Actor-Network Theory for Development

Working Paper Series

Actor-Network Theory for Development working papers apply the ideas and concepts of actor-network theory to issues and cases within international development

Paper No. 5

Technological Change in Developing Countries:
Opening the Black Box of Process using Actor-Network Theory

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2013

Table of Contents

Technological Change in Developing Countries: *Opening the Black Box of Process using Actor-Network Theory*

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2013

Abstract

Processes of technological change – innovation, transfer, adaptation, implementation – are central to development. Yet they are typically black-boxed in research accounts so actors and practice remain hidden. This paper applies one aspect of actor-network theory (ANT) – moments of translation – to a case study of technological change in the Sri Lankan public sector. Such application has its challenges but ANT provides a rich, detailed account of technological change processes for development. It can offer three unique insights that expose: the formation and dissolution of socio-technical structure; the active role of technology; and the 'translation' of interests, identities and ideas during these processes.

1. Introduction

> Much of the economic and social progress of the past few
> centuries has been due to technology. Technology has been
> central to both economic growth and many elements of social
> welfare (World Bank, 2008: 2)

Technology has always been seen to play a central role in socio-economic development, and change in technology has thus been seen as an essential ingredient of development strategies throughout the world (Bell and Pavitt, 1993; Evenson and Westphal, 1995). There has therefore been intense interest in processes of technological change: the processes such as technology innovation, diffusion, adaptation, implementation and use that make the connection between technology and development. It is these processes – rather than, say, the context within which they occur, or the impact of technological change – which form the focus for this paper.

Since the 1960s, the number of these technological processes that have been the focus of research interest has steadily accumulated: adoption then transfer then adaptation then innovation, for example, all being added to the roster; in part reflecting the real expansion of capabilities and processes within developing countries (Bell and Albu, 1999; Niosi, 2008). This process accumulation has been accompanied by a conceptual accumulation, with theories of technology and development dealing particularly with the macro-level (e.g. exogenous and endogenous growth) being joined by micro-level theories (e.g. technological capabilities, and learning) and meso-level theories (e.g. national systems of innovation).

As explored further in the next section, a variety of conceptual ideas has been brought to bear by researchers interested in processes of technological change. Deriving from these conceptualizations, there have been differing views on the composition of these processes (e.g. as linear vs. non-linear); the determinants of these processes (e.g. the role of the technological vs. the social); the level at which analysis of process should take place (e.g. macro vs. meso vs. micro); and the nature of technology within process (e.g. artifact vs. system vs. knowledge). Despite this breadth of perspective, one can also see that the great majority of research to date on technological change in developing countries provides little detail on what actually goes on during technological change; in particular what active role is played by both individual people and by the technology itself.

Given these are issues that actor-network theory (ANT) – from its application in other disciplinary fields – is known to address, the purpose of this paper is to open the black box of technological process using ANT. It will assess the alternative conceptualization of technology and development that ANT offers: one in which the dynamism of technological processes becomes the heart of enquiry; one in which individual human actors are recognized and investigated; one in which technology actively participates. Specifically, the paper will apply the 'moments of translation'

framework (Callon, 1986) to the case of a new digital technology-based system in the Sri Lankan public sector.

To date, actor-network theory has hardly been used within development studies. The intention here, then, is to allow readers – especially those involved with technology and development research or practice – to understand the application of (one aspect of) actor-network theory in the field of technology and development, and to draw conclusions about the particular insights it provides into processes of technological change.

This begins, in the next section, with a more detailed review of literature and ideas on technological change and development, reviewing the different conceptualizations that have been used to date, and identifying issues that have as yet received relatively less attention. Actor-network theory is then briefly introduced before the methodology of the reported case is outlined. That case is then analyzed from an actor-network perspective before a discussion and conclusions about the contribution that ANT-based enquiry might make to studies of technological change and development.

2. Literature Review and Conceptualization

2.1 Technological Change Processes

There is a sense in which science and technology rather dropped from the development agenda in the 1980s and 1990s, only to re-emerge in the 2000s (e.g. African Union, 2005; Leach and Scoones, 2006). But in terms of development research (judged by publications in development journals[i]) and development practice (judged by science and technology indicators[ii]), technology has continuously played an important role.

However, that role has changed over time. One can divide the technology and development field into: *context* (e.g. policy, infrastructure, markets and other structural institutions, technological trends), *process* (discussed next), and *impact* (i.e. development outcomes). As noted above, the focus here will be just on the process aspect, within which there has been a development of issues over time (Bell and Albu, 1999; Juma and Yee-Cheong, 2005; Niosi, 2008). In the 1960s, the main process of interest was *adoption*: with an often-simplistic assumption that technology as embodied in fixed capital had merely to be moved from its point of invention in the global North to its point of use in the global South for development to ensue (Evenson and Westphal, 1995). In the 1970s and 1980s, attention shifted more to *transfer*: opening to greater scrutiny the choices, channels and mechanisms by which the move from North to South took place, and changing the view of technology from a physical artifact to a system of artifact plus 'people, procedures and organizational arrangements' (Bell and Albu, 1999: 1717). In the 1980s and 1990s, the process of *adaptation* was incorporated: understanding the changes to

these various system components that needed to be made in order to get technology to work effectively in developing country contexts (Barnett, 1990). In the 1990s and 2000s, there was growing interest in *innovation*: seeing technology as embodied knowledge developed by learning supported by networks of organizations and institutions (Wignaraja, 2003).

Rather than associating particular time periods solely with one process of technological change, it is more appropriate to see this as an accretion of processes within the technology and development field over time; in part reflecting expanding practice in developing countries as capabilities have grown; in part reflecting growing academic insights. Those insights have been based on development of a series of conceptual frameworks. A foundational development has been the shift from exogenous to endogenous growth theory (Mayer, 2002). Where the former saw developing countries as passive adopters of a global stock of externally-invented artifacts, the latter sees technological processes and endowments of knowledge within a developing country as central to long-term economic growth. This opened the way to research the whole breadth of technological change processes – transfer, adaptation, innovation, etc – within the global South.

2.2 Understanding Technological Change Processes

How have these processes of technological change been understood to date? We will discuss the conceptualization of five issues.

Process Composition. Early models of technological change in development characterized the process as a set of discrete stages along the lines of invention – production – transfer – implementation – use (e.g. UNIDO, 1984). Subsequent research questioned this simplicity with work on innovation and development, for example, demonstrating that processes of technological change contained activities that ran synchronously, iteratively, even cyclically (Lundvall et al., 2009). Despite recognition that the linear stage model 'functions more as a "straw man" in critical discussions of technology development' (Fleck, 1993: 171) than as a reflection of reality, it remains a strong paradigm within technology and development (Veldwisch et al., 2009).

Process Determinants. Technologically-deterministic accounts of technology and development – such as those inspired by the modernization development paradigm of the 1960s – are largely silent on the question of what determines processes of technological change. Their determinism relates to technological impact rather than process (Wilson, 2008). It is more socially-deterministic accounts derived from dependency theory and beyond which have offered insights into processes. These began as relatively simple structuralist accounts, which saw social structures such as class determining the nature of technological change (de Gregori, 1978), but then progressed to a more nuanced and complex structuralism which incorporated social constructions such as institutions, organizations and networks and their interactions as determinants of technological processes (Juma and Yee-Cheong, 2005). Very occasionally, more dualistic views have been brought to bear on technology and

development; which see social structures impacting technological change, and technological change impacting social structures (Shen, 2010).

