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Datafication, Value and Power in Developing Countries: Big Data in Two Indian Public Service Organisations

Richard Heeks¹, Vanya Rakesh², Ritam Sengupta³, Sumandro Chattapadhyay⁴ & Christopher Foster⁵

Abstract

Motivation: Datafication – growing presence, use and impact of data in social processes – is spreading to all sectors in developing countries. But, to date, there are few analyses of real-world experiences of datafication in developing country organisations.

Purpose: We address this knowledge gap by analysing evidence of big data in practice in relation to three key issues: implementation, value and power.

Approach and methods: Using interview, observation and documentary sources, we analyse implementation and impact of big data systems in Indian electricity and transport public-sector organisations.

Findings: Big data systems have been much slower to implement than anticipated, and the paper exposes the nature and scale of implementation challenge facing such systems. These are already delivering value for some managers within public-service organisations but, as yet, more operational than strategic and incremental not transformative. Big data systems are facilitating a shift in power from public to private sectors, and from labour and middle management to Panopticon-type control by central managers. Big data intersects with politics especially around the imaginaries of wider stakeholders, changing their view of the financial and political issues that technology can address.

Policy implications: Policy-makers and practitioners can better understand and plan for big data in development using three frameworks presented in the paper: information value chain, decision pyramid, and big data—power model. These expose key issues of implementation, organisational value and power that must be incorporated into big data policy and projects. Benefits of datafication have been largely restricted to senior managers, private contractors, and some politicians. To spread these to other stakeholders including workers and citizens, actions must be taken to address both practical and political issues arising in the datafication of development.

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Introduction

Datafication – growing presence, use and impact of data in social processes – is spreading to all sectors within developing countries, impelled by diffusion of digital technologies (Taylor & Broeders, 2015). There are examples of researchers using new datasets to demonstrate the potential contribution of data to development (Albanna & Heeks, 2018). And there are speculations, hopes and concerns about the datafication of development (Spratt & Baker, 2015; Hilbert, 2016). But, to date, there have been relatively few analyses of the real-world experiences of datafication in developing country organisations.

This is particularly true of big data; a label typically attached to new datasets that represent “3Vs”: much greater volume of data than previously available, greater velocity (reduced time lag between an event and availability of data about that event) and greater variety (integrating more diverse forms and types of data) (Dumbill, 2012). Implementation of big data systems in developing countries is still quite limited and quite recent. As a result, there have not been many studies – literature has been based mainly on prototype applications and/or conjectures – and the purpose of this paper is to address this knowledge gap. It selects two case studies of big data application in the Indian public sector; one in the electricity sector, one in the transport sector. It then asks how these were implemented and what impact has been associated with these applications; both the organisational value of big data and also the wider intersection between big data and power. The paper’s main contribution is to provide a systematic insight into the challenges, impacts and implications associated with datafication of development based on substantive real-world case evidence.

The article is divided into six sections. Next, we review literature to date on datafication and development, looking specifically at big data. We identify frameworks for analysis of datafication and development. We then describe the two Indian case studies, and our fieldwork that gathered evidence on those cases. Findings are divided into three parts: big data system implementation, organisational value derived from big data, and shifts in power associated with big data including the way in which big data intersects with wider politics. We then discuss findings in light of existing evidence on big data and development before drawing overall conclusions and recommendations.

Big Data in Developing Countries

We base our analysis of existing evidence on big data and developing countries on nine literature reviews on this topic (Kshetri, 2014; World Bank, 2014; Lokanathan & Gunaratne, 2015; Spratt & Baker, 2015; Taylor & Broeders, 2015; Ali et al., 2016; Hilbert, 2016; Sengupta et al., 2017; Albanna & Heeks, 2018). We analysed this using a foundational data systems model: the information value chain (Heeks, 2018). This process model charts the chain of steps linking a data system to development results: capture of data, its processing and visualisation as information that then informs decisions, which lead to actions, which create results. Shaping those steps is a framework of knowledge which can itself be developed through addition of new information.

Via this model, we identify three main issues within the big data and development literature: implementation, value, and outcome (Figure 1).

Figure 1: Issues in Big Data and Development Literature Mapped to the Information Value Chain Model

Literature covering big data *implementation* focuses on challenges to be overcome for big data systems in developing countries to operate, or which are preventing fully-effective

implementation of those systems. Two domains of challenge dominate. First are those relating to technical issues particularly “upstream” in the information value chain; i.e. linked to handling data and information. These encompass digital technology, including lack of: devices to capture data, telecommunications infrastructure to reliably transmit data, computing power to analyse data, etc. (Kshetri, 2014; Ali et al., 2016). They cover data: limited extent of digital data in developing countries and its relative inaccessibility, poor quality, fragmentation across different sources, etc. (World Bank, 2014; Lokanathan & Gunaratne, 2015; Ali et al., 2016; Hilbert, 2016; Albanna & Heeks, 2018). And they cover the need to develop new techniques in order to analyse and visualise development-related datasets (World Bank, 2014; Lokanathan & Gunaratne, 2015; Sengupta et al., 2017). The second domain of challenges relates to human capabilities. Again, the focus is upstream in the value chain: concerned more about developing countries lacking skills to clean, integrate, analyse and visualise data (Kshetri, 2014; Lokanathan & Gunaratne, 2015; Hilbert, 2016; Albanna & Heeks, 2018) than about the capacity to make decisions and take actions on the basis of that data.

