IT INNOVATION IN A HEALTH INFORMATION SYSTEM IN KENYA: IMPLICATIONS FOR A SUSTAINABLE OPEN-SOURCE SOFTWARE MODEL IN DEVELOPING COUNTRIES

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Abstract: The paper proposes a business model analysis framework to identify the main issues that need to be addressed within the context of a specific developing country for the sustainable development and growth of OSS. Based on the longitudinal case study of the Ministry of Health in Kenya, the paper analyses how the adoption and usage of technology has influenced the structures of its health management information systems and the related implications for the health service delivery. The analysis focus onto the human-mediated interplay between the intrinsic material features of the IT artefact and the main elements of the surrounding institutional and technological environment and their influence in relation to the donor-driven reforms of the health sector. Empirical results are then used to critically discuss the main implications of the institutional and technological environment characterizing Government IT innovations in developing countries such as Kenya for the development of local OSS sustainable products. Finally, the main factors identified are then used to build an OSS business model analysis framework. The framework can be used to better understand the major issues that need to be addressed at different institutional levels for the sustainability of OSS in the Governments of developing countries.

Keywords: Open source software, public sector IT innovation, developing countries, health information systems

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INTRODUCTION

Information and Communication Technology has been recognised as a key enabler of human development and poverty alleviation. The strategic role of ICT for development (ICT4D) is voiced in the United Nations' Millennium Declaration (UN, 2000) as one of the targets of Millennium Development Goal Number 8.

The Millennium Development goals were endorsed in the year 2000 by the member States of the United Nations in response to the declining development scenario of most developing countries. From this time on, the MDGs represented the main framework of reference within which most development and technical assistance projects were conceived, particularly, in the area of essential public services such as health care (UN, 2000).

Hence, following the international endorsement of the MDGs, one of the major areas of intervention of development programmes has been the restructuring of the public service of developing economies in order to improve accountability and good governance (Ciborra, 2005; Fountain, 2002; Heeks, 2001; World Bank, 1997). Being informed by the New Public Management doctrine (Hood, 1991), most of these programmes leverage IT to transform hierarchical structures into flatter, more information efficient organisational forms (Dada, 2006; Osborne & Gaebler, 1992).

With particular reference to the health care service, since the early 80s the donor community has stressed the need to decentralise the health care system to the districts to guarantee increased efficient service delivery and equitable access to the health care for the local communities (Kimaro & Sahay, 2007; WHO, 1978). As the call for efficiency and equity in the health service intensifies (MDGs 4, 5, 6), the decentralisation efforts is now followed by the need to integrate the health care system to rectify the inefficiencies caused by the donor-driven development of stand-alone vertical programmes (e.g. HIV/AIDS, Immunisation, Malaria, etc.) (Chilundo & Aanestad, 2004).

In both processes, decentralisation and integration, the performance of Health Management Information Systems is a key issue to be addressed. On the one hand, timely and accurate managerial and epidemiological information can be used to empower the planning and decision-making capacities of the districts to better provide for the health care needs of local communities. On the other hand, integrated health information can support coordinated and effective actions in the health care delivery. Based on this consideration, Information Technology is viewed as a critical investment for the restructuring of HMIS and the Health care system overall.

Still, the usage of Information Technology in the improvement of health care systems in developing countries seems to have produced very poor results. The literature on health management information systems depicts a failure scenario whereby most systems are still manual with the exception of few "islands of automation" (Saxena & Aly, 1995) represented by stand-alone computer databases mostly concentrated at the central national level, but also scattered across the subordinate levels of the health care systems (Chilundo & Aanestad, 2004; Kimaro & Sahay, 2007). This has been mainly attributed to: the piecemeal approach of donor funding to IT systems (Ciborra & Navarra, 2005; Kimaro & Nhampossa, 2005); high

financial risks and maintenance costs due to the vendor lock-in to foreign proprietary software solutions (Ciborra, 2005; Simon, 2005); the adoption of top-down technology-centred approaches (Lee et al., 2008) against the inclusion of local stakeholders' prerogatives in the system design, adaptation, and implementation (Krishna & Walsham, 2005; Macome, 2008).

Open Source Software has widely been proposed as the right solution to the unsustainability of most IT systems in developing countries (Braa & Muquinge, 2007). Due to its non-proprietary nature, OSS is believed to enable the production of local information technologies that can bring more sustainable and effective development results, particularly, in the framework of poor contexts such as the public sector in Africa. In particular, OSS can facilitate the development of local IT expertise (Camara & Fonseca, 2007), major flexibility in local customization, and guarantee low costs, interoperability and the "avoidance of vendor lock-in" (Simon, 2005).

Still, there exist many challenges that prevent the development dividends of OSS and locally produced technologies from being fully achieved. These are related to a poor supportive institutional environment including the lack of a policy-enabling framework, the low perception of the business opportunities for the thriving of a local open-source industry exacerbated by the hostility of multinational manufacturers of proprietary software, and the lack of a human capacity building infrastructure for the training of local developers (push factor) which is also due to the poor attractiveness of open-source in terms of job-opportunities (pull factor).