This complexity was perhaps compounded with accounts that allowed for some degree of agency; that is, some freedom from structural determinism in explaining technological change processes. However, where agency is recognized it is often inextricably linked to social structure; for example, where organizations are the identified actors in technology innovation, transfer, implementation (e.g. Hall et al., 2001). One actor has been notably missing from these studies: people, either as individuals or even, often, as groups of individuals. Accounts and conceptualizations of technological change in development tend to be de-humanized. While it is quite reasonable for this to be the case for some theoretical abstractions; that it is the dominant – verging on universal – formulation seems perverse: in practice, humans are of course integral to all technological processes (Leach et al., 2007).

Treatment of Process. Typical approaches to processes of technological change in development include studying the national policies and prices which shape those processes; studying the networks of organizations and institutions which both shape and enact those processes; and studying the organizational sub-components which similarly shape and enact those processes (e.g. Iammarino et al., 2008; World Bank, 2008; Ryan, 2010). Research has therefore, by and large, studied the factors which affect processes of technological change, or the social structures that are seen to perform such processes, or has developed a taxonomy of such processes. But it has largely failed to describe those processes in any real detail. In other words, process has been black-boxed by researchers – sometimes quite literally, with diagrammatic models in which processes of technological change are represented as a single box (e.g. Wignaraja, 2003) or as a set of boxes (e.g. Saad, 2000). We therefore have the irony that, while processes of technological change are the object of enquiry in this part of development studies, they are rarely directly enquired into. Yet, when they are, technological processes in practice are found to be complex, messy and dynamic – there is an awful lot within the black box of process that is struggling to get out (Veldwisch et al., 2009).

Level of Process Analysis. The scale at which technological change processes are to be understood has varied (e.g., again, Iammarino et al., 2008; World Bank, 2008; Ryan, 2010). Initially, processes – e.g. of exogenous and endogenous growth – were understood at the macro level, with the state as a key actor. Later ideas – e.g. on technological capabilities, and learning – examined the micro-scale of the individual organization; while others – e.g. on systems of innovation – looked typically at meso-level networks of firms and research institutes within one industrial sector. Work has occasionally looked at more than one scale (for instance, recent work drawing from the systems of innovation tradition; see Lundvall et al., 2009) but this is more the exception than the rule; in general, writing on technological change and development has focused on one particular level. This has therefore imposed limitations on the understanding of technological change in development since the variety of levels covered by prior research suggests that all levels must play some role.

Nature of Technology within Process. As noted above, there has been an accumulation within development of different understandings of technology itself (Bell and Albu, 1999). It may be seen as a physical artifact. It may be seen as a system of elements – material, human, organizational – which, together, are necessary to effect the transformation of inputs into outputs. More abstractly, it may be understood as the embodiment of knowledge in such systems; that knowledge developed through learning. What it has not been – at least in the literature on technological change and development to date – is an agent that plays any active role in the process of change.

Individual humans are largely absent from this literature through a matter of methodological choice: there is an implicit understanding that they still remain agents within the process. But the absence of technology as an agent is more of a conceptual taken-for-granted: that technology is acted-upon but not itself acting.

2.3 Moving Forward with Conceptualization of Technological Change Processes

Within the five issues a number of different perspectives can be seen, some of which are the subject of disagreements and debate; for example, around the determinants of technological processes. But there are also a number of elements – individual people, practices of change, the technology – that are somehow 'present but absent' in most accounts of technological change in developing countries. They are very much an assumed part of technological change, yet they are rarely directly examined by the research accounts of that change.

What we have, then, is an image of research approaches that stand outside the technology processes they seek to investigate, freezing them in time and concealing their main actors and actions. To research technology and development often seems as if it is to research stasis. It might be research-as-lepidoptery: looking from the outside at various cases that are pinned down and lifeless, seeking patterns. It might be research-as-autopsy: pulling the pieces out of the case and laying them on the table in the hope of understanding how they work. What has largely been missing is research-as-kinesiology or research-as-sonography: attempting to understand technological processes from a dynamic, human perspective that investigates them as 'living' practices.

Such issues are not confined to analysis of technology within development; they reflect broader concerns in development studies: about the emphasis on the stasis of structure rather than the dynamics of process; about the absence of individual actors (Mosse and Lewis, 2006; van der Ploeg, 2006). In the discipline overall, this has led to at least a partial shift in focus from grand narratives to specific instances; from context to practice; from entities to actors (Mosse and Lewis, 2006; Sumner and Tribe, 2008).

For technology and development research, an obvious response to the lacunae noted above would be to draw on ideas from science and technology studies (STS) which, for many years, have followed the shift in focus just noted. However, analysis of recent papers on technology published in development studies reveals three things: that conceptualizations from STS can offer a series of novel and timely insights into technology and development (e.g. Leach et al., 2008; Shen, 2010); that such conceptualizations inform only a very small minority of work in the technology and development field[iii]; and that work specifically framed around the STS-developed actor-network theory is almost entirely absent.

There is work that identifies ANT as a theory of potential relevance to analysis of technology and development, but which does not then apply it (e.g. Oreszczyn et al., 2010). There is work in which ANT is mentioned among other ideas as part of the general pattern of influences on the research (e.g. Knudsen, 2003; Beban, 2008). More than this, there is work that specifically discusses ANT but which then analyses technology in a development setting through a more general lens of sensibilities from STS (e.g. de Laet and Mol, 2000; Veldwisch et al., 2009). It seems appropriate to say that such work has been 'flavored' by ANT rather than framed by it. The potential for ANT in this part of development studies has therefore yet to be explored.

Yet we know from work within other fields, that ANT is applicable to processes of technological change, and that it is seen as making a novel contribution.. In the information systems discipline particularly, actor-network theory has been used to address what were seen as shortcomings in prior conceptualizations and literature (e.g. Walsham, 1997; Hanseth et al., 2004). It has also found application in relation to agro-food technologies (e.g. Goodman, 2001), energy technologies (e.g. Jolivet and Heiskanen, 2010), transportation technologies (e.g. Latour, 1996a), and others.

Even within these fields, the application of ANT to cases of technological change in developing countries has been rare. For example, there are cases provided by Braa et al. (2004), Madon et al. (2004), and Andrade and Urquhart (2010), but the foundation, frame and focus of these studies is information systems rather than development studies. Thus, while past work demonstrates the potential relevance and contribution of actor-network theory in relation to technological change and development, it has not offered a clear-enough signal to 'cross the disciplinary fence' and spark significant consideration of ANT within development studies itself.

Where relevant, we will draw on some of these sources later in the paper in order to fulfill our purpose: to use actor-network theory to frame analysis of a case study of technological change and development, and thereby evaluate the new insights an ANT-based account may offer into the issues identified above.

2.4 Actor-Network Theory

To understand a little further before our analysis, we provide here a short overview of ANT. Recognizing the almost-overwhelming limitations of summarizing an ever-

growing, ever-changing body of ideas[iv], we focus here on one particular aspect. Actor-network theory is a pragmatic, recursive sociology of process that focuses on the way in which actors – which can be both human and non-human – seek to build and maintain networks (Law, 1999).

Translation is central to this sociology of process. It involves one set of actors 'translating' – that is, reinterpreting and displacing – the interests (goals, problems, solutions) or even identities of other actors, so as to align those actors' interests with their own (Law, 1992). It is the mechanism by which the networks progressively take form, resulting in a situation where certain actors control others. Here, we have chosen to apply ANT's 'moments of translation' approach. This choice was partly guided by the relative clarity of this approach and its previous application to case studies of digital information systems (e.g. Sarker et al., 2006). The choice was reinforced as its fit to the particular case analysis emerged during the research process.