Value deals with direct organisational and developmental improvements that big data can make. The literature reflects that there are relatively few examples as yet of big data application leading to large-scale, sustained development results (Taylor & Broeders, 2015; Albanna & Heeks, 2018). Thus, most examples cited are “proof-of-concept”: projects – often led by computer/data science researchers – showing the potential for a contribution but not an actual development impact. For instance, demonstrating feasibility of using social media to track food prices (UNGP, 2014 cited in World Bank, 2014) or potential to measure poverty from mobile phone call detail records (Blumenstock et al., 2015 cited in Albanna & Heeks, 2018). There is also more general reflection on potential of big data to contribute to global development, relying heavily on the proof-of-concept literature or on experiences in the global North (e.g. Lokanathan & Gunaratne, 2015; Spratt & Baker, 2015; Hilbert, 2016).

Because of this early-stage, overview nature of evidence to date, conceptualisation of the value of big data for development has been very limited. Only high-level categorisations of big data applications are offered, by development sector (Lokanathan & Gunaratne, 2015; Ali et al., 2016; Albanna & Heeks, 2018) or by type of data (World Bank, 2014; Ali et al., 2016; Hilbert, 2016; Albanna & Heeks, 2018). But this offers no detailed insight into value. For that, one needs a micro-level perspective, drawing from the information value chain’s

indication that the value of data comes from its conversion into information and use in decisions.

A generic approach links value of big data to its features, in enabling decisions which are quicker and/or lower-cost and/or of better quality than previously possible (Kshetri, 2014; Albanna & Heeks, 2018). But that offers no differential sense of value. For the analysis that follows, we therefore adopted one of the most widely-used models of organisational decision value: the pyramid notion of three levels (e.g. Turban et al., 2018). Operational-level decisions involve day-to-day supervisory actions dealing directly with front-line employees. Tactical-level decisions relate largely to middle-management, medium-term processes. Strategic-level decisions are those which relate to overall organisational goals. As well as relating to types of decision, this model also represents levels of value: it is strategic decisions which can deliver greatest organisational value.

Outcome issues are broader impacts associated with growing use of big data in development⁶. These are increasingly being analysed through the lens of “data justice” (Heeks & Renken, 2018) for which two main perspectives emerge from the literature. First, data rights: for example, all the reviews mention fears about loss of privacy through illegal access to big datasets or growth of surveillance of populations by the state or private corporations. Second, data-based inequalities. Most reviews implicitly or explicitly relate this to a “big data divide” (Hilbert, 2016). This generally means that unequal access to digital technology or to big datasets or to data-related capabilities leads to unequal access to the development benefits of big data. It also means that lack of representation of some populations within big datasets means they are denied the benefits of decisions and actions that use those datasets.

Some reviews (Kshetri, 2014; Spratt & Baker, 2015; Hilbert, 2016) recognise that these issues may empower some actors such as large corporations or the state at the expense of others. But only Taylor and Broeders (2015) explicitly link these inequalities to concepts of power, noting the lack to date of – and need for – power-based analyses of big data and development. They identify a shifting terrain of power; particularly a potential

⁶ Value can be associated with the idea of “imminent development”: intended, incremental changes arising from application of big data; while outcome can be associated with “immanent development”: wider or longer-term, sometimes unintended changes that are emerging as big data is applied in development (Hickey & Mohan, 2005; Murphy & Carmody, 2015).

“privatisation” of development if power shifts to those private-sector actors who control big data resources, capabilities, discourse, etc. Building from this work and from Heeks (2017), we develop a simple model for analysis of datafication and power (Figure 2). This identifies a number of sources of power that can impact the central practice of a data system; understood as the information value chain. These sources include:

- control over resources: specifically, who owns and controls the data within the big data system;
- epistemic control: who has the knowledge developed by the data system, and the impact of the wider discourse around the system;
- institutional control: both formal institutional forces like rules and regulations, and informal institutional forces like norms and values;
- structural position: implications of new structures and positionality of relations arising in association with the big data system.

Figure 2: Big Data Systems and Power

Overall, the emergent literature highlights a set of key issues in application of big data to development. There has been discussion of the different technical and human challenges that may arise during implementation. However, with the lack of scaled cases, there is little exploration of how implementation links to changes in value within organisations. Likewise, while there has been some hypothetical discussion regarding power and data, there is little instantiation of this in developing country contexts. We therefore now move to apply the models identified in this review to two big data case studies; described next.

Case Background and Methods

To investigate these issues further, we undertook two case studies of big data-based datafication in India⁷: “Stelcorp”, an anonymised state-owned electricity generation and distribution corporation in “Janakari” state, and Bengaluru Metropolitan Transport Corporation (BMTc) which runs buses in Bengaluru. Following an initial scanning exercise of possible cases, these two were selected because their experiences with big data – while still relatively recent – had progressed far enough to draw conclusions about implementation, value and outcome.

Findings come from four sources combined and analysed through the lens of the models presented above. First, seventeen interviews with senior, mid-level, operational-level and technical staff in both organisations plus discussion with four external technical contractors and advisers. Second, direct observation of the big data systems in operation, covering data capture, visualisation and use. Third, primary documentation: tender documents, technical reports, strategic plans, annual reports, audit/regulatory reports, policy documents, trade union correspondence and newsletters, etc.⁸. Fourth, directly-relevant secondary sources: published case studies from private partners, evaluation reports, case analyses and academic literature on both organisations.

Case One: Stelcorp

⁷ Findings integrate material from two working papers that describe each case study in greater detail: Sengupta et al. (2017) and Rakesh et al. (2018).

⁸ The requirement for anonymity in the case of Stelcorp means it is not possible to cite some of these documents since to do so would enable case identification.

Stelcorp, the state electricity generator, serves more than 15 million customers (c.80% in rural areas), employs over 15,000 staff, and has annual revenues over US\$1bn. Its private-sector ICT collaborations – including a main partner, “Digicorp” – have been particularly aimed at addressing the problem that, in India, an average one-third of power generated is lost (Min & Golden, 2014). Losses fall into two types. Technical losses result from resistive/heat dissipation of transmitted energy and from breakage/malfunctioning of grid components. But the majority of losses are commercial: “inefficiencies in billing, meter tampering, illegal connections, and use by flat rate consumers that exceeds their nominal allotments” (*ibid.*, p. 619).