In consideration of the ascertained limitations of OSS, the paper aims to propose a business model analysis framework to identify the main issues that need to be addressed within the context of a specific country for the sustainable development and growth of OSS. The model will address the main requirements for the development of OSS core applications in public service management and delivery (e.g., health management information systems).

This will be achieved by analyzing the case study on the adoption, usage, and evolution over time of a computerized epidemiological information system in the Ministry of Health in Kenya. The analysis will focus onto the human-mediated interplay between the intrinsic material features of the IT artefact and the main elements of the surrounding institutional and technological environment and their influence in relation to the donor-driven reforms of the health sector. Although the computerised information system studied is not open-source, empirical results provide a solid basis of discussion of the main implications of the institutional and technological environment characterizing Government IT innovations in those developing countries like Kenya for the development of local OSS sustainable products. An OSS business model analysis framework will hence be suggested to better understand the major issues that need to be addressed at different institutional levels for the sustainability of OSS in the Governments of developing countries.

THE OPEN-SOURCE SOFTWARE MODEL: MAIN CHALLENGES FOR DEVELOPING COUNTRIES

Open-source can overcome the shortcomings of proprietary foreign applications through drastically reduced costs, international independence from powerful commercial entities, and local ownership of software solutions (May, 2006; Weber, 2003).

The main model underpinning the development of most OSS products is the distributed development process, whereby, OSS developers launch a product or contribute to the development of an existing one on a voluntary basis without the expectation of a secure and immediate earning income (David, 2006; Weber, 2003).

Most programmers are attracted by the "community-oriented" approach of OSS as it provides the opportunity of training and attempting something new. However, this approach is not completely free from a commercial logic.

Participating to OSS projects is viewed as an effective means to attract future income (David, 2006). Thus, the legitimacy of OSS comes from the Open Source technological environment and the awareness of the business opportunities it offers.

Still, if on the one hand the voluntary and communitarian approach offers a space for gaining new skills and capacity building for developers, on the other hand, most projects do not pass the development phase, and most of them are dropped, unless they are not taken over by a software vendor (Simon, 2005).

Thus, the traditional development model of OSS products does not seem to favour innovation as it does not have a strong basis of investment to sustain it. In contrast, the commercial-driven model seems to be the most effective at the moment for the sustainability of OSS products: "the industry needs the profits from proprietary software to help fund open-source development" (cited from Simon, 2005).

The main OSS products targeted by this model are either infrastructural applications (e.g., Apache Web Server, operating systems) or established commercial software products (e.g., Open Office) (Camara & Fonseca, 2007). Generally, one of the main revenue approaches characterizing the commercial-led model is "value-added service-enabling", whereby a company gains competitive advantage by offering a series of support and consultancy services targeting specific open source products (Fitzgerald, 2006).

On the one hand, the community-led model has not the investment capacity to guarantee sustainable OSS products and innovations. That is why, successful community-led projects usually target the development of products that have a "high degree of shared conceptualisation", based on established and popular conceptual models (e.g., Open Office Suit) and standards (e.g., mySQL) and high modularity, whereby the project can be broken into many independent modules (Camara & Fonseca, 2007) allowing the setting up of distributed development teams. The downside of this approach is that it limits innovation to "reverse-engineering existing designs or following accepted standards" (Camara & Fonseca, 2007).

The commercial OSS model, on the other hand, does not provide the incentive to invest in innovative open source business administration and service industry systems (e.g., financial information management systems, health management information systems, etc.). In fact, most private software businesses do not want to take on the risk of an innovation that will not guarantee enough sustainable competitive advantage due to its non-proprietary nature. Like the community-led model, most OSS commercial products have a "high degree of shared conceptualisation" as they propose products based on established standards or similar to existing commercial products with little innovation. Users and developers already know these products reducing the design effort and benefitting from the low risks of "reverse engineering" (Camara & Fonseca, 2007). Since the design process is centrally controlled and tied to the company's commercial objectives, OSS products characterized by low modularity are usually preferred (Camara & Fonseca, 2007). A major risk of these products is that they may face a low competitive advantage with respect to incumbent vendors who own large amounts of resources to quickly emulate OSS products and anticipate them with a more innovative product on the market (Simon, 2005).

Both the community-led and commercial OSS model, thus, have a very low driving force towards innovation. This "conservative trend" is particularly common in developing countries

where most programmers prefer to work to adapt existing western developed applications and be paid. Most IT managers do not want to take the risk of developing new OSS products to substitute legacy systems (Camara & Fonseca 2007). This hinders the social and economic impact of OSS by limiting its potential to create local knowledge, and meet different end-user requirements (Braa & Muquinge, 2007; Weber, 2003).

