on this domain starts from concepts of 'frugality' or frugal information systems. This can be broadly defined as doing more with less, something of great interest to a world where resource constraints are likely to increase as the global human population expands in numbers and in consumption. We aim to develop a better understanding of what constitutes a frugal health information system (HIS), which can provide some implications of how they may be developed in similar contexts. We also ask the question of 'frugal for what' or, in other words, how does a frugal approach contribute to a better world. In order to address this question, we draw on the work of the development economist Amartya Sen and his capabilities approach.

The rest of the paper is organized as follows. In the next section we develop our theoretical approach to frugal information systems and to the question of frugal for what. We then outline our research methods and describe the case study of hospital information systems in an Indian state. We next analyse our case study through the lens of the theoretical perspective described earlier. We develop some grounded concepts of how the information systems can potentially contribute to improved development outcomes. Finally, we draw some conclusions from our research and identify future opportunities to build on the work in the future.

Theoretical Perspective

A recent paper by Watson et al (2013) addresses the topic of frugal information systems and defines this as follows:

'A frugal IS is an information system that is developed and deployed with minimal resources to meet the pre-eminent goal of the client' (p177).

The paper goes on to describe various desirable goals for frugal IS including for example universality, defined as the desire to overcome the friction of IS incompatibilities. In addition, Watson et al suggest a list of design guidelines and principles including the use of open source, public rather than proprietary data, and crowdsourcing for innovation. The paper is described as a 'view from practice' and the goals and guidelines are useful. However, the paper does not offer an approach to the question as to how to theorize the nature and purpose of frugal IS. We attempt such a theorization below, and the approach will be illustrated and developed in the case study and analysis later in the paper.

Frugal Innovation

Frugal IS can be thought of as a form of 'frugal innovation' and Bhatti (2012) puts forward an insightful theoretical approach to understanding this. As shown in Figure 1, frugal innovation can be thought of as involving Schumpeterian or business innovation, social innovation, and institutional innovation. Each of these will be described below, but of particular importance, according to Bhatti, are their intersections, namely where two or more types of innovation are pursued at the same time. The reason for the choice of this framework is that, by looking at the technical, institutional and social dimensions in conjunction, it provides for a more comprehensive analysis of innovations, than approaches which primarily focus on the organizational dimensions of IS innovation (Avgerou 2010). We discuss some examples of these intersections below after giving some basic definitions.
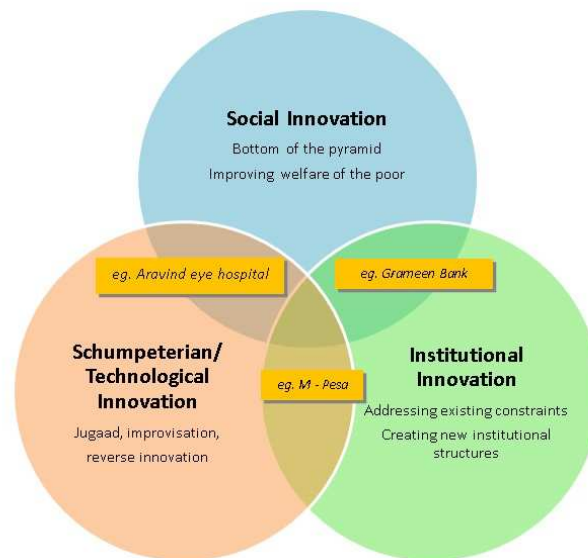
Figure 1. Frugal Innovation: Adapted from Bhatti's (2012) Framework

Schumpeterian innovation is the classic form of innovation normally associated with business or technological innovation. Key debates in this area include the need to mobilize resources to enable entrepreneurs to innovate and start new ventures. In the context of developing countries, fewer resources may normally be available but recent literature emphasizes new processes and approaches in such contexts such as that of *jugaad,* improvisations in severely resource-constrained contexts (Radjou et al 2012). Indeed, there is an argument that such innovations are of high potential value to rich countries, a process sometimes labeled as reverse innovation (Immelt et al 2009).

Social innovation is also a topic with strong resonance in developing country contexts, not least through the notion of the bottom of the pyramid model referred to earlier, namely the market represented by people with incomes in the lowest category. Affordability constraints are vital here in order to provide products and services which are within the reach of the poor. Social innovation also emphasizes attempts to improve the welfare of the poor directly through, for example, innovation in health care provision or educational opportunities.

Institutional innovation involves tackling the constraints which arise through established institutions of various types such as political, legal and technological environments. In some contexts, in addition to the constraints of existing institutions, there may well be institutional voids making it necessary to create institutional structures from scratch. Institutional theory is a long-established theoretical approach to understanding institutional stability and change (Scott 2001), although it has sometimes been criticized as dealing inadequately with institutional innovation.

In addition to providing the theoretical framework of the three types of innovation, Bhatti (2012) gives some examples of the intersecting circles. For example, the Aravind Eye Hospital in India reinvented their business model of serving rich patients profitably to use surplus revenue to subsidize free eye surgery for poorer patients. In addition they reinvented the intraocular implant to manufacture locally for $5 rather than an import cost of $200. Bhatti sees this as an example of frugal innovation at the intersection of technological and social innovation. With respect to the intersection of social and institutional innovation, Bhatti provides the example of microfinance for the poor as pioneered by Grameen Bank in Bangladesh. This involved new microfinance institutions and changed user approaches to borrowing and saving. As an example of Schumpeterian and institutional innovation, mobile phone banking such as M-Pesa in Kenya is mentioned.