The foundation for moments of translation is Callon's (1986) history of scallop fishermen in St. Brieuc Bay in France and a scallop breeding program proposed by a group of research scientists. Following the scientists and their program, Callon identified four particular moments in which there was a form of translation of interests, each of which he named:

- *Problematisation* – the principal actors [in Callon's case study, the researchers] try to make themselves indispensable to the other actors [fishermen, the wider scientific community, scallops] by defining the nature of the problem those actors face in achieving their goals and by identifying a single way forward [the scallop breeding program] which is described as an *obligatory point of passage* (OPP).
- *Interessement* – the principal actors lock the others into place by interposing themselves, weakening the links of other actors to alternative interpretations and strengthening their focus on the problematized OPP [the scallop breeding program is accepted as the way forward by the various actors].
- *Enrolment* – the principal actors put interessement into practice by actions that define the roles that are to be played in enacting the OPP and the way in which the others will relate to one another within the network [those participating in the breeding program accept their roles within it].
- *Mobilization* – the principal actors borrow the force of their passive agent allies and turn themselves into their representatives or spokespeople [the research scientists speak on behalf of the wider scientific community, the fishermen, and the scallops].

However, in Callon's case, the stability and unity of the alliance is subverted when the scallops and then the fishermen reject their designated roles. This *dissidence* or betrayal leads to the eventual failure of the scallop breeding research program, and points to the potential failure of translation processes.

Though this is just a thumbnail sketch, it helps illustrate more widely-demonstrated features of ANT which suggest it has potential to address the issues raised earlier (e.g. Latour, 2005). It has a central concern with process which it focuses on in rich

detail, exploring what – in traditional technology and development terms – might be called the 'nano-level' of practice that lies below the organizational level. It could therefore open the black box of technological processes to understand the actors and actions inside. Agency is present but precarious: many ANT analyses tell how actors more or less, and for a period only, manage to constitute their networks. Wider structures do not dominate the narrative: in some ways there is no social order, there are only endless attempts by actors at ordering through formation and stabilization of networks.

The list of actors includes individual people or small groups of people that are explicitly identified and followed. It also includes non-humans such as the scallops. The St. Brieuc case (like the Sri Lanka case presented below) does not place great emphasis on this, but non-humans can also include technology as an actor. Even before the specific case application outlined here, then, we can see that ANT appears to highlight aspects of technological change that prior accounts from developing countries have largely left in shadow.

3. Methodology

Having presented a very brief synopsis of one aspect of ANT, we now move on to an overview of the selected case study and the approach used in researching it. We have chosen to analyze the case study of introducing new financial technology into the Sri Lankan public sector. As discussed further below, access to the case study was a key determinant. However, we also selected the case because it shows some features typical of technological change in developing countries.

There are growing examples in developing countries of 'laboratory'-based research and development activities (e.g. Niosi and Reid, 2007). However, the bulk of the relation between technology and development still remains focused on the operationalization (transfer, adaptation, implementation, use) rather than invention of technology (World Bank, 2008). This case is an example of the former. It includes a number of other elements found in many large technology projects in developing countries: the presence of donor funding and oversight; knowledge, artifacts and consultants from overseas; and status as one part of a broader program of change. We also believe it to have two other valuable representations. The majority of technology and development case studies have been drawn from industry and agriculture. Yet technological change is central to the service sector; something this case represents. And there has been a rapid rise in the role of information and communication technologies in developing countries; and that is the focal technology in this case.

Our overall research approach is therefore that of the case study, focused on the specifics of attempting to implement a new technology-based finance system in one specific public sector. Case study methodology is deemed particularly appropriate for the detailed description and analysis of process, and it typically utilizes a number of different research methods (Yin, 1994; Thomas, 1998).

One method was based around author Stanforth's position, from September 2000 to July 2003, as a member of the international consultant team working on financial reform in the Sri Lankan public sector. She was continuously engaged with the main actors involved in the case project. During this project involvement, she was not actively engaged in deliberative cycles of conceptual reflection and action. However, she did record data informally through a diary process, and formally through internal documentation for the project. Hence, this is seen as an engagement of participant observation rather than action research; with participant observation seen as compatible with case study method (Easterby-Smith et al., 2012).

This method was supplemented by analysis of documentary evidence made available through access to the full range of documentation related to the specific case application of new technology. In all, then, three types of documentation were analyzed – an author-written diary, author-developed documentation on financial reform, and project documentation on the particular technology application. Finally, the participant observation and document analysis methods were complemented by interviews with key project stakeholders. These interviews were carried out in Sri Lanka during six weeks of field visits undertaken from October 2003 to November 2005. Twenty-four interviews were held in total covering senior officials responsible for project leadership and facilitation, mid-level officials responsible for project implementation, and representatives from local consulting, international consulting and donor agencies. Consistent with other ANT-related field studies (e.g. Madon et al., 2004), the research approach used therefore provides two types of triangulation/cross-checking. First, it uses multiple methods for data-gathering. Second, it uses multiple sources of data.

4. Case Study

Our chosen point of departure is an official ceremony in 1999 that marks the signing of a formal agreement between the Sri Lankan Ministry of Finance (MoF) and the Asian Development Bank (ADB) to fund a technical assistance project. The project design document has been prepared by a foreign e-government technical specialist who leads the ADB mission (ADB, 1999a).

At its heart the project design foresees the introduction of new public expenditure management (PEM) technology – new hardware, new software, new procedures – into five of the Ministry's departments. The departmental leads for each of the five components will facilitate the inter-linking of the expenditure systems so that they form the expenditure modules for a broader integrated financial management information system (IFMIS). The agreement is concluded by the Secretary Treasury, and the Director-General of the External Resources Department (notably not one of the five that will implement the new technology).

If we move the clock forward four years, to 2003, we find that new expenditure management technology has been introduced into the Ministry. However it is

different in nature from that specified in 1999. We will now trace through the evolution to gain an understanding of how this divergence arose as the project was performed into being.

4.1 Phase One: Building Networks Around Best Practice Solutions (1999-2001)

Problematisation
We have identified the *ADB delegation* as the focal actor in the early part of this story. They are our 'heterogeneous engineer' (Law, 1987, p. 117) shaping and assimilating the various networks through processes of translation where they seek to gain control over others. Through both actions and documents, they seek to determine a set of actors and define the identities and interests of those actors in such a way as to establish this technological change project as an obligatory point of passage in the network of relationships they are building. The formal agreement brings four other actors into the story whose assumed problems and goals, as defined in that document, are formal and rational.

Substantial investments have been made in existing *expenditure technology* (including computing systems and financial procedures). These enable aggregate expenditure control, but identified weaknesses in their informational base mean they do not produce timely, accurate and secure expenditure reports sufficient to support broader resource allocation decisions that are consistent with longer-term public service goals (ADB, 1999b). The design document indicates expenditure technology must be re-engineered and thus upgraded to the international 'best practice' of an IFMIS, with the PEM Systems project as the way to achieve this goal (ADB, 1999a).

Government officers in the MoF and line ministries are analyzed as underperforming not just due to inadequacies of the technology, but due to poor working conditions that limit training and promotion opportunities. The PEM Systems project will motivate them to implement expenditure reform via a revised human resource management approach that provides up-to-date technical skills and qualifications, and which recognizes and rewards staff skills and performance.