This raises the need to have a sustainable model which allows high levels of innovation in OSS projects that have a low degree of shared conceptualization, meaning a high potential towards innovation, and high modularity (Camara & Fonseca, 2007), which, in turn, enables to cope with the production of high complex IT business and service systems (David, 2006).

The main challenges towards the development of this approach are not purely economical as illustrated above. Other issues are involved, such as the kind of expertise needed to design and manage high modular software with low interdependence between modules, the lack of documentation, and the need to create a sustainable critical mass of users (David, 2006).

The technical knowledge and expertise required for the implementation of complex OS management and service architectures (e.g., health management information systems) are particularly lacking in developing countries (Tierney et al., 2008). Under these circumstances, OS solutions involve reduced costs only partially. The costs to sustain local products may be higher than on developed countries' markets.

Likewise, in developing countries OSS benefits from an even smaller base of users than in developed countries limiting their power to contrast the land-locking hegemony of proprietary platforms.

This issue is particularly challenging as OSS users need to be more skilled than average proprietary software users. Whereas proprietary software is tested before being released to the market, OSS applications are tested along usage after having been made available to the public. Users have thus the possibility to contribute to fix bugs and may contribute to the final release of the products (Simon, 2005). This approach may constrain the growth of OSS users' base in developing countries where most users do not have programming skills. Thus, the diffusion and sustainability of OSS solutions will strongly depend onto a business model that targets the larger sections of the population providing user-friendly interfaces, linguistic translations, and user manuals (Simon, 2005).

In developing countries, there is need for applications that meet information needs of average users (Camara & Fonseca, 2007). This does not happen as most applications developed are infrastructural (web servers, OS, programming languages). The adoption of OSS products needs large investments to adapt them to the local markets.

THE CASE STUDY OF A HEALTH MANAGEMENT INFORMATION SYSTEM IN KENYA

THE MULTIVOCAL AND MULTILEVEL INSTITUTIONALIST FRAMEWORK

The case study adopts a multivocal and multilevel instititutionalist perspective to analyse how new and old rules, norms, and cultural meanings influence technology innovation and the usage of IT in information processing within the national health management information systems of the Ministry of Health in Kenya.

The paper posits that the context of the African public sector is characterized by complex interlinkages between various actors (e.g., international agencies/donors, ministries, public employees, etc.) (Kimaro & Sahay, 2007) who act under the pressure of multiple rationalities (Chilundo & Aanestad, 2004). In particular, the paper recognizes two main logics (or sets of

meanings) underpinning the actions of these actors. These are either embedded in imported reform models such as the New Public Management (Hood, 1991) competing with the logics of the Old Public Administration (Lynn, 2006). The latter characterizes the "personal nature of African bureaucracies" and is supposed to inform the actions of local public employees in contrast with the "managerialist" rationality enshrined in exogenous reforms (Smith et al., 2008) (Table 1).

The conflict between these two different sets of meanings influences the misalignment between the formal rules (e.g., policies, planning and data reporting structures) underpinning the implementation of health information systems and the informal constraints to its prescribed usage arising from the divergent interpretations of local IS users (Chilundo & Aanestad, 2004; Kimaro & Sahay, 2007).

New Public Management Logics	Old Public Administration Logics	Literature
Managerialism Increased responsibility and decision-making power to middle-management (disaggregation, agencification) Decentralisation of power to the periphery De-politicisation of implementing structures and functions	**Bureaucracy and politicisation** Decision-making is concentrated at top of hierarchy Centralised input controls, rules and procedures	(Bajjaly, 1999; Hope, 2001; Olowu, 2006)
Accountability Result and performance-oriented management system	**Political affiliation** Political rewarding system	(Grindle, 1997; Hope, 2001; Owusu, 2006; Peterson, 1998)
Market Competition Externalisation of the public service to market	**Monopoly** Weak market economy Internalisation of service delivery (insourcing)	(Ciborra, 2005; Grindle, 1997; Hope, 2001)
Customer-orientedness Responsive, diversified and "exclusive" service Customer identity of beneficiaries	**Politicisation of service** Central (external) political control Public service complies with international/national policy priorities	(Ciborra, 2005; Drori, 2008; Grindle, 1997; Owusu, 2006)

Table 1. Institutional logics of the New Public Management and Old Public Administration

Under this perspective, the case study presented in this paper provides an historical longitudinal analysis of the opportunities of change enabled by the institutional environment and by the resource-material environment (IT technical features, human resources, information tools). Drawing from a multilevel institutionalist perspective (Chreim et al., 2007), the context of HMIS of developing countries is viewed as made of three levels, the macro or policy level e.g., formal policies), the meso or organisational level (e.g., management structures) and the user or agency level (Kimaro & Sahay, 2007). Macro and meso levels institutions are interlinked (Chreim et al., 2007) and enacted by IT users at the micro or agency level. The way IT users enact competing sets of meanings encoded in the

institutional environment affects the development, integration and usage of a technology conditioning its organisational impact.