Perhaps the most interesting example provided by Bhatti, from the perspective of this paper, is that of the intersection of all three circles of innovation, which we will illustrate later using our own case example. Bhatti (2012) outlines the case of the Rickshaw Bank project in India. This enabled rickshaw drivers to own rather than rent rickshaws. Technological innovation was used to redesign the rickshaws, social innovation to restructure the prevalent practice of renting to owning, and institutional innovation to license and recognize rickshaw owners as formal contributors to the local economy. Bhatti argues that any of the three innovations in isolation would not have been likely to succeed but, by combining the three, more than 30,000 rickshaw drivers have benefitted.

Frugal Innovation for Development

Bhatti's framework provides a way of theorizing frugal innovation but it does not provide a theoretical answer to the question as to the ultimate purpose of the innovation. It could be said, in response to this critique, that surely the eye patients of the Aravind Eye hospital benefitted from their implants, the poor in Bangladesh from their microfinance, the unbanked in Kenya from their access to cash transfer facilities and the Rickshaw drivers in India from their new ownership arrangements. Probably yes, although not necessarily in all cases and at all times, and don't we need something theoretically sharper than merely noting some potential beneficiaries and their possible gains? The ICT for development (ICT4D) literature has addressed a related question in arguing that we need to better theorize what we mean by development rather than leaving it as a theoretically unexplored territory (see, for example, Heeks 2006).

One theory of development which has received much attention in recent years is the capability approach (CA) due to Amartya Sen (see, for example, Sen 1999). Sen is an economist by background, but the CA is a much broader approach than is typical in economic theories of development that focus solely on issues such as income, expenditure and growth models. In contrast, the CA focuses on the 'freedom' which individuals have to lead the lives that they value. Thus, we should look at poverty not solely as lowness of income, but impoverished lives, namely the deprivation of freedom to undertake activities that a person might wish to choose. Two major constituents of the CA are functionings and capabilities. Functionings refer to realized achievements and fulfilled expectations for the individual, whereas capabilities refer to effective possibilities for achievements. It is important to note that Sen does not specify what these capabilities and functionings are since he argues that different capabilities and functionings may be relevant in different contexts.

Little mention is made by Sen of the role of ICTs but a number of ICT4D researchers have recognized its potential to theorize the impact of ICTs on development. An interesting example is the work of Kleine (2013). She develops an operationalization of the CA into a choice framework with four elements: agency, structure, dimensions of choice, and development outcomes. Kleine's work is consistent with that of Sen, emphasizing the importance of choice itself as a primary development outcome with a range of secondary outcomes which may or may not be relevant in specific contexts. These may include, for example, easier communication, increased knowledge, healthier environment, increased income, more voice, more autonomy etc.

In this paper we will draw from the work of Sen and followers such as Kleine to investigate and analyse the effects of the frugal hospital information systems in an Indian state on freedoms and choices for recipients of public health care. More specifically, we will look at how the systems affected capabilities for the patients. But, in line with Sen, we did not specify these changed capabilities in advance of the study. Rather we examined the empirical material to derive these in a grounded way from the extensive field data. We aim therefore to answer not only the question of the nature of the innovations in our case study but also provide some insight on the purpose of the innovations in terms of potential development outcomes. We turn now to the research methods for our study.

Methods

This is a case study based analysis of the overall design, development and implementation of the project from its start in 2009. While one author has been closely associated with studying the project on the ground, the other author, while not being directly involved in this project, has studied ICT initiatives in

India for more than 3 decades, and provides the perspective of a "knowledgeable outsider" in developing the analysis presented in this paper.

The study is longitudinal and multi-level in nature, initiated in 2009 and still ongoing. The author involved in the field project has made more than 2 dozen visits to the different hospital sites, supporting processes related to requirements study, interactions with the team on design, capacity building efforts, and meetings with officials of the state to evaluate progress and discuss strategy. He has thus met the same staff multiple times, and witnessed some of their changing perceptions with the evolution of the system, allowing for the development of a longitudinal perspective. The study is multi-level, involving varied engagement from the global to the single patient or doctor. The global level engagement comes with the use of the OpenMRS (Open Medical Record Systems – openmrs.org) platform which has involved multiple discussions with the global developers and also users. At the national level, we have kept abreast of the policies on open source, the kinds of standards being mandated, and the systems which other vendors are developing. The state level engagement has been crucial in getting project approval, resourcing, identifying reference hospitals, endorsement of design and various others. In individual hospitals, there have been multiple rounds of meetings and discussions with administrators, doctors, patients, para-medics, support staff and various others, coming from different wards, operation theatres, pharmacy, and stores. This has contributed to the development of a multi-level and multi-stakeholder perspective towards the story of the implementation of the hospital system.