In 2008, and building on earlier programmes, the central government initiated the Restructured Accelerated Power Development and Reforms Programme (R-APDRP) (Narasimhan et al., 2011). In Stelcorp, this funded c.US\$50m-worth of digital information system technologies to address both technical and commercial loss (Figure 3):

- Automated, online digital meters installed across higher levels of the power network, especially in urban areas. These monitored all urban feeders stepping-down voltage between sub-stations and transformers (typically serving c.25,000 customers); all urban transformers stepping-down voltage to households (covering 50-100 customers); and all bulk power consumers (factories, food processing plants, cold storage facilities, etc.). These capture and transmit a variety of network “health parameters”: voltage, current and event alerts such as tampering or power outages.
- Stand-alone digital meters installed on all rural feeders and transformers. These perform the same function as online meters but must be read manually by a human meter-reader. They, in theory on a monthly basis, offload data onto a handheld device – the Common Meter-Reading Instrument (CMRI) – and then upload that data at their divisional office.
- Basic digital meters that just record level of energy usage, replacing almost all pre-existing analogue meters for ordinary customers. Their data must be entered into the CMRI by a human meter-reader and then uploaded at a local centre largely for billing purposes.

All this data is fed into an organisation-wide data system: the Meter Data Acquisition System (MDAS). ICT partner Digicorp developed this system, and is also responsible for: designing and operating the software architecture underpinning MDAS, data management, and

training Stelcorp staff. MDAS acts as the organisational data repository, storing hundreds of terabytes of data on energy use, faults, losses, plus data on revenues. It can process and communicate that data across the organisation since MDAS is available in all Stelcorp administrative and technical offices.

Figure 3: Stelcorp's Data System

Case Two: Bengaluru Metropolitan Transport Corporation

BMTC has 6,400 buses and nearly 34,000 employees. Every day it carries five million passenger journeys over 2,000 routes and 8,000 bus stops in Bengaluru, collecting over US\$700,000 in revenue, and its buses travel nearly 1.2 million kilometres (BMTC 2019a, BMTC 2019b). This requires a large number of operational, tactical and strategic decisions, and generates huge amounts of data which could be used to guide that decision-making.

Historically, that data was not captured or was captured very inefficiently using paper-based systems. With growing size and complexity creating increasing decision-related problems, in May 2016, BMTC launched its Intelligent Transport System (ITS); a project initially conceived in 2012, beginning implementation in 2013, and with an initial cost of c.US\$1.2m (Akshatha, 2015). The main implementer was private-sector IT company, Trimax alongside two other private-sector advisory firms.

ITS involves four components (Figure 4):

- Vehicle Tracking System (VTS): installed in all 6,400 buses with a tracking unit using the mobile network to transmit real-time data on bus location. It includes a “voice kit” allowing two-way communication between bus crew (driver plus conductor) and either the BMTC central Control Room, or managers at one of roughly 40 bus depots (major bus stations).
- Electronic Ticketing System: resembling a credit card reader with integral printer, more than 10,000 of these handheld-devices are used by bus conductors to issue tickets. Their recorded data – ticket price and time, bus stop of issue, bus number, etc. – is uploaded to the central system every five minutes via the mobile network.
- Central Information Systems: main servers record c.100 gigabytes of data daily, allowing that to be visualised in the Control Room which contains a wall of large screens. Data is also routed into a Depot Application which can generate specific information: crew duty rota, driver log sheet, kilometres travelled, fuel usage, ticketing summary, etc.
- Passenger-Facing Systems: Central Information Systems data feeds passenger interfaces that provide general timetables, maps, journey planners and real-time updates. These include overhead display screens and touch-screen kiosks at major bus stations, and a mobile app.

Figure 4: BMTC's Intelligent Transport System

Sources: BMTC, 2013; Bhattacharya, 2016a; BM, 2016; Ramakrishnan, 2016; BMTC, 2017; Jha, 2017.

Findings

Implementation

Both applications took some years to get the data component of the information value chain functioning effectively; a necessary foundation for the chain to operate. Some issues have been technical. Stelcorp engineers complained up to half of meters were unreliable in terms of recording or connectivity; thus undermining data availability and quality. In BMTC, there were initial breakdowns in mobile network connectivity, and ticketing machines running out of charge. Both had required system design revisions but managers still reported occasional connectivity problems. Passenger-facing systems have had ongoing problems: while they do work at times, fieldwork visits to depots found neither public screens nor kiosks to be operational. Similarly, the mobile app has had many complaints about bugs, slow operation, and limited abilities to plan routes or predict bus arrival times (CM 2017 and Google Play store customer reviews).

A second technical issue has been the data foundation: for big data systems to work, they must digitally and uniquely identify huge numbers of organisational assets. For BMTC, it took many months to map and identify its 8,000 bus stops, many of which had the same name (Jha, 2017). Stelcorp's challenge was far greater – to geo-locate all of its more than four million assets (feeders, transformers, pylons, etc.) and issue a unique ID to its more than 15 million customers. This took five years and, though declared completed in 2015, interviewees stated that some errors in both geo-location and customer ID coding regularly emerge.

There have also been technical challenges around interoperability. Big data necessarily means bringing together many disparate elements of an organisation, and this created problems, especially for Stelcorp. Engineers reported meters being sourced from different producers, making it hard to standardise data into a common format: some still has to be re-assembled by human intervention. The new billing information system was designed around a common cycle for all consumers on a transformer; i.e. everyone billed on the same day each quarter. But both practice and MDAS are based around different meter-reading and billing dates for all consumers with no common cycle. This has left some customers unbilled, and has a knock-on for accuracy of calculating transformer-level losses.