The *private sector consultants* are shown in the project design document as having knowledge of international PEM technologies, and expertise in IFMIS implementation that would help deliver technical assistance. The *MoF leadership* will provide formal approval as representatives of government, and are positioned as advocating the introduction of technology best practice. Resourcing this project will enable both these actors to play a lead role in modernization while also, in the suppliers' case, meeting their commercial interests.

The ADB reveals itself to be a body that will work with the Ministry to supply what the latter lacks in the way of specialist technical and financial resources. The longer-term aim is, as stated in the Logical Framework, 'to establish the prior conditions for

PEM to support a public sector reform program' (ADB, 1999c, p. 1) which it is anticipated will follow via a major loan portfolio.

The ADB design document thus tentatively identifies the actors and their interests, based on the pre-history of the project. It positions the technological change of the PEM Systems project as the obligatory point of passage, through which the actors need to pass in order to avoid obstacles that stand between them and their interpreted goals, as summarized in Figure 1.
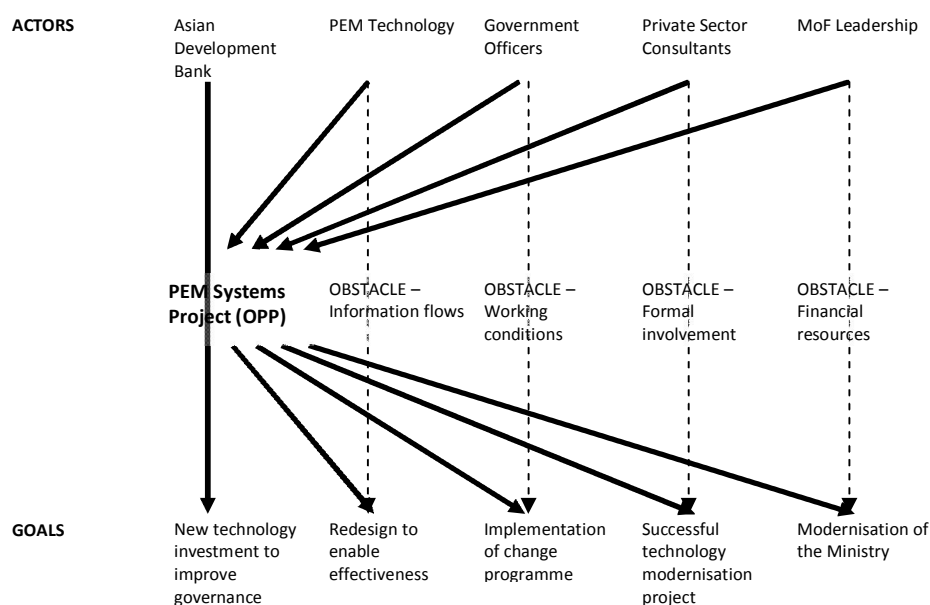
ACTORS	Asian Development Bank	PEM Technology	Government Officers	Private Sector Consultants	MoF Leadership
	PEM Systems Project (OPP)	OBSTACLE – Information flows	OBSTACLE – Working conditions	OBSTACLE – Formal involvement	OBSTACLE – Financial resources
GOALS	New technology investment to improve governance	Redesign to enable effectiveness	Implementation of change programme	Successful technology modernisation project	Modernisation of the Ministry

Figure 1: Phase One Problematisation

Interessement

The design document has defined groups, interests and a single technological way forward in theory, but the focal actor must now get the other actors to engage with, and commit to this course of action. It will do this through devices that seek to lock that commitment in place, blocking the actors from alternative courses of action.

The signing of the formal agreement between ADB and MoF is one part of this. It commits them both to the PEM Systems project as the only technological choice and the only course of action. The established bureaucracy of hierarchical decision-making also allows a macro-network of all government actors to be folded-up into representation by one person alone: the signatory Secretary Treasury. Speaking and signing on their behalf, his commitment debars a search for alternative solutions within government. He also formulates a procedural OPP within the project – a Steering Committee that he will chair which will draw representation from the other actor groups, and through which all main decisions must pass.

Government, and ADB itself, are further locked in place via the funding agreement: ADB to finance technology development and implementation; Government to meet local project expenses including workshops and financial incentives for officers working on the project. The main private sector supplier – an international

accounting consultancy which bid for and won the tendered contract – is locked into place through a signed contract with terms of reference (ToR) based on the project design document (ADB, 2000a).

Overall, then, ADB's interessement strategy has acted to isolate actors from other influences through inscribing their project design interests into formal agreements and contracts, through the bureaucratic hierarchy that allows agreement with a single representative actor, and through the Steering Committee (not the ADB itself) as the recognized project control body.

Attempted Enrolment
Like actors, interests, problems, goals and technology solutions during problematisation, so roles and relations have now been defined during interessement. But enrolment requires actions in order to enact the defined roles and relations, for – in the translation model – these things are truly formed and adjusted only during action.

As the project gets underway in mid-2000, attention now turns to the consultants who, acting as the delegated representatives of the focal actor, will start enacting their ToR through dialogue with officers in MoF departments. The intention is to clarify the roles of the latter, leading to a series of launch workshops, and then a technology strategy document.

However, the consultants – most of whom are drawn from the consulting firm's US headquarters – decide that it is difficult for them to locate their project office in the MoF's old colonial-era building. They opt instead for space high in a modern Colombo tower block that overlooks the Ministry. The project design inscription of working side-by-side with Ministry counterparts, and of an evolving and co-located technology implementation network now looks undermined. Based on an analysis of international best practice in e-government technology projects, they also develop a case for shortening the timescale for technology implementation from three years to two, with project finances now used more intensively. This is confirmed and the consultants are enrolled, through the signing with ADB of an amended contract that they then begin to implement (ADB, 2000b).

The physical distancing of the consultants is matched on the government side by the distraction of parliamentary elections. The Steering Committee therefore does not meet, and alarm bells ring louder for the ADB when the External Resources Department reports that the five departmental task forces due to implement the project have not been formed.

A technology specialist from the ADB is sent to Sri Lanka to undertake a set of review missions from the beginning of 2001; thus becoming a temporary operational OPP for the project. He finds the counterpart funds from government – supposed to provide salary incentives for officers to join the project task forces – have instead been spent on the consultant's project office which they and the Secretary Treasury believed to be a necessary symbol of this project's modernization goals.

The consultants are proceeding with their technology strategy document but they are using an ADB-approved methodology aligned with international best practice for development and design of financial technologies (ADB, 1999d). The consultants enact this in a demonstration of their technological knowledge and authority through meetings and memoranda they believe will convince government officers to engage. But those officers – without financial incentives, with distractions of first elections and then preparations for financial year-end, and with allegiances to the existing PEM technology – do not do so. The ADB reviewer therefore concludes that MoF leadership has withdrawn from the network, and that use of technical authority by both the consultants and the ADB is failing to enlist the intended users (government officers) to support the proposed new technology.

This might have led to a pause in the project but the consultants – driven on by a desire to issue and then bill for one of their main project deliverables – produce a first draft of the technology strategy. This causes controversy. They claim it speaks for all actors and their interests (as outlined during problematisation), and they inscribe into it the presence of a strong, cohesive and participating local network. The gap between these claims and the perceived realities among Sri Lankan actors is too great. The MoF leadership reject the draft strategy and call for an urgent review of the project.

Attempted enrolment has revealed that problematisation was based on formally-defined goals that did not match the actual and immediate concerns of local actors: not just financial issues but also an unrecognized commitment to the existing expenditure technologies among many government officers. There is no cohesive local network, the project is not a workable OPP that could stand as a route between all actors and their goals, and the Steering Committee is not an operational OPP for the network, having met only twice in almost a year of project activity.