The three-level perspective is quite relevant in the context of the African public service. The macro or policy level is where institutional arrangements accompanying IT implementation entail political solutions (Horn, 1995; North, 1990) emerging from the intersection of interests of various actors, including Governments, donor agencies, and international commercial entities (Ciborra & Navarra, 2005; Kimaro & Nhampossa, 2005; Sander et al., 2005). However, the meso or organisational level may have important mediating and, at times, moderating affects (Dada, 2006) onto policies and other external environmental factors, in particular, where organisational behaviour is informed by different professional norms (e.g., medical management, data management staff, etc.). Finally, the micro-level is where the linkage between macro and meso level institutions is shaped (Madon et al., 2007), at times, through personal or social relationships that may substitute bureaucratic official procedures (Smith et al., 2008) (Figure 1).

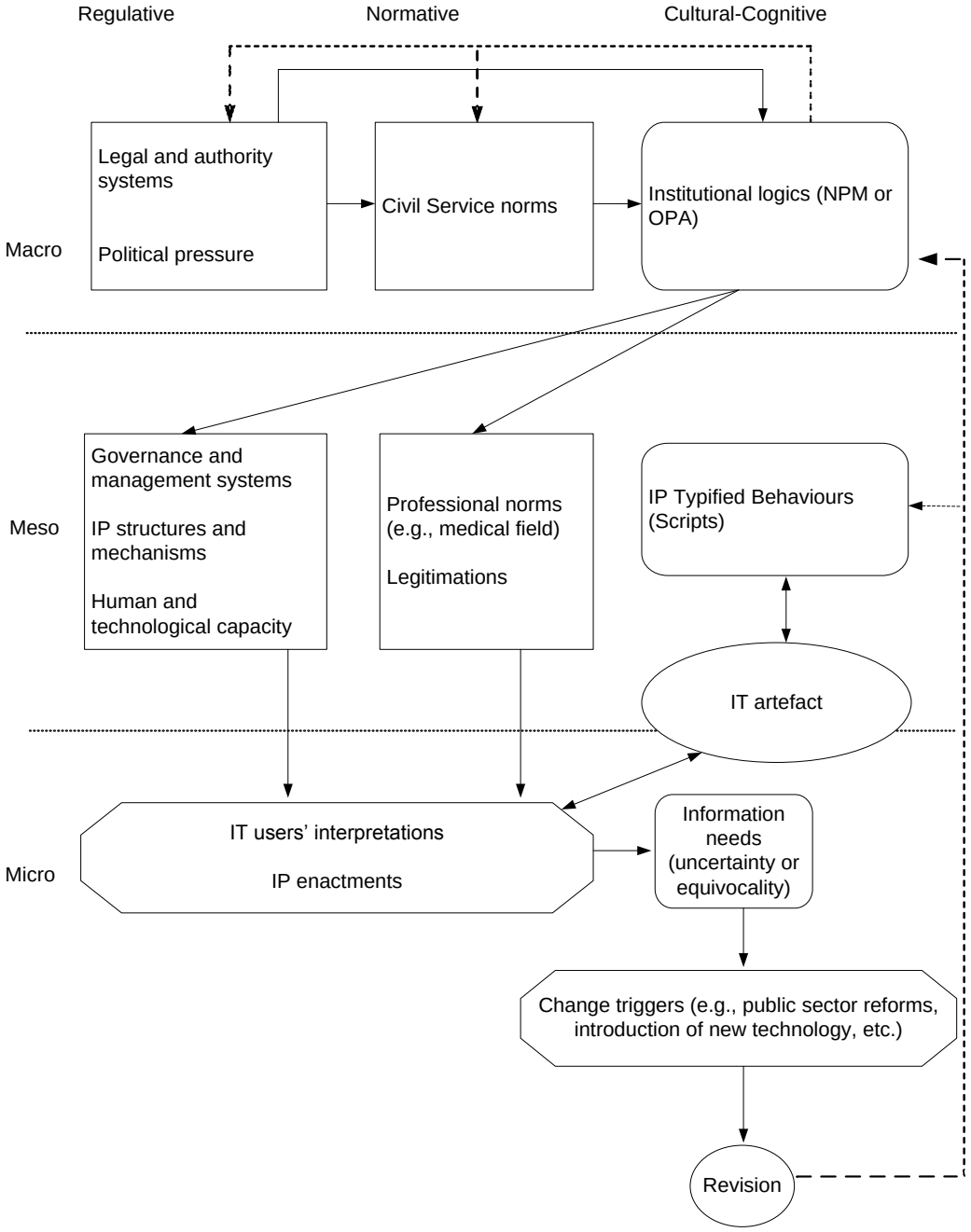

Figure 1. Multilevel institutionalist framework

In addition, the enactment of institutions at different levels is associated with the means enabling the mobilization of interpretive resources of the institutional environment (Sewell, 1992). These means are represented by the technical features of the IT artifact and of the surrounding technological/material resource environment, including the physical and human resources available. Therefore, if on the one hand the mobilisation of interpreting and legitimating resources conditions the enactment of the material properties of IT, the design of the latter may facilitate new meanings and practices underpinning technological innovation, thereby, reshaping the institutional order of the public health sector.

