TECHNOLOGY DEBT: TOWARD A NEW THEORY OF TECHNOLOGY HERITAGE

Complete Research

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Abstract

Investment decisions related to information technology simultaneously constrain and facilitate prospective options. Hence, past and present decisions in relation to information technology investments impact future decisions and the maneuverability of organizational IT. The purpose of this paper is to develop and explore a new theory for better understanding how technology heritage impacts future decisions. The study expands a previous metaphor from software engineering and management (technical debt) into a broader theory of technology debt, and explores the proposed theory through the case of four investment decisions at a large, public university. As the findings show, there are clear indications of the theory being useful, and this is elaborated on in relation to future studies.

Keywords: Technology debt, technical debt, IT governance, IT management, debt

1 Introduction

Organizations today have a substantial amount of their IT resources tied up in what is commonly referred to as an ‘installed base’. This constitutes all previously developed and acquired systems and applications, the more infrastructural elements of IT such as networks, servers and storage, user communities and support functions. This installed base has been developed over time, added to and subtracted from in parallel with changes in management, governance and organization (Bygstad, 2010; Hanseth and Lyytinen, 2010; Tilson, Lyytinen and Sorensen, 2010).

While at the same time constituting the necessary infrastructure for value creation within the organization, this heritage also constrains the organization’s ability to adopt new technology through a variety of factors such as vendor lock-ins (Subramani, 2004), high switching costs (Witten, Chakrabarthy and Wakefield, 2010), substantial complexity (Hanseth and Lyytinen, 2010) and institutionalized mechanisms for coordination and control.

As previously noted in the literature on IT Governance, many CIOs are stuck in a position where the inherited technological base limits their actions and decisions (Kuk and Janssen, 2012; Chun and Mooney, 2009). With a constant pressure on the IT function for short-term efficiency and productivity (Xue, Ray and Sambamurthy, 2012; Guillimette and Paré, 2012), CIOs are often caught in a position where they need to continue down what may very well turn out to be a dead-end street.
In this paper we argue for a perspective where technology heritage is regarded as a metaphorical debt. This perspective builds on three assumptions. First, previous decisions within IT have created a situation where the organization is faced with a debt. Second, debt is associated with an obligation of repayment with interest, and in the case of technology management, interest is argued to be materialized in a limitation of manoeuvrability (Pita, Cheong and Corbitt, 2011). Third, debt is regarded in line with corporate finance theory as a necessary element of the corporate capital structure, and not something inherently negative (Merton, 1974).

This research draws on institutional theory, network economics and information infrastructure, and, expands the previous metaphor of technical debt from the literature surrounding software development and management. Within software development, debt has long been a metaphor for understanding software related aspects of faults and mismanagement, often related to agile programming methods such as SCRUM et cetera (Tom, Aurum and Widgen, 2013). As we argue, this perspective on debt can be expanded to encompass more aspects of how IT is managed. The objective of this study is to add to the theoretical body of knowledge on how technology heritage is conceptualized and to initiate a debate concerning how technological heritage impacts decisions. This is done through the development and exploration of a theory of Technology Debt. The central contribution of this study is a new proposed theory for the increased understanding of technology heritage.

2 Previous Research: Technology Heritage and the Bitter-sweetness of Past Decisions

The constraining aspect of technology has previously been addressed through three main research streams, as seen below.

2.1 Network economics

Research on technological infrastructures has shown that they can lead to increasing returns through positive feedback mechanisms (Arthur, 1994). One aspect of increasing returns is path dependency, which expresses that previous technological decisions, for instance standards and design, exert strong influence on later decisions. A famous example of path dependence is the qwerty standard, which is not optimal for today’s keyboards, but nevertheless used everywhere.

Path dependence is closely related to another phenomenon, namely lock-in (Shapiro and Varian, 1999). When a particular technology is adopted, it is also embedded in standards, contracts, user knowledge, technical integration and organizational routines, often making it prohibitively expensive and risky to change technology. Thus, high switching costs have become endemic to the IT sector.