Other challenges have been human. Both organisations had to undertake major training initiatives to build the necessary skills to operate the new technologies and data systems. But reported challenges were less about skills than about acceptance of technology. At

BMTC, bus crews were concerned about surveillance potential of the new devices. Early in implementation, there were a few examples of vehicle tracking units being burned, filled with water, or shielded with metal casings (Jha, 2017). At Stelcorp, managers indicated a small minority of human meter-readers were not going out to read data from digital meters but were, instead, just logging average values based on consumption levels in earlier months. In both organisations, interviewees and other sources (e.g. Bhattacharya, 2016b) indicated some reluctance from middle managers to implement the new systems.

Value

Implementation challenges have, over time, been sufficiently overcome that the information value chain is operating at least to some extent. Collected data is being processed into information, which is feeding decisions and actions, leading to organisational results and value. We analyse this for each organisation in turn, per the decision types identified earlier: operational, tactical, strategic.

At BMTC's *operational level*, all interviewees and reports indicated vehicle tracking units and electronic ticketing machines (ETMs) working well enough to allow new decisions and actions. For example, analysis of driving patterns from VTS data provided exception reports to the central Control Room: skipping of bus stops, deviation from planned route, speeding, or being stationary. Control Room staff reported and could be seen then intervening with individual bus crews based on those reports, investigating issues via the two-way voice kit.

Bus depot managers reported two main impacts (Jha, 2017). First, introduction of ETMs made crew roster scheduling, end-of-day audit and cash reconciliation easier. This led to reduction in revenue discrepancies and cases of "ticketing pilferage". Second, traffic police would previously issue fines – which the depot manager had to handle – for claimed traffic violations by bus drivers. Other road users would issue compensation claims for accidents. Often, these were known to be fake but there was no independent mechanism to check whether a bus was in fact speeding or stopped due to an accident. Data from the Vehicle Tracking System now allowed some ability to cross check. As a result – perhaps from the perception as much as reality of vehicle tracking – the number of fake fines and compensation claims issued had significantly reduced.

Use of big data for *tactical-level* decisions like management of routing, scheduling and fare setting appeared to be more potential than reality. BMTC plans to use ticketing data to offer reduced fares on routes identified as having low off-peak passenger numbers. BMTC interviewees also had aspirations to analyse daily/seasonal patterns in data to rationalise routes, schedules and bus operations, and to enhance efficiency in crew operation and management. But none of these plans had actually been implemented.

ITS was intended to contribute to four *strategic-level* BMTC goals (Mishra, 2016; BMTC, 2018b; Kidiyoor, 2018; Philip, 2019):

- Service reliability: 12% of services were cancelled in 2018-19 compared to an average 6.5% in the five years prior to ITS introduction.
- Citizen centricity: the passenger-facing systems have been steps forward but are not yet fully operational or effective in providing information and journey planning support for travellers. Daily passenger-journey numbers were down by c.700,000 in 2018-19 compared to 2015-16, so aspirations of helping move more passengers onto buses were not realised.
- Revenue management: passenger revenue fell 12% from 2015-16 to 2018-19 compared to an average 10% growth over the previous five years.
- Organisational capabilities: fleet utilisation fell below 90% for the first time in 2016-17, falling to 84% in 2018-19 while costs per km were at their highest-ever level.

There are many internal and external factors other than ITS that contribute towards organisation-wide performance; not least steady extension of Bengaluru's Metro system which carries passengers who might otherwise use buses. However, the evidence shows a lack of overt short-term impact of ITS on strategic performance indicators, and suggests a lack of contribution as yet to wider measures of urban transportation like journey times, congestion, pollution, etc.

Given its longer history, big data in Stelcorp is providing more organisational value and contributing across all decision-making levels. *Operational* activity covers billing and electricity distribution system faults. Billing was reported to be more accurate than previously but no faster since it occurs via the same, i.e. quarterly, cycle times. Faults – short-term power outages caused by equipment malfunction – were earlier detected via laborious trial-and-error testing in the field by linesmen⁹ using a mix of guesswork, intuition

⁹ They are all men.

and experience. Faults are still not reported automatically by MDAS but from outside by customers or linesmen. However, managers can now drill-down within MDAS to identify likely problem location and functioning of relevant online (i.e. excluding rural areas) assets like transformers. A “docket” system also operates that automatically identifies to managers faults not rectified within a set timeframe. Thus, alongside better, faster location and resolution of problem sources, there is also better process monitoring.

Tactical decisions relate to loss detection and internal performance management. Unlike faults, losses are identified on a longer-term basis by retrospective calculation and may have multiple technical/human causes. MDAS has made it easier and quicker to identify the source of losses. As with faults, the information value chain still operates in “pull” not “push” mode: managers must find relevant data within the system rather than being alerted via automatic exception reporting, and their pull is reactive – driven by external events – more than proactive identification of problems.

Regarding internal performance management, a structural innovation was formation in 2015 of Stelcorp’s central Finance and Energy Management Unit (FEMU). FEMU has responsibility for oversight of all organisational data including performance of the distribution network and its components including losses, and adherence to consumer billing cycles including levels of collection and disconnections. These can be broken down into the Corporation’s various zones and districts.

These performance indicators then lead to internal decisions and actions. FEMU holds general monthly meetings with zonal-/divisional-level managers and weekly video-conference discussions with individual offices. These review performance and plan interventions e.g. further actions on loss prevention. Officers complain about this. Historically, they were accountable to their immediate superior, with whom they would discuss, explain, negotiate and agree performance issues. That has now been replaced with direct accountability to FEMU, with whom – given FEMU’s whole-organisation span of control – relations are more distant and formal; discomfoting for managers.