4.2 Phase Two: Re-Building the Project on New Foundations (2001-2003)

A crisis ensues and a senior delegation from the ADB is sent to Colombo in mid-2001 to meet with the MoF leadership. The technology specialist is notably absent from this delegation, and the ADB mission must seek to de-enroll actors already locked in (such as the consultants) and re-problematise the project so that a new single course of technological action is identified that will converge multiple group interests.

De-Enrolment and Re-Problematisation
The ADB delegation becomes a new, albeit temporary, OPP for the project. They seek to reassure all actors that the review is in their interests. Even those most associated with the earlier problematisation – the consultants – are told by an ADB officer, 'The review is not an attack on you; it is to assist in ensuring you can meet your contractual responsibilities'.

On the basis of pre-mission consultations with the main actors involved undertaken by an ADB change management expert, the ADB mission concludes, however, that the earlier plans for technological change were over-ambitious and incorrectly sequenced. In a troubled project, the ADB is looking for 'quick wins' from technology and two actors previously folded-up within the government hierarchy start to be heard: the lower-level government officers and the existing expenditure technology.

The ADB mission therefore proposes that a first step should be the integration of existing information systems within the Ministry before seeking a government-wide roll-out. Alongside new technology design, there are also new plans for a technology implementation process which will be more centered around Ministry staff. The ADB mission leader states at a meeting, 'The MoF must now specify its needs in writing. The experts on this mission will review the technology strategy and provide their views to the MoF, so that MoF feedback can be provided to the consultants. A cross-departmental Task Force must meet informally as the focal standing group for the consultants and Secretary Treasury has suggested a monthly Steering Committee meeting, which he will chair.'

The consultants are told that their technology design based on their reading of international best practice was not an appropriate guide in this situation. They are subject to an implicit threat that they must abandon this technology or their contract will be quite publicly curtailed. Likewise, the Secretary Treasury and other senior MoF managers are put on notice to ensure commitment of themselves and others or else the ADB funding may be cancelled. These are forceful pressures that de-enroll the MoF leadership and the consultants from the network supporting the original technology choice.

Although the PEM Systems project remains the OPP, its technology design and its problematisation have been altered, as summarized in Figure 2. The *consultants* are understood to be focused on meeting the terms of their contract and on retaining their reputation for good work. *Government officers* within the MoF departments are still grouped as one and identified as requiring some form of motivation to adopt the technological changes to be proposed by the project. The *current PEM technology* remains in the same state as in the original problematisation exercise, over two years earlier but is viewed more as a foundation to be improved than a problem to be redesigned. The *MoF leadership* is seen as focused on the specific goals of the project but with delegated responsibilities for its future direction. While the MoF is cast as more focused, the *ADB* still sets the particular technological change within the broader continuity of its long-term support to fiscal management reform and hence to wider public sector reform (even though the 'quick wins' approach means technology's incremental contribution to reaching those goals will be even smaller than during the Phase One design).
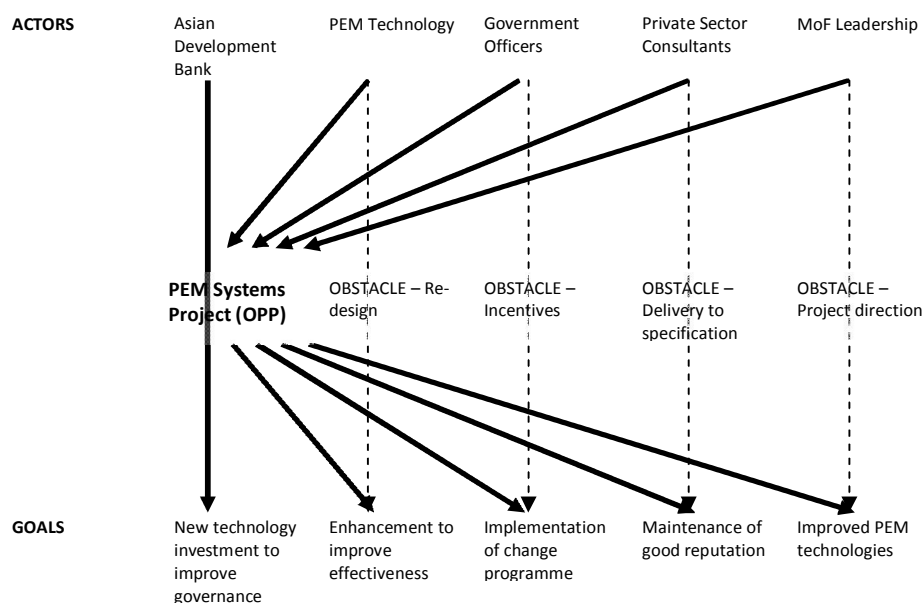
Figure 2: Phase Two Re-Problematisation

Interessement

Prior to the formulation of a new agreement, the ADB mission uses other techniques of interessement in an attempt to ensure commitment to the new problematisation. It makes quasi-public statements alongside the Ministry of Finance in meetings that summaries the perceived problems and goals. It works with the consultants to plan the new project scope and budget, leading them to feel they are shaping the way forward even though this is all done within the frame set by the problematisation. It gains agreement with Secretary Treasury for a full-time project director to be appointed from within the MoF and intended – more than the Steering Committee or cross-department Task Force – to be a true operational OPP for the new project.

Half the ADB money has already been spent and some project components have to be scaled-back, postponed or dropped, leaving only three – not five – MoF departments involved in the technological change: the State Accounts Department, the National Budget Department, and the National Planning Department. Much of the MoF counterpart funding has also been spent. In view of the latter, the consultants (most of whom are now from Sri Lanka, not the US) and project office are moved into the Ministry; a move presented as undertaken to improve working practices. What little money is left will be directed at incentivizing local participation but cannot go much beyond pay for travel and expenses.

A new LogFrame is produced, with a new technology design based on building a local area network across the Ministry, enabling greater integration and sharing of digital financial data, and upgrading the internal accounting systems (ADB, 2001a). This then leads a new Memorandum of Understanding to be signed between the ADB and MoF.

Revealingly the technology design and implementation process are virtually unchanged from those the pre-mission expert outlined privately to the ADB mission before they left for Colombo. Compared to Phase One, therefore, the ADB has remained the focal actor but has problematized and interested rather better. The mission has skillfully ensured that the various debates conducted and decisions taken give the appearance of a multiplicity of choices. This is a performance of the art of the possible that has engaged many of the actors. Yet the ADB had already decided what is and is not possible. They have pulled off the 'double trick of managing the simultaneous performance of singularity and multiplicity' (Law, 2002: 160).

Enrolment
Through negotiation, bargaining and other devices, the ADB now seeks the active enrolment of the main actors in the network. Heads of the three involved MoF departments are given selection choice over which consultant they will work with, and they exercise this by rejecting a number of candidates, thus gaining ownership of their role. The custom-built accounting technology in the State Accounts Department was betrayed by the Phase One technology strategy, which planned to replace it. The strategy produced in Phase Two (ADB, 2001b) seeks to build upon and upgrade it. Where earlier the technology stood largely mute and sidelined, mis-represented within the first OPP and represented only through some of the staff, now it steps forward and agrees a role of active collaboration with the consultants.