There have been multiple data collection sources, including through meetings and discussions the team has had with the State officials across different issues of design, requirements, training, infrastructure, support, and data analysis. Data so generated have often been documented in minutes of meetings, email correspondence and reports, but often have stayed in the minds of people present at various conversations. Several progress reports, evaluations and presentations have been made at different stages which provide a concrete history of events. Training manuals, requirement documents, FAQs, and other kind of correspondence related to support also provide useful material to understand project related issues. Presentations have been made in research seminars to university departments, and also some presentations in international conferences.

For this paper, the two authors have engaged in discussions related to analysis, building on earlier discussions they have had on notions of better world, development, and innovation. While one author could bring forth interesting empirical examples and insights, the other could relate them to theoretical ideas of frugal innovation and its conceptual linkages with the capabilities approach. There was thus an interesting "conversation" between data and theory, which helped to focus on insights regarding the notions of a "better world", and frugal information systems in the context of hospital IS in the public sector in India.

Case Study: Hospital Information Systems in an Indian State

The case study section starts with a brief description of the case context for the hospital information systems project. Following this, and building upon the Bhatti framework presented earlier, we first provide a brief overview of the initiation of the complex and extensive case study, and discuss the three elements of frugal information systems – technical, institutional and social innovation. This then leads to the analysis of the question of "frugal innovation for what?" in the following section.

Case Context

The case study is based on a large and ongoing project to design, develop, implement, and support a hospital information system (we call HospIS) within the network of 20 district and sub-district hospitals in the public health sector of an Indian state (we call STATE). A district is a sub-unit of an Indian state, and typically would host a population of 2-3 million. In the district, the first line of care is a Sub Centre (SC - catering to a population of about 5000) which falls under the jurisdiction of a primary health care (PHC) covering a catchment population of 30,000 to 40,000 under 5 -7 SCs. A district hospital is typically 250-300 bedded, serves as the referral institution for all SCs and PHCs in the district, and has at least 5-6 specialist doctors, facilities for surgeries, in-patients, blood transfusions, and other forms of specialist

care. The district hospital reports to a tertiary referral institution of a state level medical college, which provides super-specialty services like cancer care.

The context of computerization of the district hospital system in a state in a developing country is arguably extremely complex. There are high patient loads, to the extent of 500-700 in a day, where OPD (Out Patient Department) doctors get a few minutes to see a patient, within which time they need to have a conversation with the patient, make a diagnosis, reassure the patient that he or she will soon be well, and prescribe medicines and diagnostic tests. There are normally no easily available past records to rely on, and often the patient is not able to be very articulate about their condition. This doctor-patient encounter takes place, as crowds of patient queue up to meet the doctor, often waiting inside the same OPD room. Infrastructure is most often inadequate, both technology related and also diagnostics, implying that the doctor needs to rely on intuition and experience to make a diagnosis, aspects which are necessarily difficult to standardize and inscribe into software code. Human resources capacity is most often limited in terms of numbers and skills, and the doctor often needs to carry out many administrative and clerical tasks in addition to the clinical. Filing systems are manual, and patients are not in the habit of carrying records of their prior doctor visits, which makes it difficult to access past records, making the encounter largely based on the "here and now".

Historically, governments and donors have focused on strengthening information systems for the primary health sector (called Health Management Information Systems – HMIS), while (district) hospital information systems have been largely neglected. Braa and Sahay (2012) attribute this neglect to district hospitals being complex sites where showing results is very resource intensive and challenging. For example, the entire HMIS of a district could potentially be managed with one computer, while within just one hospital facility there may be the need for 10-15 computers to operationalize a hospital information system. However, over the last 3-5 years, a number of states in India, such as STATE, have taken up pilot initiatives, as they come under pressure to improve clinical care and with insurance schemes becoming more widespread.

Initiation of the HospIS project in STATE

STATE has been progressive in strengthening their HMIS, and quite early on in 2008 took the decision to introduce HospIS. STATE consultants developed a Request for Proposals (RFP) for the same, and 53 companies responded. The RFP inscribed visions of a paperless hospital, including requirements of telemedicine, SMS based scheduling, digitizing of medical images and videos, and various other technological interventions. This vision was at serious odds with the existing reality of the hospitals which had poor infrastructure, highly manual systems that were unstructured and based largely on informal and personal relations. Finally, none of the 53 vendors were selected for the job for reasons both technical and financial, and the tender was scrapped. STATE then approached a national NGO (we call INGO) which was already working with them to support their HMIS. INGO specialized in open source based systems, worked with an idealistic zeal of strengthening public health systems in the country, and took it as a challenge to design, develop and implement such a HospIS for which they had limited prior experience.

A first step was for INGO and the STATE to dialogue on system scope and how to make the utopian visions of the RFP more realistic. INGO emphasized a focus on the "core" modules, related to clinical care, hospital administration and management, while removing modules for diet, laundry or archiving digital images, which may be "nice to have" but were not essential. Through such discussions, the scope was reduced to 10 essential modules from an initial set of 20. Another point of negotiation was to design for a hybrid system combining paper and computer rather than something fully automated. For example, it was agreed that the doctor would write prescriptions on paper rather than selecting drugs from a drop down menu. Further, an incremental approach was adopted where one module would be introduced at a time, rather than all together. The initial modules were those relatively simple and with higher public visibility (for example registration), and later the more complex clinical ones which would involve doctors who were expected to be more resistant to change.