MDAS feeds into *strategic* planning such as electricity network developments. Plans for major extensions or upgrades use three levels of data: top-down political/policy directives; bottom-up consumer complaints or demands; “mid-across” historical technical data. While

all three are used for selection of locations for action, the latter is used for specific planning of initiatives. It has historically been weak, based on basic, aggregate statistics and rudimentary calculations. Now, though, there is more objective data to stand alongside the relative subjectivities of politics and consumer complaint. Modelling of network upgrades, though not yet automated, can be based on more quantified, objective data. Modelling of extensions into entirely new areas has incrementally improved because by definition there is no MDAS data for as-yet-unserved areas; though related data will be used. One sign of problems here was an audit of Stelcorp's rural electrification programme which found one-quarter of newly-installed transformers failed due to load under-estimation.

As with BMTC, the picture is disappointing at the broadest scope of organisational value. The whole intention of the new data systems was to reduce losses and make associated improvements such as increasing revenue collection efficiency. In the years since 2009, this has not happened. Alongside steady deterioration in its overall finances, the corporation's performance can be assessed on three key parameters:

- Aggregate technical and commercial (AT&C) losses – the overall measure of difference between units of power supplied and revenue collected – dropped significantly in 2010 but then rose back up to earlier levels and has remained roughly static at one-third up to 2018. This, as noted earlier, has been a typical average across India.
- Billing efficiency – the proportion of supplied electricity that is billed to customers – was static until 2011 but has dropped since by a few percentage points to around two-thirds.
- Collection efficiency – the proportion of billings collected – has been volatile between 93% and 100% throughout the period since big data was implemented without so far demonstrating stability of improved performance.

As discussed later, there are reasons for this but, more than five years after the major big data-related reforms began, their impact is not yet seen on these most-aggregate measures of Stelcorp's performance.

Outcome: Power and Politics

Big Data-Associated Changes in Locus of Power

In both cases, particularly Stelcorp, advent of big data has been associated with shifts in locus of power. We consider four here; the first three summarised in Figure 5.

Figure 5: Power Shifts Associated with Big Data

First, is an upward shift in power from labour to management. Central managers now have greater resource and epistemic control through the Panopticon effects of big data systems. For bus crews, the central Control Room can directly see driver behaviour and conductor ticketing in real-time. Bus crews no longer control that data or the knowledge of their behaviour that entails. It has also allowed practices to change, with managers directly intervening to administer bus crew actions. Likewise, for meter-readers, central managers can now directly monitor their behaviour and performance, and make decisions accordingly. The technologies associated with big data systems can also bring automation of human labour; reducing importance of labour as an organisational resource. 40% of meter-readers have lost their jobs due to introduction of online meters, and continuing roll-out will cut numbers further. For bus crews, partial automation of ticketing has eroded the role of and necessity for two-crew operations, and pressure for substitution of the conductor's role with digital technology will continue to grow.

The second shift is from middle to central management. Previously, data was relatively "sticky": restricted to localised organisational enclaves. Staff were accountable to their immediate middle managers, who accessed data on staff, negotiated its implications, and held power over their juniors. Big data systems enable central management in BMTC and

Stelcorp to directly access performance data from all levels of operations. New practices are underway by which they undertake and communicate performance management, obviating the need for intermediating management layers. Institutional power of authority is shifting as staff and managers now significantly see themselves as accountable to BMTC's central Control Room and to Stelcorp's FEMU, and a looser institutional power is arising as big data allows a stronger audit and performance management culture. In terms of positionality, the central units now have a direct structural relationship to organisational staff and managers. Hence, both organisations have begun stripping out middle-management layers; reducing numbers and, in the case of BMTC, closing five divisional offices that used to intermediate between depots and the central management team.

The third shift is from public to private sector. Previously, the corporations were responsible for their own data and data systems. This is no longer the case. While *de jure* ownership lies in the corporations' hands, *de facto* ownership has shifted, particularly for Stelcorp. Data system providers – Digicorp for Stelcorp, Trimax for BMTC – control a key resource: knowledge of data system design, construction, operation and maintenance. While they could in theory be replaced, it would be very difficult to do this in practice due to the criticality of the data systems and dependency on the private providers' knowledge. Hence, for example, complaints from Stelcorp staff. Engineers were unhappy about the speed with which Digicorp fixed data system problems, but felt they could do little about this. IT staff complained about their lack of control over Stelcorp data and software, their dependency on Digicorp, and their diminution to what they saw as just clerical roles. Managers raised concerns that Digicorp could make commercial use of analytical value from Stelcorp data; e.g. selling data or analysed information to electrical appliance and equipment manufacturers.

Finally, one shift in power has not occurred much: from public corporations to citizens. For BMTC, there is some greater operational transparency through the – albeit flawed – passenger information systems. But neither corporation has embraced open data¹⁰. Talking with managers, there was no open data impetus within Stelcorp and the only data available in the public domain is rather outdated aggregates like division-wise AT&C losses. For some time, BMTC has been talking about plans to open up its real-time data (e.g. Akshatha, 2016), but at the time of writing there was no visible sign of this.

¹⁰ The potential 4th V of big data: increased visibility (Heeks, 2018).

Big Data and Politics

There is a symbolic, interpretive aspect to the epistemics of big data (Boyd & Crawford, 2012). Big data changes the “imaginary” of organisations: not just what is visible about the organisation, and to whom, but also their perceived image of the organisation (Boellstorff, 2013; Taylor & Broeders, 2015). In BMTC, daily operations of bus fleet and crews were largely opaque to management prior to ITS, but they are increasingly visible and thus changing managers’ perceived picture of BMTC. Big data is changing the landscape of possibilities within the organisation. For example, with a revival of plans for driver-only buses – a change trialled but abandoned in the 1990s – but now once again seen as possible by managers; something they specifically link to advent of ITS (also Philip, 2017).