2.2 Information infrastructure

The research on information infrastructures is concerned with the dynamics of large, sociotechnical systems (Hughes, 1983; Star and Ruhleder, 1996). An information infrastructure is defined as ‘a shared, open, heterogeneous and evolving socio-technical system (which we call the installed base), consisting of a set of IT capabilities and their user, operation and design communities’ (Hanseth and Lyytinen, 2010). As information infrastructures grow, its value for the stakeholder increases. However, the complexity of the structure also grows, both in terms of technology, but also in terms of information volumes (Kallinikos, 2006; 2011). This implies that the information infrastructure is not only a resource, but may also constitute the greatest hinder for organizational agility and innovation.
2.3 Institutional theory

Central to this theme is that individual action is shaped by shared systems of rules and resources that not only restrain capacity for alternative action but also the inclination to do so. Organizations find themselves constrained by a surrounding environment (DiMaggio and Powell, 1983) and past decisions (Sahlin-Andersson, 1996). In the IS field, insights into the regulative regime of technology is found in the works of researchers such as Orlikowski (2000) and Kallinikos (2011).

This latter line of reasoning have long highlighted the impacts of faltering in the strategic planning and governance of IT. Contingency studies within the field of IT Governance have long argued for specific settings for particular contexts, such as promoted by Ein-Dor and Segev (1992) and Banker et al (2011). While these studies have looked into issues of optimal fit between governance practices and the organizational needs, they have received substantial critique for oversimplifying the intricate interplay between IT and the organization (Sambamurthy and Zmud, 2000). In addition to this, we argue that they have also simplified and neglected the historical dimension; through not sufficiently taking into account the role technology heritage plays in the choice of governance settings. Within institutional theory, a specific stream of research has focused on what is referred to as institutional logic (Thornton, 2004; Suddaby and Greenwood, 2005, Lounsbury, 2008). Friedland and Alford (1991, p.248) summarize the concept through identifying the institutional logic of the state as ‘rationalization and the regulation of human activity’, and that of capitalism as ‘accumulation and the commodification of human activity’. In line with this, institutional logic is understood as the underlying logic of a particular institution (Lounsbury, 2008).

As this short review shows there is a substantial body of research concerned with the challenges of technical heritage related to future decisions. We believe, however, that this research should be extended with a stronger theoretical link to economics and finance theory.

2.4 Economics and Finance Theory

Within finance, debt has long been considered to be a central element of the corporate capital structure (Merton, 1974; Jensen and Meckling, 1976; Myers, 1984). Elliot and Elliot (2002) define debt as ‘an obligation owned by debtor to creditor’ with the expected repayment with interest. At the same time, it is the utilization of a future expected earning, i.e. a means through which the firm can secure future earnings. In balance sheet terms, debt is a category of liabilities, which should be matched by assets. Debt is acquired through loans of various forms, which are often associated with an interest rate and hence an operating cost in terms of interest on the loan (Modigliani and Miller, 1958). In terms of settling the debt, the firm can use mechanisms such as amortization plans (Gibbard and Stevens, 2011). In handling the corresponding asset, this is often depreciated over a set period of time, in order to periodize the value of the asset (Carnegie and Napier, 1996).

According to Elliot and Elliot (2002) there are a number of different reasons for a firm acquiring debt. These reasons include solving temporary cash flow problems, lowering costs, fiscal advantages, income gearing, timing and dilution of voting power. With debt being a central concept within finance, numerous examples of theoretical models for better understanding and managing it. Notable examples of theoretical approaches to understanding debt include the work of Fisher (1933 and Greenwood, Hansen and Stein (2010) to name but a few.

3 Method

We conducted our investigation in two steps; first we developed our key concepts, then we explored and assessed the concepts in a practical setting.
Since this paper aims to develop and apply a new construct (technology debt), the initial phase of research consisted of a structured literature review of the appending fields. After going through literature related to technical debt, technology heritage and financial accounting in relation to debt, the identified components were combined to form the basis for the new construct. Following inspiration from Guimmette and Paré (2012), the approach is inductive and informed by the grounded theory perspective, searching for theories that fit what Gregor (2006) would describe as ‘Type IV’, since they focus on describing theoretical constructs and their inter-relationships. After identifying the theoretical constructs and their inter-relationships (the process model), we moved on to creating typological theory (Doty and Glick, 1994), to further decompose the overarching theoretical construct of technology debt and increase our understanding of its possible composition. The typology was created through a structured literature review where instances of debt were combined to categories following inspiration from grounded theory.