A hospital in the state capital was selected to be the reference one, where the system in its entirety of 10 modules would be designed and implemented, and then be taken in an incremental manner to the other

19 hospitals. The process was initiated through an 11 person INGO team based in the STATE. By mid-2010, the 10 modules were operational and under implementation in the reference hospital. Around then, the process to scale it to other hospitals was initiated. By 2014, 18 of the 20 hospitals had been covered. Further, the system has also been customized and adapted to some other states in the country, and also two other countries. Given the constraints of space, it is not possible to tell the story in totality, but we will provide some elements of the technological, institutional and social innovations that underpin the efforts.

Technological Innovations

An important first step was to identify the platform on which to build the application. Being trained and groomed in the world of open source technologies, INGO started to identify existing applications and analyzed the challenges in customizing them to the context of the STATE. Some fully developed hospital information systems were studied, but were found difficult to reverse engineer in the absence of sound documentation, and were also seen to be "too heavy" with functionalities which were not needed in the STATE requirements. Stripping down these not-needed features was seen to be a complex task, and it was uncertain how it would affect other modules when stripped. Finally, INGO selected OpenMRS (Open Medical Record System), a globally known platform for building clinical systems, and which had been used quite extensively in the management of clinical care to HIV Patients in Kenya. However, this platform had not been used for developing integrated hospital based systems, which was the requirement in STATE. Further, INGO had not the experience in working with OpenMRS, and capacities had to be developed by and large through self-study, trial and error, and support through the global developer community.

Initially, INGO had an 11 person team which included 4 developers and the rest from the public health domain. A couple of the developers had prior experience of working with OpenMRS. The work was divided with the public health people doing requirements study and the interactions with users, and the tasks of database and software development being done through the developers. As is usually the case, there were constant frictions between these two groups, and the public health group feeling held hostage by the other group through their limited understanding of the technology. There were various incidents of breakdown, for example the lead developer leaving and taking his team members with him. The remaining people were forced to start the design and development process from scratch, which made them get into the details of the technology and start to engage with it. As this process unfolded, it was seen that the public health group could do a lot of the tasks which were previously black-boxed by the technologists. For example, the populating of the database with "concepts," customization tasks like defining menus, adding or removing a field, changing logos, which comprised a lot of the customization work, slowly became non-developer dependent. While this was rather liberating given the shortage of skilled OpenMRS developers, it had larger implications on how INGO could approach capacity development on the technology.

A number of different elements of technological innovation can be seen in the project. First, the use of an open source platform based on global best practices was a first for the public sector in India. The INGO team set up in STATE through an extended and extensive engagement with both the technology and the hospital's systems, could build an integrated district hospital system which had not been done before in the context of a developing country using this platform. This application has been deployed on a public open source repository which potentially can be taken up by other users, representing a "reverse innovation" flowing also from the South to the North. This approaches of demystifying the tasks of the developer and shifting it to the realm of non-developers represents a cost-effective and more sustainable approach to building capacity in the hospital information systems domain in the future both in STATE, but also other potential implementations. This process of understanding and redistributing the tasks involved in making the technology work can be seen as a technological innovation, building upon the systemic innovation of using a global best practice platform in the public sector in India.

Social Innovations

In the context of frugal innovation, social innovations include making improvements in the living conditions of people, especially those who are disadvantaged and disenfranchised. Social innovations should help to enhance the social aspects of human functions and civil society. The population who visits district hospitals in India is typically from the poor and disadvantaged segments of society. Those who are rich and resourceful will typically be receiving their health care services from the private sector. Therefore using the hospital information system to improve the experience of patients in the hospital, or enhancing the quality of their care, can be seen as directly contributing to strengthening the social aspects of human functioning of the less privileged.

Anyone who has visited a district hospital in India will have been struck by the milling crowds waiting to get medical care. In a typical hospital, like the reference one in STATE, each doctor would see 50-75 patients daily. A challenge which exists then is the unruly queues at different points such as registration, in front of the doctor's office, the pharmacy and billing counters. Often, women, children, and old people who are not strong enough to take the pressures of the queues, are pushed behind, having to wait a long time before receiving service. One of the important aims of the system has been to try and structure these queues, so as to make the experience of the patient in the hospital more manageable and painless. Together, with the introduction of the system there have been various process related changes to try and achieve these aims. For example, there is a central registration where all first time and repeat patients have to pass through and get an "OPD (Out Patient Department) slip." This slip in addition to noting the basic demographics of the patient will identify the particular OPD the patient needs to visit, and once entered in the registration system, the patient details would show up in the OPD doctor's queue. As a result, the patient does not need to try and push and shove in entering the OPD doctor's room, or use personal influence on the doctor's assistant, but can be seated and wait to be called based on the number in the queue. There were similarly queuing systems built in other parts of the system. For example, in the past, the patient paid for different services (like lab tests and X rays) at different points, but now in the system all the billing was centralized to one point, improving the waiting time and experience of the patients.