METHODOLOGY

The paper illustrates the adoption of a new computerized health management information system at the Division of Vaccines and Immunisation of the Ministry of Health in Kenya. The division represents one of the units of analysis of the case study of three health management information systems in Kenya: the central Health Management Information System, the Disease Surveillance and Routine Immunisation Information System of the Division of Vaccines and Immunisation, and the HIV/AIDS information system of the National AIDS Programme. Data were collected during a field visit at the Ministry of Health in Kenya. For the Division of Vaccines and Immunisation a sample of eleven out of thirty-eight semi-structured interviews (one hour average each) were collected. These were corroborated with around 2,000 pages of documents out of a total sample of approximately 5,000 pages.

Staff members with the earliest date of deployment were selected in order to capture the longest longitudinal accounts possible. Moreover, the sample included not only health records officers, the direct users of the information system, but also medical management and technicians, i.e., the indirect users of the information system. The inclusion of different organisational roles into the sample of informants was part of a "comprehensive sampling" strategy (Miles & Huberman, 1994, p. 38) in order to have a more systemic view of the evolution of the information system and technological changes.

The questionnaire was structured according to the theoretical framework in Figure 1. Questions were asked regarding their main functions in the division, changes in their working practices, professional values, technological changes and institutional reforms.

Documents were collected from the archives of each division and the central library of the Ministry of Health. These included Government policy documents, minutes of meetings and reports from the information systems covering a period from 1980 up to date. Relevant international agencies' policy and project documents were also retrieved online.

Data analysis was also framed within the theoretical framework of Figure 1.

Interviews were first transcribed and coded in NVIVO 8. Starting from a pre-defined set of codes for each level (macro, meso, and micro) and pillar (regulative, normative, and cognitive), new codes were created along the process of data analysis (Miles & Huberman, 1994 p. 58). Time-series codes were also created starting from 1980 with a five-year interval. After coding each set of interviews for one division, codes were reviewed and similar codes were grouped under common categories ("pattern coding", Miles & Huberman, 1994, p. 69). As a consequence, all data from the first division had to be reviewed and analysed again to take into account the new concepts.

Once the coding of interviews had been completed, an "interim summary" of findings (Miles & Huberman, 1994, p. 77) was drafted to review emerging issues. The interim analysis allowed to better identify the issues that needed to be corroborated or complemented by the subsequent analysis of documents.

Like interviews, the coding of sets of documents per each division was alternated with the grouping of similar codes into broader categories. For each division, new data from collected sample of documents were searched, analysed, and coded until a stage of saturation where no more concepts could be developed was reached (Strauss, 1987, cited in Miles & Huberman 1994, p. 62).

DESCRIPTION OF THE CASE STUDY

In 2004 the Division of Vaccines and Immunisation (at the time called Kenya Expanded Programme on Immunisation) adopted EPI-Info, public domain (free-of-charge) statistical software for epidemiology, in order to decentralise health information processing to the field. EPI-info was developed by the Centers for Disease Control (CDC) which supported its implementation in the division together with WHO. EPI-Info is a no-charge, non-exclusive, royalty-free, and irreversible license product. Its simple programming language allows non-programmers to easily build and customise data based management systems. Its first Windows version, Epi Info 2000, was released in 1999. Until then, it could be run as a DOS program in a Windows-environment (Harbage & Dean, 1999).

Official documents evidence that health records officers started advocating for a decentralised integrated computerised system in 1997. Still, the management did not fully engage in it until the stepping in of a new contributor to the mission of the global immunisation programme, i.e., the Global Alliance for Vaccines and Immunisation (GAVI).

Founded with the objective to mobilise resources for vaccines to developing countries, GAVI started its activities in Kenya around 2000 and supported the immunisation programme not only through the introduction of new vaccines (e.g., HiB in 2001) but also by contributing to the strengthening of the monitoring and evaluation system through its "performance-based grant programme. [1] In order to monitor the performance of the health information system, GAVI started performing periodic Data Quality Audits (DQAs).

However, contrary to expectations, the chip in of the Global Alliance for Vaccines did not succeed in increasing the level of donor funding. On the contrary, donor contribution to the Programme shrank from 83% in 1999 to 47% in 2001 (WHO, 2001) as external resources were diverted to other priority areas (e.g., HIV/AIDS). At the same time, there was an increase in the national public expenditure on vaccines from 17% in 1999 to 53% in 2001

This notwithstanding, the perception of the need for reliable quality data to justify funding was still high, putting emphasis onto the strengthening of the information processing capacity at the lower levels. Thus, based on the recommendations contained in GAVI DQAs, the Management Unit of the Programme started mobilising donor funding for the decentralisation of the information system.