This is seen even more strongly for Stelcorp. As noted above, overall losses have not reduced and the percentage of customers who receive bills has actually gone down somewhat since big data. Respondents, internal and Electricity Regulator reports all aver that the big data innovations described above are reducing technical losses from transmission resistance/heat and from faults. There was also some evidence that online metering was reducing losses from bulk consumers in urban areas. But there has been a compensatory increase in theft and defaulting among ordinary consumers; especially in rural areas.

This is associated with what interviewees described as Stelcorp’s “unprecedented” expansion of rural connections in recent years, reflected in doubling of the consumer base. It is the newly-electrified rural areas of the state which have particularly been returning highly-inefficient billing patterns and high loss levels: above 50% compared to losses well below 25% in urban areas. Those loss levels arise as technology has intersected with the politics of electrification in Janakari State. Rural electrification has been a political tool in state elections, with parties seeking support by ensuring maximum access to electricity for rural constituents with minimum imposition of payment¹¹.

This leads field-level staff into direct conflict with local politics as they seek to collect unpaid bills or disconnect defaulting or illegally-connected consumers. The result has been repeated

¹¹ See Min and Golden (2014) for analysis of the wider pattern in India of rising commercial losses in the run-up to state assembly elections as politicians seek to attract votes by interfering with the electricity supply process.

complaints from staff trade union representatives about growth in theft of electricity in rural areas, about an increase in threatened and actual violence against field staff, and about a lack of effective response from either Stelcorp or local police. Some Stelcorp officials rationalised all this as a “social cost” that utilities had to pay, which still contributed towards national development goals.

This could be read as a silencing of big data in the face of big politics: the capability for accurate metering and billing of almost all consumers being overridden by electoral imperatives. But there is a little more to it than this. From comments of regulators and Central Government, it becomes clear that reductions in technical and urban losses thanks to big data are necessary in order to allow the State Government to “get away” with its political approach to rural electrification. Technical and urban loss reductions offset growth in rural losses and so Stelcorp avoids regulatory intervention when reporting overall performance to national regulators.

Second, big data has changed the epistemics of electricity; has changed in particular the political imaginary of electricity in the state. Interviewees explained that, previously, the mental image politicians and other senior officials had was one of blackouts and brownouts, requiring slow, limited, and incremental spread of the electricity network. Big data seems to have changed that – partly through the reality of improvements it is delivering such as faster fault rectification but equally through the promise that it holds – to a paradigm of continuous, high-quality, universal power. Through the transition of imaginaries partly facilitated by big data, policy and strategy have therefore changed; feeding into and being fed by the ambitions of politicians to deliver electricity everywhere and everywhen. New plans and promises are now based on the idea that all districts – and all voters – can have 24 x 7 power. The data-enabled growth in connectivity has thus helped fuel a politically-enabled growth in free appropriation of electricity.

Discussion

In reviewing the findings, we again use the three-issue, literature-derived structure of implementation, value and outcome.

Following multi-year *implementations*, both big data systems are operational in their corporations, based around fast-growing datasets already involving tens up to hundreds of terabytes of data. As discussed in the literature, they have faced several challenges. Most can be mapped against the information value chain's upstream parts: sorting out foundational datasets, and operation and use of equipment from which data derives.

Much of this would be anticipated, given these are the first and large-scale applications of big data in these large public-sector organisations. They suggest timescales for big data implementation will be several years, even to get to a basic operational state. Second, that even when operational, there may be an ongoing requirement for human intervention in parts of the system intended to be fully automated. Most of these issues are likely to be transitional rather than permanent: like a number of findings, they reflect that we are still relatively early in these systems' life-cycle. However, while not permanent, these problems have been persistent and they are not ephemeral: instead, they seem inherent in moving to big data-based operations.

The challenges appear more technical than human-related. This is somewhat surprising. The literature expresses concerns about lack of big data capabilities in developing countries but the cases did not really reflect this. Most likely this was because the organisations had had several years to build capabilities and because, as discussed below, they were not yet fully exploiting all the potentials of big data and were relying on capabilities within their private-sector partners. Resistance to big data systems was not a significant theme in the literature and, while observed, it was somewhat muted. Stelcorp field staff (linesmen, meter-readers) and BMTC bus crews are heavily unionised, and big data-related technologies represent a potential or actual threat to jobs. Yet resistance has been individualised and fragmented. Union grievances and strikes have related to traditional issues: pay, assaults on staff, staff suspensions; not to digital technologies. Some resistance has come from middle managers, as they seem to have more-clearly recognised the threat that big data systems pose to their jobs. But even this has been limited and unorganised.

This relative and initial antipathy of middle managers towards big data systems, alongside the much broader challenges of organisational change in large, public-sector organisations explains two other patterns in the extraction of formal organisational *value* from big data. First, that it was taking some time for value to emerge. In information value chain terms,

upstream processes of datafication have appeared more readily than downstream conversion of that data into decisions, actions and results. Second – with decisions, actions and results now in evidence – direct impact of datafication is being felt most in relation to operational decisions; least in relation to strategic decisions; with tactical decisions somewhere in between.

From this, it can be argued that, to date – while these organisations have moved far beyond “proof of concept” – they have only extracted relatively incremental value from big data. Changes have occurred most at operational level to work of front-line staff. There is no sign yet of the value of big data in the most strategic, organisation-wide performance indicators including major issues such as electricity losses in Janakari state and traffic congestion in Bengaluru. The pattern of incrementalism can be seen for each of the big data 3Vs. Volume of data reflects capture across the whole breadth of each corporation’s operations; providing central managers an overview vision. But major volume-related potentials of big data – analysis to help optimise operations, application of data-mining techniques to identify otherwise unseen patterns, use of machine-learning techniques to improve strategic decision-making – remain unexploited.