A full-time project director is drawn from the National Budget Department and he convenes the Task Force to meet on a regular basis, so both these entities start to fulfill their assigned roles. The consultants have their contract once again re-negotiated but this includes an immediate payment for their revised technology strategy, and they begin enacting their roles in a new contract they see as both commercially profitable and technically viable.

This is therefore a more carefully-developed approach to enrolment and lock-in than that adopted in Phase One. The ADB team has engaged in direct negotiations with the key actors rather than the earlier delegated approach undertaken via the MoF leadership and consultants. They have directly targeted a few key individuals within the main groups rather than the more diffused actions of Phase One which, for example, allowed a folding-up of all government actors – staff and technology – into the role of Secretary Treasury.

Still, though, questions remain about the stability of the network and its ability to implement the revised technology design. Will the two Ministry departments no longer involved de-stabilize the network? Will the lack of salary supplements for MoF staff cause them to lack commitment? Will the more limited contribution of technological change to longer-term reform goals weaken the commitment of either the Ministry leadership or even the ADB itself? Will the technology continue to collaborate?

Mobilization

Given those questions, and also the difficult history of the project, there are concerns about the implementation of the intended technological change. However, the project director works to stabilize the network in two ways. First, through local actions that stabilize the actors involved with implementation. Second, by ensuring a continuous stream of intermediaries – progress reports, outlines of technology deliverables, working papers – are passed up to the actors involved with oversight: the MoF leadership and the ADB.

He finds an additional source of funding so that all MoF officers attending Task Force or working group meetings are paid an attendance allowance in addition to any travel and other expenses. He works with the consultants to ensure designs for specific technology components are developed via considerable discussion with departmental counterparts. Given the local user inputs, some of these designs stretch the boundaries of the new LogFrame. However, the ADB program officer requires this remains unaltered in order to avoid any potential for renegotiation to unravel the network, and insists 'the outputs and activities have been sufficiently widely defined to enable flexibility in delivery'.

As new technologies are delivered, they also play their part by inscribing and enacting the interests of others. A Ministry-wide local area network is quickly and extensively used as it enables digital communication and ready sharing of financial data and documents within and between departments. In the State Accounts Department, a new software 'layer' is added on top of various custom-built databases and spreadsheets. Using the same technology, it aggregates financial data from all these sources and then presents it as a unified accounting report that – unlike all previous national accounts – is on time and receives a supportive rather than qualified opinion from the Auditor General (Chandrasena, 2003). The National Budget Department asks for a new integrated budget system (IBS) even though the LogFrame sanctions 'definition' rather than 'development' of such technology. As it is being developed, colleagues in the National Planning Department ask for a capital projects module to be added to the IBS. Once delivered, the IBS works to maintain enrolment of other actors – it becomes a symbol of the success of the PEM Systems project, and it is publicly championed by the new Secretary Treasury.

Beyond enrolment, then, the actors in the network are becoming more aligned in their interests, accepting the project and its technological choices as an OPP and the project director as a spokesperson on their behalf. This has happened in part as the technological change process has moved from ADB team 'push' to local actor 'pull'.

New actors are also enrolled. Since the new technology has agreed to produce national accounts that are compatible with international accounting standards, it receives the support of Sri Lanka's Institute of Public Finance and Development Accountancy (to which many MoF officers belong, and in which the Director-General of the Public Finance Department – one of those excluded as a result of the project re-design – is active in advocating adherence to international standards). As a result, the Institute is mobilized to hold a two-day national conference to review PEM

Systems project accomplishments, and to present the Ministry's plan for medium-term reform (which is the final deliverable of the project) (MoF, 2003).

The conference marks the end of the PEM Systems project and both seeks and serves to mark the alignment of the network around a technology that both has been delivered and has itself delivered on its promises. The presence of more than 200 public finance officers, and conference addresses by key individuals – the Minister of Finance, the Secretary Treasury, the Auditor General – validate and add legitimacy to the achievements of the PEM Systems project and its particular version of technological change. But they also – through a traditional lamp-lighting ceremony to open the conference, by tracing the history of public accounting in Sri Lanka back to the 10th century, by tracing the history of post-Independence public finance – emphasize continuity rather than rupture, and place the current project as a first step within the overall reform program plan. Speakers also identify the importance of the reform plan as a solution to problems that still exist. So the conference also seeks and serves to segue from mobilization around the current technological change to a new problematisation around the proposal for medium-term reform.

By mid-2003, then, the mobilization phase has produced an apparently fairly stable and durable network that has delivered technological change via an agreed OPP. It now includes new actors: not just those new technologies but also other allies that can speak on behalf of the project and potentially carry the message forward into a future program of reform that will include further technological change.

5. Discussion

We have provided an ANT-based account of technological change that focuses on a single case study – the introduction of new financial technology into Sri Lanka's Ministry of Finance – and which uses a particular fraction of ANT ideas: moments of translation. We will now discuss the perspective that this account offers on the five ways in which technological change within development was earlier shown to be understood

Process Composition. The account has been agnostic about the composition of technological change as outlined earlier. Its description of what happens during technological change has been focused on formation of networks in Sri Lanka, not on differentiating innovation from transfer, or implementation from adoption. It would retain that 'focus elsewhere' whether in practice there are separate, linear stages, or (more likely) a complexity of overlapping, iterative technology-related activities.

One could argue that it merely substitutes one linear model of process for another: the four 'moments' were presented above as separate stages, and there are cases which can be described by just those four stages in linear order (e.g. Madon et al., 2004). However, a simple and linear model was not Callon's (1986) intention: hence his use of the term 'moments which in reality are never as distinct as they are in this

paper' (p. 224) rather than steps or stages, the allowance for iteration and reversal, and the explanation that translation is an ongoing process, 'never a completed accomplishment' (p. 196). These are reflected in the Sri Lankan case, with unraveling of the initial problematisation and interessement, a re-iteration of the moments, and the sense that any ANT account merely captures a slice of an ongoing process of network formation and dissolution.

Process Determinants. As the case study reflected, ANT-based accounts have little interest in 'development impact' and, in any case, the Ministry's technology was simultaneously constituted of and constituting of heterogeneous actor networks of which it is only one part. There is no room in such accounts for technological determinism.

For similar reasons, this perspective cannot be socially-deterministic, at least in the conventional sense. Networks – e.g. of those for and against the consultants' initial design documents – are the core of what limited social structure there is within ANT accounts, and these were seen to be divergent, competing, transient, reversible. There is thus no basis for structural determinism in such a complex and shifting picture, in which space is provided for the agency of individuals and groups to be expressed.

Indeed, ANT actually 'reverses the polarity' of conventional cause-effect flows in social science. Rather than social structures helping to explain the process by which the PEM technologies were developed for the Ministry, it is the processes – particularly understood as the processes of translation that occurred during technology development – which help to explain the emergence of social structures: the actor-networks. Where traditional accounts describe structure and use this to explain process, then, ANT describes process and uses this to explain structure. To call this 'process-determinism' seems too much: the notion of determinism is not really in the ANT lexicon. In the Sri Lanka case study, the emphasis is less on why things happen than on how things happen. For similar reasons, it seems difficult to label the case study as 'actor-deterministic': the sense is that the actors perform technological change as much as cause it.