It followed that between 2001 and 2003 the Programme Management Unit asked for donor support for the set up of a "decentralised […] multiuser window based programme which can be used in a networking environment". The proposed system was an ambitious project meant to decentralise data processing to the lower levels, starting from the provinces all the way down to the facilities. It represented a radical shift from the Computerised EPI Information System (CEIS) in place at that time.

CEIS was an unlimited license software installed at the central Management Unit in the early 90s with the support of USAID in order to accelerate the "analysis of epidemiological data". CEIS was a dos-based and centralised IT system designed for the management and statistical

[1] The DPT-III indicator measures the injection of the three doses of the trivalent vaccine against Diphteria, Pertussis, and Tetanus.

analysis of epidemiological data. Due to its stand-alone architecture, it only provided a single-user environment and hence a centralised processing of information. Immunisation and surveillance data for immunisable diseases were sent from the field and entered into the system by a health records officer at the central management unit in order to generate reports on immunisation and diseases incidence rates.

The division was not satisfied with CEIS performance due to its lack of stability ("it keep on crashing") and cumbersome data processing determined by its centralised architecture: "the section is constrained by lack of sufficient computers to amicably handle the data sent to KEPI. Data entry is done in an old Olivetti computer donated by UNICEF 10 years ago […]. Following the need of timely and complete data, KEPI would like to utilise the current modern technology to access data from the districts…"

Still, it took almost four years before the implementation of the new system started. Until then there are reports of misalignment between type of technologies and information processing practices on the ground and inconsistent data processing across the different levels of the information system causing duplications and delays. In particular, not all districts were equipped with information technology. Some keyed in data collected from the health facilities into Excel sheets to be printed and sent to the national level. Others still relied on a manual reporting system with a higher risk of "arithmetic errors introduced during manual aggregation of data".

In the meantime, between 2003 and 2004 CEIS broke down forcing the programme to rely on Excel, which, although being an efficient data analysis tool, posed no little constraint to the maintenance of an updated immunisation and disease data base given its low data storage capacity.

Finally, in 2004 Epi-Info was implemented in the provinces which became in charge of data entry whereas data analysis was still performed by the central data management unit. More specifically, the provinces would receive data from the districts and enter them into the system. Data would then be shared with the central data management unit of the programme either remotely through the network server or by sending data sheets by e-mail.

However, the partial decentralisation of the information system did not bring about the decentralisation of planning and management structures at the lower levels. In fact, being the adoption of the new IT system limited to decentralisation of data entry to the provinces, both districts and provinces were not empowered in decision making as data analysis was still performed at the central level. Moreover, the Government commitment to decentralisation was still very low as district budgeting and financing mechanism had been left out of the reform. According to the final evaluation report of the World Bank project for the "Decentralisation of HIV/AIDS and Reproductive Health", "the centralised financial management system […] limited the ability of the system to disburse resources to the districts […]. This failure […] has frustrated implementing districts as they have very little control over resolving implementation constraints and created service delivery gaps in the supported districts". This involved the low ownership of the new computerised information system at the provinces and districts which were not motivated to ensure an efficient functioning and maintenance of the system and its expansion to district and facility levels.

DISCUSSION OF FINDINGS

Data show that discourses in favour of a new computerised system enabling the decentralization of the health information system initiated a few years earlier than the beginning of GAVI performance-based scheme. In particular, these discourses originated at the meso level from health information officers. These discourses were apparently motivated by the poor performance and reliability of the old system CEIS. It is arguable that the

perception of such inadequacy was characterised by the technological environment in which actors where embedded. More specifically, the "framing" (Davidson, 2006; Orlikowski & Gash, 1994) of CEIS as an inefficient centralised Dos-based system might have been determined by an increased awareness of the possibilities offered by the new material technological environment ("current modern technology"). Based on this argument, the major promoters for a new system within the programme management unit might have been the health records information officers who, most likely, were more exposed to certain technological advancements, in particular, after the introduction of Windows and more easy-to-use data analysis application suits such as Excel.

The exposure to more advanced technologies was also due to their frequent relationship with international development partners and consultants. Thus, if on the one hand the exogenous influence of international partners at the macro-policy level was instrumental for the transfer of new IT-related knowledge, the endogenous normative pressure of health records information officers facilitated the legitimacy of new integrated and networked information systems contributing to reduce the gap between institutional accounts and enactments of decentralisation. It was under this institutional pressure, that health records officers started a persuasive action to convince their leaders of the importance of a more advanced IT system in exchange of additional financial resources, thereby elevating the cognitive legitimacy of a decentralised computerised system to the middle-management level.

This persuasive action was facilitated by the new endogenous ownership and, hence, legitimacy, of the Programme represented by the increase in Government funding against a decrease in external donations. This time the need for a new system was not anymore to be accountable to donor partners but was made necessary to have a major stake in the Government budget. Apparently, compared with donors' external legitimacy, the government endogenous legitimacy offered more opportunities for durable funding and, hence, continuity of the Programme's activities. Under this perspective, the Government funding scheme represented a stronger incentive for the management programmes to actively engage in fund raising for a sustainable well functioning computerised system.