Big data’s velocity functionality – ability to enable faster decisions and actions – has been used by managers to deliver faster depot management functions in BMTC, and faster fault rectification in Stelcorp. But other activities have not yet been changed: e.g. billing and calculation of losses in Stelcorp still happen with a one- or two-month time lag. In Stelcorp the greater variety of data now available is being used to make better planning decisions around losses in the network. But – mirroring the point about data mining and machine learning – the opportunities to extract value by integrating the different data now available have not yet been realised. Managers could plan and deliver better customer services by combining consumer and infrastructure data or, in BMTC, by combining passenger and bus journey data, but so far they have not done so. We can finally interrogate a fourth V – visibility – associated more with open than big data. These corporations could in theory open up their data, allowing local enterprises to extract more business value from it and becoming more transparent to citizens and civil society. But so far they have not done this either.

This pattern is somewhat unexpected. The assumption within most earlier-cited literature is that new data systems will be applied to strategic and outward-facing purposes. Instead, managers are using the technologies more for enhanced surveillance or replacement of internal staff, rather than optimisation of services for customers or addressing other major corporate and developmental goals. Technical and capability limitations explain this in part, but this focus for value extraction also reflects the particular interests and agendas of those with power within the organisations; organisations in which industrial relations form a continuous source of tension and site of conflict for managers.

Turning to **outcome**, there is a vibrant debate in India about data rights – privacy, security, surveillance, access, representation, etc. – in relation to Aadhaar, the unique ID number allocated to all citizens onto which a host of public and private services are being layered (Taylor & Broeders, 2015; Bhatia & Bhabha, 2017). But, possibly because Aadhaar sucks the oxygen away from debates about other big data applications in India, there have been no such arguments relating to Stelcorp and BMTC. The only time interviewees mentioned these issues were as rationales for not opening up corporate big data to the public (also Menezes, 2018).

The majority of literature on big data and development takes an a-political perspective; seeing big data systems as technical artefacts. Such a perspective is not supported by the findings here, which show big data intimately enmeshed with issues of power and politics. Hence, evidence of the “shifting terrain of power” associated with advent of these big data systems, and need for a political lens to be incorporated into any analysis of datafication and development. This is not simple social determinism: big data changes the landscape of possibilities and imaginaries. However, the terrain shifts do tend to run along the lines of interest of those already imbued with power, with contextual dimensions of power—interest – rather than, say, the technocratic aims of the Sustainable Development Goals – thus significantly shaping the development impact of big data.

Our findings support particularly Taylor and Broeders (2015), including evidence of a “privatisation” of development as relative power moved from public- to private-sector stakeholders; that is, from corporations to their ICT partners. This has previously been understood in terms of changing resource ownership: that data formerly in the public domain is now privately held. This was not quite the case here – the public corporations do

still own and can access their data. Instead, the public-to-private shift occurs through privatisation not of the data itself but of the surrounding knowledge about big data systems and analytics. There are still question marks over who exactly controls the overall dataset, but it is not so much control of the resource as the epistemic capabilities linked to that resource which matter here.

While not identified in the reviewed data-and-development literature, there were also shifts within organisations. In particular, a relative weakening of labour and middle management in favour of central management, epitomised by the Panopticon spectacle of control rooms with walls of large display screens visualising the results of real-time, big data analysis. This could be understood in terms of changes in the sources of power identified in the Figure 2 model: greater control by central managers over data and technological resources, new practices of performance management and meetings, institutional power from the authority of central control rooms and management units and from introduction of an audit and performance management culture, new knowledge about the organisation now held by central managers, and a new and direct structural relationship between central managers and other staff. Existing tensions within the organisations – between management and workers, between senior and middle managers – are exacerbated by this heightened form of managerial control. While flashes of resistance have occurred, workers and middle managers have been relatively mute in their reaction. The “boiled frog” image comes to mind: that those who are incrementally but inexorably losing power, privacy, etc. as a result of datafication do not fully grasp the implications and potential of big data.

This is not yet the algorithmic management associated with big data, but it is a precursor of that in which central managers alone know the performance of workers as individuals, groups and whole. Big data has been used to central managers’ advantage largely because only they have full access to the data being gathered across the organisation and to the skills and knowledge to utilise that data. As with the private contractors, then, this supports the “big data divide” argument: unequal access to digital technology, big datasets and data-related capabilities is leading to unequal access to the development benefits of big data.

While the realities of data-based control might not be as great as the image, it was the new imaginary of the corporations that had seeped into the minds of senior managers and politicians. The image and discourse of big data had triggered a growth in “solutionism”: the

idea of technical solutions to often-complex problems (Taylor & Broeders, 2015). For BMTC, this was the problem of its large-scale financial losses. While these had systemic and contextual causes, managers saw big data systems could help by halving crew numbers on each bus. In Stelcorp, this fed a much wider concern: that of local politicians to be re-elected. While big data in practice had not particularly been associated with a reduction in blackouts and brownouts, the new imaginary it fostered had helped drive massive expansion in rural electrification.

Understanding the datafication of development must therefore not merely attend to shifts of power between public and private sector but also to changing relations between management and labour, and between the state and its citizens. The latter are formative and complex. The cases offered no sign of the “big brother” surveillance state that disempowers citizens and which several literature items raised. This, despite the possibilities for monitoring individual energy usage and bus journeys (the latter via increasing use of credit card payments). Nor was there any mirror-image “sousveillance” of public-sector performance by citizens that opening up of big data allows. There was, instead, a mild improvement in some aspects of service, and the largely-unexpected impact on political agendas; something to add to the roster of impact dimensions to investigate when analysing big data and development.