However, 'The process of translation that builds and changes networks is political in nature.' (Avgerou, 2002: 61). One could therefore make an argument that – if anything – the process of technological change is shown by ANT to be driven by politics; both in the sense of the interpreted, translated and actual interests of particular actors, but also in terms of how power is enacted by those actors in order to try to have their particular interests met through the creation, expansion and stabilization of a network of perceived common interests. We have seen how the focal actor – and the one with most theoretic grounds for power – the ADB, failed in its attempt to push through a technology design of its initial choosing. This was due to the creation of what might be termed a 'counter-network' of Sri Lankan government officials and technology whose interests were threatened by this design. Once the ADB was willing to abandon its attachment to a particular technology solution, and use what one could call 'soft power' techniques of negotiation,

bargaining, and transfer of ownership (though also threats of resource withdrawal), it was able to realize its broader interests in upgrading financial technology as a prelude to wider reform.

These examples are a reminder that actors are central to the Sri Lankan story. We noted above that, previously, where actors are identified in the literature on technological change and development, they are typically organizations. Organizations were present in our case study but, where humans have seemed absent or invisible in most of this literature, here they form a central point of interest. We see the actions and interests not just of groups of people – such as the ADB delegation, the consultants, or the government officers – but, at times, of individuals: the Secretary Treasury, the ADB technology specialist, the Project Director, and others.

Treatment of Process. Like other ANT-based accounts, the case study given here provides a thick description – a relatively granular level of detail on what occurred within technology-related processes associated with the new financial system. Far from the rather static or snapshot view of technological change in developing countries that has typically been offered, ANT provides the basis for a rich picture of the longitudinal dynamics of technological change. This therefore fits the idea of technology and development research-as-kinesiology: offering a 'sonogram' of a technological change process that traces its workings over a period of time.

And far from a distant, external view of technological change process that has been typical, ANT has provided a detailed picture of actual practice. Indeed, not only does ANT open the black box of technology process to shine a light inside; in some ways, that is all it does. Aspects that one would find in most literature on technological change – a characterization of organizational structures, an outline of policy types, an investigation of resourcing levels, etc – are absent here; making way for ANT's preoccupation with process-as-practice.

Level of Process Analysis. In providing its account of the Sri Lankan financial technology, ANT moved readily between levels or, rather, transcended the whole concept of level or scale. Actors described as participating in the heterogeneous actor-networks included individuals, technological systems, groups within and across organizations, and national and international organizations. Each one of those – because they are themselves heterogeneous actor-networks – may also be constituted by multiple actors operating at what are traditionally understood as different levels. Hence, the way in which the Minister stood for all government actors in signing the initial agreement, or the way in which the consultants stand for a large international network of best practice. As a result, an ANT-driven perspective does not have to make decisions about which level of actor or analysis to focus upon; something that may be particularly relevant for analysis of technological change in development, which often crosses organizational and national boundaries.

Nature of Technology within Process. The technology in the Sri Lanka case study is an actor-network. Focusing on the latter element, the network, we can see parallels

with the systemic view of technology present in the wider literature; a sense that Sri Lanka's financial technologies are socio-technical systems rather than just a technical artifact. But ANT is offering more than just a systems approach – it is opening up technology to reveal it as a socio-technical network of actors which constitute and operate through the technology, and which inscribe their interests into that technology.

Even more of a departure from prior work is the former element. As noted above, in the great majority of technology and development literature, technology is only seen as a silent passenger in, or output from technological processes. But via the moments of translation account above, technology is shown to play an active role. Along with its allies, the existing PEM technology resisted the initial design document, and the attempts to translate its interests via the project OPP; it shaped the revised project design which meant it would be improved rather than replaced; it co-operated with the consultants as they sought to implement that revised design; and it allowed some flexibility of technological developments within that implementation. As new technologies were developed in Phase Two, they also became network members, and actively shaped those networks through the interests they inscribed and spoke for, and through the functionalities they offered.

6. Conclusions

We can conclude by asking if the ANT-based case study has told us something about technology and development that other accounts would not.

It has opened up the process of technological change to detailed scrutiny. It has spotlighted individual human actors and exposed their role in technological change. But, while these are inherent features in the use of ANT, they are not inherently absent from other accounts – it is just that process-oriented or individual-actor-oriented approaches have, to date, rarely been used to understand technology in developing countries.

ANT is more innovative in the way it can be seen to crash or dissolve many of the dyads present within the technology and development literature: linearity vs. non-linearity of technological change; technological- vs. social-determinism of impact; macro- vs. micro-scale as the appropriate level for analysis of technological processes.

Each of these dyads has been the subject of debate with, as seen earlier in this paper, resolutions being attempted with a weight of evidence coming down on one side (as in the case of non-linear accounts of change), or via dualistic approaches which seek to incorporate both components (as in accounts that allow for society shaping technology and technology shaping society). Our ANT-based account is rather unique in neither opting for one of the monads, nor in attempting some dualistic resolution. Rather, it sidesteps these issues. As just described, it is agnostic

about the composition of technological change processes; non-deterministic about the causes of those processes; and non-scalar.

However – in the language of sales and marketing – all of the above are <u>features</u> of ANT, but are they <u>benefits</u>? In other words, we have yet to identify the unique insights ANT has offered on technology and development as a result of its perspective.

Three candidates emerge from the Sri Lanka case study.

As noted above, where traditional accounts typically describe structure and explain process, this account has done the opposite. Through the detailed description of the processes of technological change in this developing country, it has helped to explain the structures – specifically, the actor-networks – of relevance to that technological change. We have come to understand not just what those networks of relations are – both networks and counter-networks – but the detailed process by which they came to be formed, dissolved, re-formed, and so on.

The ebb and flow of structure in technological change has been explained, in part, by highlighting an active role for technology in development. The active role ascribed to technology may vary but even in this case study – where it was not given particular prominence – we have seen how technology shapes, enables, co-operates, resists. An ANT-based account therefore represents a clear departure from previous literature on technological change and development because of its symmetry in handling the human and the non-human (the latter going well beyond technology in the conventional sense to also encompass texts, objects, plants, animals, etc – e.g. Ernstson, 2011).

This is more than a passive materiality that just seeks to recognize the importance of material objects in technology and development projects. It is an active materiality that brings technology to the fore in a way that other theories do not. Because technology can be shown to play a role, this helps us understand, for example, why project outcomes emerge as they do; an understanding which would be impoverished or flawed if it were only to focus on the human actors. By recognizing the agency of non-human actors in development through ANT, we gain a deeper insight.

The agency of human and non-human actors leads to assemblage of networks through a third insight that ANT has offered, and which determined the whole composition and conceptualization of the case study; the notion of translation. At a general level, the moments provided the structural framework for the case chronology. More specifically, we have seen how translation shifts the goals of a particular group: for example, how the consultants' interests in successful contract fulfillment were altered by the ADB to align with the project re-design. We have seen how translation can shift identities during technological change: again, the consultants were transformed from a group imposing international expertise from a position that was, literally, outside and above that of the government staff; to being

a group that facilitated by working alongside those staff. And we have seen how translation shifts the network of relationships: yet again, the consultants moved from being rather isolated to being part of a concerted actor-network that involved most of the other Sri Lankan actors.

Translation therefore exposes the way in which the interests of particular actors in a technological change project can be changed over time; how their identities and relations can be changed. It exposes how ideas move and change. That is, it shows not just <u>that</u> these things change, and <u>in what way</u> they change, but also <u>how it is</u> that those changes come about, and <u>how they relate</u> to a technology project's trajectory.