At the same time, however, this raises the question of why the implementation of the IT system was delayed for so long? Being it a free-of-charge and easy-to-customise system, one would have expected a faster process. Moreover, the institutional accounts for accountability underpinning GAVI's recommendations for a well functioning routine immunisation information system let assume a more responsive support by the donor community, if not towards vaccines funding, at least, in relation to a new computerised system.

It is arguable that the slow pace through which the whole process was carried out was due to a discourse misalignment between the cultural-cognitive legitimacy of the new IT system driving the supportive action of the health records officers and management at the meso level and the socio-political legitimacy of a well functioning monitoring and evaluation system by donor partners and decision makers at the macro level.

Although donors recognised the importance for a more efficient information system at all levels, they might not have been ready to commit considerable funding for its automation. One of the reasons behind it might be the higher demands of the Programme with respect to 10 years before with CEIS. This time there was not only the need to equip the management unit with a computer and a software tool for central data analysis and storage. The set up of a networked and decentralised IT system required a lasting large-scale effort involving the equipment of all provinces and districts with IT tools and the necessary human capacity. This kind of engagement was too demanding if compared with the preferred piecemeal and short-term approach of donor-funded initiatives which had led to the fragmentation of the health information system reinforcing the institution of disaggregation. Along with this argument,

international partners' donations for vaccines were not that high to justify such a massive investment in technology.

Likewise, the macro-level endogenous socio-political legitimacy of the information system was lacking, particularly, with regard to its automation needs. At that time the central government support to automation was still very poor. IT investments were hardly considered as a priority, being the Government torn between shrinking budgets and high demands for primary commodities such as vaccines. In addition to this, there was little awareness among decision makers of IT as a powerful control and monitoring tool.

That is why the Programme management was still forced to plead for donor funding for the new IT system with all the drawbacks that the lack of continuous commitment by donors implied, not only in terms of delays, but also reduced scope witnessed by the roll out of the new system only up to the provinces and not at districts and facilities as planned.

Data evidence low Government commitment not only in relation to IT but also in relation to decentralization which influenced the low ownership of the health information system at the lower levels of the health system. In fact, the Government delayed all substantive reforms for the effective decentralization of decision making structures within the health sector meaning that the socio-political legitimacy of decentralisation at the national macro level was still very weak if compared, on the contrary, with the strong cultural-cognitive legitimacy of centralization. Such legitimacy of decentralization was therefore reflected at the micro-level of action of the information system. As districts and provinces did not perceive any change towards the decentralization of decision making, they envisaged a "passive" utility of the health information system, limited to the administrative task of reporting immunization and disease data for usage by the central level. This lied at the root of the lack of any entrepreneur action at the lower levels of the health care system for the strengthening of the information system.

OPEN SOURCE SOFTWARE BUSINESS MODEL ANALYSIS FRAMEWORK

The case study raises useful implications for the identification of the main factors that may affect the development of a sustainable development model of Open Source Software in developing countries. The focus onto the public sector provides even more salience to such implications. In fact, the Governments of developing countries can constitute the major adopters and, consequently, promoters of local OSS innovations. Governments can ensure a more sustainable funding to OSS projects (Camara & Fonseca, 2007). Moreover, given the inclusiveness and equity values underpinning the delivery of public services and the monopolistic (or quasi-market) regime in which public sector organizations operate, the development of OSS is less driven by competitive advantage opportunities in the market but more by the effective needs of the service itself. Thus, public-led models of OSS development could produce more innovative and complex OSS products than the private sector.

The main OSS-relevant issues raised by the case study are:

a) There is need for macro-level endogenous legitimacy of Government organizations' mission and goals to motivate meso-level management towards innovation. Such legitimacy provides management and other professional cadres with the incentive to advocate OSS solutions fuelling local demand for OSS (*OSS-innovation pull-factor or trigger*).

b) The legitimacy of OSS comes from the Open Source technological and material resource environment and the awareness of the business opportunities it offers. Such legitimacy can rise from the exposure of key professional staff at meso level to open-source software and their development environment. The main vehicles of OSS products and methodologies could be NGOs, donor partners, and foreign universities. This is particularly important in

public administration of developing countries characterized by a low presence of programmers. If new professional opportunities are perceived, some categories of public sector employees may be induced to change their roles as it happened after the first wave of automation in the early 90s in the Ministry of Health in Kenya. On that occasion, clerks upgraded to more technical expertise (e.g., programmers, and information officers). The awareness of new opportunities of professional growth motivate technical cadres at meso level to look for donor funding for their professional development (*OSS-innovation pull-factor or trigger*).