Conclusions

Summary

In summary, datafication including use of big data is an increasing reality in developing countries, as these two case studies illustrate. They have been much slower to implement than anticipated, and indicate the scale of implementation challenge facing big data systems in developing countries. The systems are already delivering value for some actors within public-service organisations but, as yet, more operational than strategic and incremental not transformative. More broadly, these big data systems are helping change profiles of power within and between organisations. And they are intersecting with politics especially around the presented image of organisations and the imaginaries of wider stakeholders.

Conceptualising Big Data and Development

The information value chain is useful in mapping progression of these systems from upstream to downstream focus, including shifts in the focus for key implementation issues. Likewise, the pyramidal model provides a simple but helpful insight into organisational value derived from big data including – one assumes – a slow trajectory from impacting lower-value operational to higher-value strategic decisions. This can only be assumed because of lack of evidence so far of strategic, transformative impact except though the changed perceptions of senior managers and politicians.

However, the case evidence has also highlighted over-simplicity of the pyramid model. As indicated, this is a model of *organisational decision* value and its insights are restricted to formal organisational value. Due to its narrow framing, it was not able to capture the bigger picture of those – senior managers, private-sector providers, politicians – who have extracted singular value from these big data systems, often at the expense of others.

It was in order to encompass some aspects of that bigger picture that the Figure 2 model was proposed. Evidence of the changing balance of power within and outside the organisations was related to the elements identified, suggesting the model can be useful in understanding the relationship between power and big data systems. However, two concerns also emerge. First, that the model appears static, whereas the main development outcomes are dynamic, emphasising the changes – in locus of power, in managerial and political priorities – associated with introduction of big data. Second, that the model has helped explain but not really itself captured the core of that dynamic, which is the changing balance of power between key stakeholders. It might therefore be better to conceive outcomes in terms of the reconfiguration of relations of power between key stakeholders associated with introduction of big data. A graphic outline is indicated in Figure 6, with those gaining power shown in bold, those losing power shown in italics. This also has the benefit of drawing out the sites for tension and even conflict that have been seen to arise during datafication.

This diagram is just a first-pass summary; as with all the models presented and discussed here there is a research agenda to apply this to a wider variety of big data systems and to analyse and understand further its components and patterns and implications.

Figure 6: Changing Configuration of Stakeholder Power from Traditional to Big Data Systems

Recommendations

While care must be taken in generalising from these cases, the evidence showed that value from big data has so far mainly been captured by a small set of stakeholders: senior managers, private contractors and some politicians. As discussed below, spreading the development benefits of big data more broadly will require active interventions and even new directions for application of data.

All stakeholders must prepare for longer-than-expected project timescales. Intended organisational value may take several years to emerge given the size and complexity of big data systems, and the need to address ongoing socio-technical challenges. Greater organisational efficiency and effectiveness including optimised customer services are coming but only in the medium term.

There is a need to further develop big data-related capabilities in the public sector. Practically, a number of challenges might have been avoided or mitigated with greater ability of public officials and technical staff to engage with implementation. Hence, lessons learned from these implementations could readily be shared with equivalent corporations in other Indian states and beyond. Politically, without greater in-house capacity, the power shift from public to private sectors will remain entrenched, making public organisations dependent on largely unaccountable and unremovable private firms. One capability set around which this will crystallise is big data analytics. Significant value will accrue to those able to more-deeply analyse the growing datasets. Public corporations must make a conscious decision to build and retain that analytical capability, must clearly make this a public-sector responsibility within outsourcing contracts, and must claim ownership of related data models. Otherwise, they will become further dependent on a private sector that captures increasing value from public data.

Though barely mentioned as yet, these big data systems and the public-private partnerships on which they are built, will need to be more-closely scrutinised around issues of data security, re-use, privacy and surveillance. The managers using these as reasons to resist opening up their data are not entirely wrong, and more effective evaluations – such as data privacy impact assessments – and policies and regulations will need to be put in place. Pressure for these must come in part from consumers, citizens and their collective will

expressed through civil society organisations that encompass or even focus on the implications of datafication. The absence of any sign of such pressure or organisational forms in these cases is a concern: without it consumer/citizen benefits of big data will arise only when in synchrony with the political agendas of others.

This also means there is limited impetus for opening up these new datasets. Yet this is data gathered about public processes and assets, paid for by public money, and the economic and political value of data for enterprise and transparency should be maximised. Potential users here include local “data economy” businesses that can add value through further analysis of datasets; citizens who can better understand the performance of their public corporations; and regulators who can gain faster and better oversight of corporate operations. Whether that can happen in practice will depend, however, on public organisations having sufficient power, access, capabilities and motivation to open the data. These may often be circumscribed by the nature of public-private partnerships and/or by political interests within public-sector organisations.

Labour employment and relations are changing: big data systems create a few new jobs encompassing the capabilities identified above in data operations and analytics. But they will likely enable whole swathes of jobs to be automated out of existence, where the core functionality of those roles – meter-readers, bus conductors, middle managers – is capturing, processing and communicating data. For other jobs that remain, management has not yet attained but has laid the foundations for algorithmic management. Unions wishing to resist these trends will need to first develop a much greater awareness and understanding of the big data systems that increasingly enfold their members; and second identify counter-vailing tactics, from requiring redeployment of sacked workers to requiring greater transparency of data used for management purposes.

As with the absence of active civil society organisations, the absence of clear union engagement is notable; the concern being that without such interventions, developing countries may be sleep-walking into a datafied future shaped by a very narrow set of interests.

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