Through the categorization of the four moments (and other acts of translation such as de-enrolment and dissidence), we also gain a specific sense of what we might call the 'political tactics' that arise during that trajectory; activities which, without ANT, would likely not be spotlighted, and would not be understood in this way. Examples seen include:
- Use of language: e.g. the association of the first project design with 'international best practice' to promote initial problematisation.
- Use of formal texts: e.g. the attempt of the formal agreements between the ADB and MoF to exclude all possible routes forward but the one chosen.
- Formation of an operational OPP: to enable control and to reduce the chances of competing actor-networks forming.
- Acts of omission: e.g. the ADB program officer turning a blind eye to the stretching of LogFrame boundaries to enable mobilization around Phase Two of the project.

6.1 Challenges of Applying ANT

Alongside these contributions, the Sri Lanka case study illustrates three challenges of using ANT to understand technological change in development: methodological, analytical, and instrumental.

In writing this account, we have tried to obey Callon's (1986) injunction to 'follow the actor', but decisions have been taken in the framing of the account that might have been otherwise such as the time frame and level of detail. There is therefore, with ANT, a potential for flexibility or – being more critical – for subjective choice in the selection of the story to be told. In some ways, this occurs because ANT requires such a thick description: a description suited to book length (e.g. Latour, 1996a) but which fits only with great difficulty into the word-length requirements of a standard journal article. This – as in the Sri Lanka case presented here – demands choices about what to cut out, and makes the actual description rather 'thinner' and less rich than ideally desirable.

Secondly, there remains a central quandary about the use of ANT: is it just narrative and descriptive or is it also analytical, even explanatory or predictive? Some argument has been made above that it does move beyond the descriptive to the

analytical in relation to the formation of networks, the agency of technology, and the process of translation.

Taking the first, the structure of networks may be what is explained rather than what explains, but there is a sense that ANT has helped understand <u>how</u> networks are created, destroyed, modified during the technological processes in Sri Lanka, but not <u>why</u>. This ANT account has provided little sense of cause and effect, and – while it stands in opposition to technological- and social-determinism – it puts forward no other determinism in their place.

There is thus the potential that ANT tells an insightful story, and illuminates aspects of technological change that most other accounts sideline – the detail of process, people generally and individuals specifically, the active role of technology, the politics within change processes – but that it offers relatively little that is generalisable beyond the methodological (such as the moments of translation framework), and nothing at all that is predictive.

Indeed, no other claims are made by the originators of ANT: 'the actor-network approach is not a theory.' (Law, 2007: 2) … 'no more than cartography is a theory on the shape of coast lines and deep sea ridges' (Latour, 1996b: 374). 'Theories usually try to explain why something happens, but actor-network theory is descriptive rather than foundational in explanatory terms' (Law 2007: 2).

Actor-network theory has therefore been variously described by researchers who have applied it in other disciplines as 'heuristic' (Andrade and Urquhart, 2010: 358), as a 'methodology' (McNamara et al., 2004: 55), even as 'a sensibility' (Bender, 2009: 317). As a result, it may be that a deeper analysis of technological change in developing countries would require us to follow the example of other authors using ANT who have sought to combine it with (other) theoretical bases, in order to generate greater explanatory power. Examples include combination with activity theory applied to analyze innovation processes (Miettinen, 1999) and combination with structuration theory applied to analyze health technologies (Brooks and Atkinson, 2004).

If ANT provides a theoretical challenge, it also provides an instrumental one. While actor-network theory studies the practice of technological change, does it have anything to say to that practice in return? Many of the foundational works of actor-network theory say nothing prescriptive or even advisory about how practitioners might use the insights that ANT offers, and there has been a concern about the lack of its applicability to practice (Vidolov, 2008, Cresswell et al., 2011).

This challenge may be easier to address since, whatever ANT's doctrine, it is possible to draw out some conclusions for those involved with processes of technological change. ANT's notion of translation is, at root, a political admonition that can be interpreted in different ways by technology project practitioners. For those who are in traditional positions of power, it encourages them to see themselves as network managers, focusing on what are sometimes pejoratively-labeled 'Machiavellian'

techniques that will assist the translation of others' interests and identities to their own technology agenda. These may range from communication through negotiation to bargaining, maneuvering, subterfuge and threats; many of which were seen in the Sri Lanka case.

For technology designers, it encourages them to take account of local users and local interests. More than this, they might also recognize the value of fluidity and flexibility, and the tension between technology design stabilization and actor-network stabilization (Ramiller, 2005). As seen in the PEM Systems case, the ADB successfully negotiated this tension on at least two occasions. By giving the appearance of design flexibility and negotiation at the start of Phase Two, they enabled re-problematisation and re-interessement of the network around their technology choice. And by allowing actual design flexibility during Phase Two, they enabled the network to mobilize and stabilize.

We can also consider those who are black-boxed by technology projects; excluded from participation in technology design and choice, and allocated pre-determined scripts and roles. ANT in theory and the Sri Lanka case in practice demonstrate such exclusion may not be permanent, and that there exists a potential agency for almost all actors particularly if they, too, recognize the value of 'playing politics' within technology projects.

6.2 Summary

The application of ANT to understand technological processes in developing countries does pose challenges for development studies researchers. The issue of practical applicability may be worked around, but the methodological limitations must be worked within, and the analytical challenge must be worked with.

If these can be handled, ANT has shown the potential to open the black box of technological change processes and offer new insights: an understanding of how the networks associated with those processes come to be formed; an understanding of the active role played by technology in those processes; and an understanding of how interests and identities of various actors are translated during those processes.

The case study suggests ANT will not help answer questions about the impact of context on technological process, nor about the developmental impact (in the traditional sense) of technology. However, it may help to answer questions such as:
- How do we explain the trajectory of a technology and development project?
- How does a particular innovation in a developing country diffuse or scale-up or sink without trace?
- What role does technology play in processes of technological change?
- How does power manifest itself in such processes? How are apparently relatively-powerless actors sometimes able to influence the direction of technological change? How are apparently relatively-powerful actors sometimes not able to get their way on a technology project?

ANT's forte is 'situations where innovations proliferate, where group boundaries are uncertain, when the range of entities to be taken into account fluctuates' (Latour, 2005: 11). All these are seen in the case of the Sri Lankan financial technology, and in cases of technological change in developing countries more generally. They may become more prevalent – and ANT's relevance and utility may rise – as the technology used in development becomes more complex, more inter-connected, more intertwined into the lives and livelihoods of developing communities, and changing at an ever-faster pace.

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[i] As an example, the frequency of research articles with 'technolog*' in the title in *Journal of Development Studies* and *World Development* has been: 2000s (0.21 articles per issue); 1990s (0.50 per issue); 1980s (0.28 per issue); 1970s (0.42 per issue)

[ii] With growth in developing countries during the 1990s and 2000s seen in indicators including total numbers of research and development (R&D) personnel, gross expenditure on R&D as a share of GDP, real terms expenditure on agricultural R&D, and public access to information and communication technologies (Bientema and Stads, 2010; OECD, 2010; UNDP, 2010)

[iii] For example, of 45 research articles with 'technolog*' in the title published during 2000-2012 in *Journal of Development Studies* and *World Development*, only two – Veldwisch et al., 2009 and Shen 2010 – make any explicit reference to ideas from science and technology studies.

[iv] Including key authors who change their minds. Cf: 'there are four things that do not work with actor-network theory; the word actor, the word network, the word theory and the hyphen! Four nails in the coffin' (Latour, 1999: 23). 'I have to apologize for taking the exact opposite position here as the one taken in Bruno Latour (1999c) "On Recalling ANT" . Whereas at the time I criticized all the elements of his horrendous expression, including the hyphen, I will now defend all of them, *including* the hyphen!' (Latour, 2005: 9).