c) Donors can't support long-term high scale IT projects due to their piecemeal approach. This prevents a thriving and sustainable OSS business environment, given that OSS needs the mobilization of large amounts of resources and big investments especially for large management and service systems integrated suits. Thus, the approach of donors in OSS would resemble that of the "low-low OSS model" (Camara & Fonseca, 2007) characterized by low shared conceptualization and low modularity. Based on this model, developing teams are supported for the development of software tools that have a reduced scope or a piloting dimension [2]. Although these projects propose innovative solutions, these cannot be extended to a larger-scale and be made available to the user as full-fledged user-friendly products (*exogenous OSS-innovation push-factor*).

d) There is also lack of endogenous legitimacy of OSS – and IT solutions in general – at the macro-policy level. This prevents Governments top-down sustainable support that, by leveraging from the normative value system of professional cadres at the meso level, can guarantee longer-term and more sustained support than donors. Following an appropriate financial and revenue strategy, the public sectors of developing countries can attain high achievements in translating "low-low OSS models" to "low-high OSS models" (Camara & Fonseca, 2007) (*endogenous OSS-innovation push-factor*).

e) A more complex issue is related to the subtler linkage between the endogenous legitimacy of the major needs motivating the adoption of a software innovation particularly under the framework of donor-driven public sector reforms (or policies). The case study has shown that the clashes between different legitimacy discourses at the macro-policy level due to the non-overlapping between donors' and national Governments' agendas can actually hinder the enactment of donor-driven public sector reforms. This affects the legitimacy of the new IT system at the micro/users' level which is not supportive of the IT system. Similar situations are common to most developing countries and can seriously affect the sustainability of OSS given the particular engagement that it needs from the users' community. A poor engagement, in fact, can prevent the evolution of local information-needs oriented solutions hindering the development of a critical mass of users that can sustain the growth of a local OSS business model and industry (*endogenous OSS-sustainable growth factor*).

Based on these issues, a framework to guide the analysis of the OSS-viability of certain business environments in developing countries has been drawn (Table 2). The framework can provide guidance in the understanding of the international development and national reforms efforts that need to be undertaken for the promotion of a sustainable local OSS business model in developing countries.

[2] See for example the open source Electronic Records Management System framework for HIV/AIDS "OpenMRS", an initiative led by the Regenstrief Institute under the sponsorship of various international stakeholders including WHO, CDC, The Rockfeller Foundation, and the President's Emergency Plan for AIDS Relief (PEPFAR). http://openmrs.org/wiki/OpenMRS

The framework needs to be verified through the analysis of real cases of adoption of OSS solutions in different public sector contexts: different countries and public sector histories, different government systems (e.g., national vs. local), different types of services (e.g., health vs. immigration services). For example, there might be cases where the exposure to an OSS technological environment does not constitute a sufficient incentive for the development of local OSS expertise. Thus, the framework sets the ground to explore alternative explanations which can then be used for its self-enhancement.

	OSS innovation pull-factor	**Exogenous OSS-innovation push-factor**	**Endogenous OSS innovation push-factor**	**OSS sustainable growth factor**
Macro	Endogenous legitimacy of public service/organisation mission/goals OSS technological/material resource environment (Vehicles: NGOs, international donor and academic community)	Donor-driven OSS pilot (low-low model: low shared conceptualization and low modularity)	Endogenous socio-political legitimacy of OSS solutions (Governments sustainable support of OSS solutions) Low-high model: low shared conceptualisation and high modularity	Alignment between endogenous (Government's) and exogenous (Donors') legitimacy of public sector reforms (or policies)
Meso	Management/professional cadres demand for OSS innovation (cultural-cognitive legitimacy)	Small (exogenous) developing teams	OSS cultural-cognitive legitimacy (professional core value systems support OSS)	Rationalisation of OSS development resources
Micro	Resource mobilisation for professional development (increased capacity in OSS development)	Pilot OSS products, low sustainability, non-full fledged user friendly solutions, small users' base	Long-term support of distributed developers team for modular development of complex OSS products (Translation of low-low models into low-high models)	Users' community engagement into local customisation and maintenance of OSS products

Table 2. OSS Business Model Analysis Framework

CONCLUSIONS

Following the analysis of the case study of a computerized epidemiological information system in the Ministry of Health in Kenya, the paper has proposed a business model analysis framework to identify the main issues that need to be addressed within the context of a specific country for the sustainable development and growth of OSS. The framework focuses onto public organizations as major promoters of sustainable OSS.

In particular, four main sustainability factors of OSS have been identified. These are OSS innovation pull factors, OSS exogenous and endogenous innovation push factors, and OSS sustainable growth factors. All these factors may affect the diffusion, adoption and growth of

OSS at different levels of the public sector. The extent and modality in which these factors interact may vary depending onto their embedding context.

That is why the framework needs to be validated or extended through comparative research between different developing contexts. Among the major issues that need particular attention are: the relationship between meso-level forces (e.g., management and professional cadres) increasing the demand of innovation and the enabling macro-policy environment; and the linkage between the sustainability of OSS and the development and implementation process of public policies that new OSS products are supposed to enable.

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