Another important aspect of the system has been to provide better documentation to the patients. In the earlier manual system, most of the information from the doctor or the lab assistant to the patient was provided on small and random slips of paper, often written in illegible handwriting. Doctors would typically not give the name of the diagnosis, and would only write down some medicines the patient should take or some prescribed tests. In the automated system, the system makes it mandatory for the doctor to enter a "provisional diagnosis" on the OPD slip which the patient gets. This is potentially empowering for the patient, who can take this slip and get opinions from other doctors in other hospitals and is not locked to the first one. Similarly, lab test results are now given as printed paper, and the values are given by the side of recommended ranges for the test. As a result, the patient gets much better context about his/her results, and can potentially be better educated on what his results mean, and to take necessary corrective action. Another interesting feature of the system which improved the experience of patients was the functionality whereby the lab assistant could enter in the system if a particular test was not functional temporarily. Once entered, this would show up in the screen of the billing clerk who would then not collect the money from the patient for the test. In the earlier system, after paying the patient would find out the test can't be done, and it would indeed be a big hassle for the patient to get a refund or come back for the test. Travel from rural areas is a time taking and costly business for a poor rural patient.

Institutional Innovations

Public health systems in developing countries are resource constrained institutions with both formal and informal constraints. A country like India invests less than 2% of their GDP in the public health sector, which is grossly inadequate. This shortage shows in the public health facilities like hospitals and primary health care centres which have weak facilities, especially given the high patient load that they cater to. Investments in ICTs clearly suffer as a result, and most hospitals remain manual, and even basic systems of registration, billing, lab tests are often done on paper. An important aspect of ICT based applications concerns the challenge of scale, as these facilities are spread far and wide to meet with the public health

goals of "health for all." Software applications, if involving high licensing costs, become prohibitive for states to deploy effectively in all their facilities, and then get limited to the capital cities.

STATE was one of the pioneers in the country in the use of open source applications within the health sector. As was mentioned earlier, they were already working with INGO on an open source platform for their HMIS. Given the positive experience they had through it in terms of encouraging flexibility and local control, and the negative experience of the failed hospital information system tender, they were willing to experiment with an open source platform for the hospital system. Contributing to this decision was also the political system, as the government in power was the party in opposition to the ruling party in the centre. They were thus ready to exercise the autonomy the Constitution offered them in declaring health as a state (and not a central) subject, and use the ICT systems which they felt were most appropriate. The OpenMRS based HospIS was the choice they decided to invest in.

There were various institutional innovations that STATE needed to carry out to be able to firstly procure the services of INGO to design, build and implement the system, and subsequently to create structures that would allow them to sustain and support the systems over time. Dealing with procurement was a challenge because typically these would involve a tendering process which would be extremely time-taking, bureaucratic, and subject to various forms of interference. However, STATE finessed this requirement by creating a tripartite agreement between themselves, INGO, and another quasi central government institution which was responsible for providing the Ministry of Health with technical support in different areas including health information systems. Since the agreement involved two government institutions, there was not the need for an external tender. The other challenge in procurement was in defining the scope of the project. Typically, software projects involve the government giving the vendor the specifications, who is then responsible for delivering the system. In this case, the requirements were not pre-defined, but building those was also part of the work scope. Dealing with these fuzzy items, including support, would be hard for the state to specify in a tender. To deal with this, STATE made a work order based on numbers of people, saying INGO would set up a team of 11 people in their state capital, who would then be responsible for all aspects of designing, developing, implementing, and supporting the system for 3 years. In this way, STATE bought in some institutional innovations in their procurement process which was historically embedded in structures of strong bureaucracy.

Case Analysis

This analysis section contains two subsections. In the first, we discuss how the HospIS project can be seen to reflect some of the characteristics of frugal innovation drawing upon Bhatti's framework. In the second, we discuss how such a frugal IS contributes to the building of a better world drawing upon the work of Sen and followers on the capability approach related to enhanced freedoms and choices. For this, we use our empirical material to inductively infer some key characteristics of choice that such a frugal IS can potentially enable. We first present Figure 2 which schematically depicts HospIS as a frugal IS drawing from Bhatti, and then discuss it.
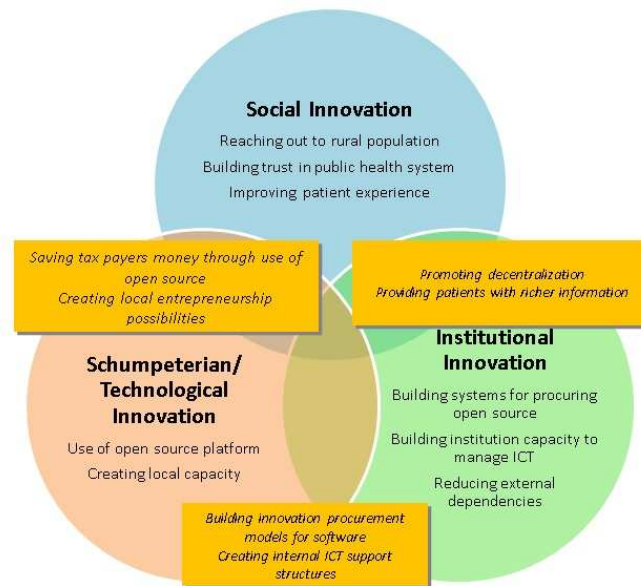
Figure 2. HospIS as a frugal IS

HospIS as a Frugal IS

A frugal innovation is described by Bhatti to lie at the intersections of technological, social and institutional innovations. We now discuss some of these intersections and how they play out.

Intersection of technological and social innovations

This intersection concerns how particular characteristics of the technology contributes to create benefits for the larger society and helps to improve the betterment of human functioning with respect to public health care.

HospIS being developed on a free and open source platform comes without exorbitant license costs thus helping to conserve valuable tax payers' resources which would be much exaggerated in the case of proprietary systems. Being unfettered by proprietary system license restrictions, HospIS allows for the state to deploy the systems also in more peripheral rural health facilities and not just in the central state systems. This then potentially enables the benefits of HospIS to reach more closer and widely to the rural population. Open source systems are not vulnerable to being held hostage to accepting periodic software license updates at increasing rates, or else having to live with the problem of not having your existing licenses being supported in the future by the vendor.

Another benefit of open source based applications is that they create the potential for generating local entrepreneurship and capacity, thus helping to strengthen local ownership of systems, and consequently reduce dependence on external elements like software vendors and international donors. In the case described, INGO is a local not for profit NGO which has been the technology partner for STATE. In the process of building HospIS and supporting it, INGO has thrived in building capacity, thus creating local resources to support and nurture the system. INGO further tied up with other local entities in STATE and trained them to carry out tasks like data entry, hardware support, and server maintenance. In the future, these and other local entities can be expected to play more significant roles (such as software bug fixing and providing capacity building support) and be able to grow and sustain the system. In this way, the case demonstrates a feasible business model of how local entrepreneurship can be made to work based on

open source software in developing countries. This provides an alternative model to building communities around open source software typically driven by high profile software developers in the Western context.

In summary, the intersection of the social and technological helps to create "more value for less" as compared to proprietary systems, and through this addresses the challenges of scale and sustainability which have been the main stumbling blocks for health information systems in developing countries (Braa et al 2004).

Intersection of technological and institutional innovations

Government institutions in India, including the health department of STATE, have traditionally worked with proprietary ICT systems developed either by private institutions, other government departments, or consultants supported through donor funds. The HospIS project implemented through INGO provided two institutional novelties. The first was in the use of open source platforms rather than proprietary systems. The second concerned the partnership with INGO, a registered not-for-profit NGO. Some significant institutional innovations were enabled to firstly procure the technology and support services from INGO, and secondly to establish institutional structures in order to sustain and support the systems over time. As noted earlier, the tripartite agreement involving two governmental agencies helped to circumvent the needs of going for a public tender. This institutional innovation related to the procurement of technology which STATE established was a first as it previously had dealt with software purchase through tenders.

The second novelty concerned establishing structures to support HospIS over time. While for the first 3-4 years, INGO was responsible for providing technical support, the larger question which the STATE needed to answer was how the system would be sustained over time after INGO left the scene. After serious deliberations also involving INGO over alternative support models within a broader context of recruitment restrictions, STATE decided to create IT cells in each hospital, and to also set up a dedicated state level support team. For training these teams, STATE asked their state level training institute to establish capacity building programmes as a part of their routine training activities. In this way, institutional structures for capacity building were to be established within the routine systems and budgets of STATE. While taking these positive steps towards establishing sustainability and institutional ownership of the systems, STATE also could initiate measures to build overall ICT capacity in the public health system, which historically had been weak. These measures can be seen as institutional innovations, as they help to deal with the traditional challenges of systems depended on external support which would die away once this support was withdrawn.

Intersection of social and institutional innovations

This concerns how institutional innovations adopted by STATE could help it better engage with its mission of "health for all" and contribute towards improving health care delivery, especially to those marginalized populations living in the rural and hard to reach areas.

The institutional adoption of HospIS by the state can be seen to have potentially far reaching social implications. Through enabling a wider institutional coverage of the systems, STATE can reach more closely to the rural population, and also help towards its goal of decentralization, a principle enshrined in the constitution. For example, HospIS while registering a patient would take in details of which catchment area the patient came from and for what service. The analysis of this referral information could potentially allow the STATE to understand which catchment areas were weak in the provision of particular services, that were forcing patients to not go to their nearby outreach PHC centres and instead come to the district hospital, which would involve higher investments of time and money. In this way, the status of particular geographical areas and patients becomes more visible which could enable the authorities to intervene in places where care was most needed.

Within a hospital, HospIS could help improve on problems of (lack of) queuing and overcrowding by structuring processes of how the patient needed to move through different departments to procure services. This improved coordination across departments makes for an enhanced patient experience in the hospital. Creating richer medical records with historical patient information would help to improve care to patients, especially those suffering from chronic diseases like TB, Diabetes and HIV which required systematic and longitudinal patient specific information. While HospIS technically provided such

information, its value would only be materialized if clinicians used such information, and could move away from the traditional methods of diagnosis and interventions based on the verbal and brief patient-doctor information. Enabling such use of information, as has been documented in other settings of both developed and developing countries (Braa and Sahay 2012) are an extremely challenging task which would take years rather than months to achieve. In this sense, information can be a necessary but not sufficient condition to reach such a state of use.

Various process improvements were made in the hospitals together with the introduction of HospIS which helped to improve the overall experience of the patients in hospitals. For example, the centralization of the billing function meant that the patient did not need to queue up in multiple lines to make payments for different services. The ability to include diet preferences in the inpatient admission form would help to ensure that a patient would get an appropriate meal with respect to his/her medical condition and in terms of the payments made (eg one who has paid as a special patient to get a special meal). Overall, HospIS created information which meant the hospital could provide the patient with more context based care based on richer patient records, and also to help the patient become more aware and knowledgeable of his/her medical condition (eg looking at the test results with respect to reference ranges). By making available the medical record to the patient, there was more freedom for him/her to get alternative opinions on their medical conditions from other hospitals or doctors.

In summary, various institutional structures and processes were established which would improve patient experience in the hospitals, improve quality of care, and also improve the patient's understanding of his/her medical situation. In the longer run, these innovations can help to improve the trust the population has in the public health system, and draw them away from expensive private practitioners.

Frugal IS and a Better World

HospIS designed and implemented as a frugal IS generates certain types of information, touches particular groups of people, and carries inherent potentiality for change. Arguably, this potentiality is created by strengthening the intersections between technical, social and institutional aspects, and would be incomplete by focusing only on one aspect. Taken together, these three aspects help to create choices that can contribute towards creating a "better world" in the particular context of its use. In this section, we discuss some of the characteristics of this information, the choices they enable, and the potential they carry towards creating a better world. Table 1 provides a summary of the section on how frugal hospital information systems can contribute to enhanced capabilities.

Table 1: Potential of Frugal HospIS to Enhance Capabilities	
Characteristics of Frugal HospIS	Potential Enhanced Capabilities
Strengthening processes to include the disadvantaged	Enhancing the visibility of health conditions of the disadvantaged. Promoting access to rights a patient to be better informed on choices available to them. Enabling citizen groups to gain information about local health conditions to help enables to press health authorities for action. Enabling health authorities to identify areas and groups that need to be prioritized for designing health interventions.
Empowering the patient	By gaining access to patients on information about their individual medical condition, providing them with more choices.

	Richer information through integration of records of OPD encounters, lab tests, drugs and others. This allows the patient to integrate all his/her individual information.
	Richer individual records, for example of lab tests and radiology examinations, made available to the patient allowing him/her to be better informed and potentially make better choices on treatment.
Making voices count	An open source application allows systems to be more decentralized, coming "closer" to the rural population, and thus placing more pressure on the health authorities to act.
	Restoring trust in the low cost public health sector draws people back from the private sector, and enhances their choices on care which may have been prohibitive earlier due to costs.
	Creating future potential for patients to express grievances against the health system, strengthening health system accountability.

Table 1: Potential of Frugal HospIS to Enhance Capabilities

Strengthening processes to include the disadvantaged

This sub-section reflects on how technical and institutional processes in the hospitals were reconfigured to potentially enable more social voices to be included in strengthening of public health systems. HospIS is designed for supporting work in health facilities which are primarily mandated to provide health care to the rural population, who have been historically excluded from mainstream health care systems. Castells (1996) has powerfully argued that by including such disadvantaged people and areas in the "network society" provides a vehicle to redress some of the ongoing tendencies of systemic marginalization. Disadvantaged groups will continue to be marginalized if their conditions remain black-boxed and not visible to those in power who are responsible for making health policy and provide resources and interventions to change these conditions. Information enabled through processes of the network society provides a powerful vehicle to break these conditions which reinforce marginalization.

Designing information systems in the network society for those entities which historically have not had the conditions and capacities to engage with them (such as hospitals in the public sector in developing countries) is a non-trivial challenge. HospIS designed in such a context, enables the processes of inclusion of disadvantaged groups and areas in different ways. For example, at the time of registration, the patient's demographic, medical, and other details (such as of a special category patient) are captured. This helps to ensure the patient gets appropriate benefits based on the category he/she belongs to. The registration information once captured becomes a permanent entity in the system, and can technically be retrieved during future encounters of the patient with the health system to provide improved continuity of care. Through the "inclusion" of these details, the database can be queried to identify how many patients by different demographic categories (gender, age groups, rural-urban etc), are seeking what types of care (eg surgeries, OPD consultations, lab tests etc). This makes health care related problems more visible to the health authorities, and provides the impetus to act upon. Whether the authorities choose to act on this visibility or not is indeed a different matter and depends on various other conditions such as political will, resources, and informational competencies (to interpret and analyze the information). While such a situation of usage indeed has not yet been reached in STATE, the failure to act on this information can also become a rallying point for the public.

Citizen groups can also demand information (such as disease profile of their village or district) from the authorities to argue for better resources and facilities to deal with their local health challenges. There are thus increased choices being created from the perspective of both the providers and recipients of health

care to identify health priorities and act on them. In the future, as we see these choices being exercised, there can be increased demand for more information which can help make visible other kinds of health priorities that people are experiencing and which may be currently black-boxed. In summary, HospIS by making visible information which previously was hidden, and making it available to different groups of people, creates the potential for enabling more choices to define and act on health priorities.

Empowering the patient

This sub-section reflects on how an individual patient can access more choices about improving his/her healthcare condition through technical and institutional design aimed at making more relevant information available. Potentially, through HospIS, the patient gets richer and more improved information on his/her medical condition, which in itself can be empowering. For example, the patient now gets a provisional diagnosis written on the OPD slip as HospIS has that as a mandatory requirement for the doctor to fill in. In the past, the doctor would not write this, and would write only the names of the medicines and tests prescribed. Once the patient has a slip with the provisional diagnosis and other details, he/she has the additional choice of taking that slip to other doctors or hospitals and to be not locked into one doctor and facility. This possibility of increased choices to access health care while being empowering to the patient, also creates more accountability on the doctor filling the OPD slip.

HospIS helps to create a richer and longitudinal medical record for the patient including details of test results, OPD and IPD encounters, drugs prescribed which are all stored in one place for each patient and can be retrieved when required. This helps to provide improved health care to patients, especially beneficial to those suffering from chronic diseases like TB and Diabetes. From the patient's perspective, there is no need to run around to different places to access different pieces of the medical record, as all of it can be accessed at one point, and richer information created through the combination of all this information.

In addition to the richness created through the integration of different pieces of information, there is also the enhanced richness of individual records. Examples of this come from the lab reports which are now printed, and carry details of reference ranges against each result. Similarly, radiology images now carry comments from the radiologist, and the patient now gets more than just the image. Through this enhanced richness of information, the patient gets a more informed understanding of his/her condition and can in principle take better decision on health care choices.

In summary, the potential to access historical, different kinds, and richer data of the medical condition of an individual patient at one point is empowering as it provides for more and better choices on where and how a patient seeks to access health care.

Making voices count

This sub-section concerns expanding the reach of the system to touch more of the social population through the use of more scalable and cost-effective systems, and making the institution more aware of its responsibilities towards providing "health for all". Historically, the rural population in India has limited possibilities to articulate their voices in shaping health care to them through the public health system. While the Indian Constitution delegates health care as a state responsibility, health care programmes and delivery takes place through a strongly centralized model. Rural populations can be held hostage to the doctors in the facilities who often run their private practice at the expense of their commitment to the public system where they are legally employed. As a result, many patients have lost trust in the public health system, and if they can afford it tend to seek care in the more expensive (and sometimes unscrupulous) private system. Those who can't afford the private sector, will either resign themselves to get what they can from the public system or visit quacks and traditional medicine practitioners.

Centrally, the Indian government established the National Rural Health Mission (NRHM) in 2005, seeking to make systemic corrections in the public health system and to restore the trust of people in it. Decentralization of systems, including information systems, was seen as a key vehicle for making these corrections, as it would allow the health department to come closer to the people, be able to hear their voices, and try to make these voices count in shaping health care delivery. Despite these aims, often the information systems developed by the government are highly centralized, and contrary to the decentralization aims. HospIS was consciously designed by STATE with these aims of decentralization in

mind, through two key vehicles. One, by covering all the hospitals in the state, and ensuring referral information is collected (and subsequently analyzed and used) from all the population residing in the catchment areas of the hospitals. Covering all facilities was important, as many of the districts in STATE are in hard to reach and hilly terrains, which are cut off from the rest of the state in the winter months. Two, by collecting patient specific (not just facility based) data, which helps to make the condition of individuals visible.

Through the different means discussed earlier, more and more individuals have been provided with the potential of raising their voices by developing an improved understanding of their own conditions. While not in place currently, there are plans to enhance HospIS in the future so as to enable patients to express their opinions and grievances. As more and more of such voices are expressed and made visible, authorities will need to give attention to these voices and make them count in planning health care delivery.

Conclusion

We started this paper by asking the question of whether ICTs are making a better world which we sought to analyze through the linkages between frugal IS and development. This is a topic of current interest to many but, as we noted in the Introduction to the paper, we need to understand what we mean by better in particular contexts and we need to be able to theorize this in a way that is more widely applicable. The chosen research domain for our paper is hospital information systems in a particular state in India. The primary conceptual notion is that of frugal information systems. We have theorized this in two stages. First, we have drawn from the innovation literature to characterize frugal information systems as a type of innovation or, rather, as the intersection of three different types of innovation: technological, social and institutional. We have used the empirical material from our action research case study to illustrate these innovations.

The second part of our theoretical framework addresses the question of frugal IS or frugal innovation for what? In other words, what are the goals of the innovation and how can they be theorized? We have drawn on the capability approach of Sen to conceptualize an answer to this question through theories of increased freedoms and choices brought about for participants. We have illustrated how the frugal IS in the case study led to increased opportunities for choice for the patients in public health systems who are relatively poorly served at the present time in most parts of India. We have discussed some of these opportunities under the themes of strengthening processes to include the disadvantaged, empowering the patient, and making voices count.

Although our theoretical framework has been applied to a single specific case, we believe that both parts of our theoretical approach have wider applicability. The notion of frugal information systems as part of frugal innovation could be used to examine other IS applications in resource constrained contexts. Our use of Sen's capability approach to theorize the goal of the innovation as enhanced choice is also of a sufficiently general nature to be applicable to other studies of IS which claim to enhance people's lives or 'make a better world'. Finally, it is worth noting one limitation of our study which leads to further opportunities in the future. Our case stopped at the point at which enhanced choices are, perhaps for the first time, available to patients in this Indian state. However, will they result just in enhanced capabilities for choice or, better, in enhanced functionings such as improved health. We hope it is the latter and further research could pursue theoretical and empirical evidence for this in the future.

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