As noted in the introduction, the outset of this theoretical development is found within the metaphor of technical debt as portrayed in the software engineering and management literature (Tom, Aurum and Widgen, 2013). Metaphors, like that of Technical debt, have long been considered valuable tropes in research (Lakoff and Johnson, 1980; Morgan, 1983;). In parallel with being regarded as of value for research, they have also been criticized for not being controllable enough for science, particularly when it comes to the value for practitioners (Pinder and Bourgeois, 1983). Putting this debate aside, we argue for the necessity of moving from metaphor to concept and theory in relation to technology debt. The value of a metaphor lies in its linking of different fields to a single instance (Bateson, 1973), and is considered a first step towards a model valuable for research. Through linking the fields of economics and finance with that of IS, we argue that a further operationalization of the metaphor is necessary.

After developing the theory a case study was conducted, in order to explore the concept in a practical setting, and to develop the specifics of the theory. The criterion used in selecting the case was complete and instantaneous access, with a conflict (in the form of a new initiative that spurred the necessity to take the heritage into account) as the main identifying mark. The case was selected on the premise of it being a situation where we had direct access to all material that was considered relevant, i.e. a selection of convenience.

The data collection involved re-occurring, unstructured interviews with the former CIO (four interviews), the CTO (two interviews), and, other individuals involved in the management of IT (Chief Architect, Data warehouse manager and Database manager) and three senior individuals with a long tenure within the organization. None of the interviews were sound-recorded due to the high level of sensitivity involved in the research, and instead the researcher was limited to taking notes. In addition to this, a total of 36 steering documents and previous audit reports for the past 12 years were collected. The data collection was conducted during a period of three months, after initially securing access from the CTO (since the CIO position was vacant and the CTO being first in command).

The case analysis and validation of the theory was conducted through going through the collected material, identifying and describing four shifts in institutional logic between the years 2004 and 2011. These shifts were accredited to four particular investment decisions and analysed through the application of the proposed theory of Technology Debt. Albeit this is not by any means a full test of the theory, we see the need for an initial exploration of the theory in an empirical setting before theory testing is possible.
4 Theory Development

4.1 Enter the Concept of Technology Debt

With the previously reviewed findings from the study of technology heritage, information infrastructures and economic theory, we propose the introduction of a new concept to approach the constraining aspects related to technology heritage. This concept is coined ‘Technology Debt’, and this section will be devoted to presenting the cornerstones of our reasoning, along with a working definition of the concept, a process model and a typology.

There are four assumptions underlying the proposed theory:

1. Debt is accumulated over time as a consequence of decisions (Merton, 1974).
2. Debt is associated with a cost of interest (Modigliani and Miller, 1958).
3. The cost of interest and the total amount of debt influences prospective decisions, through limiting the amount of funds available (Modigliani and Miller, 1963).
4. Debt is a necessary element of the capital structure of the firm (Jensen and Meckling, 1976).

Following these four assumptions, we argue that the IT function of a firm has its own particular form of debt, i.e. technology debt. This debt is in the same manner as assumption #4 a necessary element of the IT functions capital structure, yet in line with assumption #2 it is associated with a cost of interest. This interest is manifested in the decrease in potential prospective decisions, through delimiting the amount of available funds (assumption #3) in the wider notion of the term. Each decision made by the IT function will lead to an increase or a decrease in the debt and consequent cost of interest.

Technology debt is defined as:

- Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions.

We define the (interest) cost of technology debt as:

- Cost consisting of a decrease in maneuverability in future options.

Based on these definitions, we regard the acquiring of debt by the current CIO as a means for aspiring opportunities necessary at the time, at the cost of future decreases in maneuverability.

4.2 Enter the Process of Technology Debt

The process model that we propose as a means for studying technology debt focuses on the ex-ante and ex-post of the investment decision.
Technology Debt

1. In line with our institutional perspective, there are three main factors impacting the investment decision. First, the institutional heritage (‘Technology past’), constituted by the history of the organization and the fads and fashions in the surrounding environment. Second, the presently dominating institutional logic (‘Technology future’) of the organization and third, the installed base (‘Technology present’) comprised on the existing infrastructure and all its necessary supporting resources and processes.

2. The investment decision impacts technology debt through an increase and/or decrease of the debt. The increase is in the form of ‘loans’ where the investment leads to decreased maneuverability. The decrease is in the form of ‘amortizations’, where the investment leads to increased maneuverability. Loan and Amortization is treated as metaphorical.

3. Technology debt is manifested in both a direct cost associated to constrained maneuverability (‘cost of interest’), and, a recursive impact on the three main factors preceding the investment decision (1). The impact on institutional heritage is in forms such as a negative perception of the IT organizations ability to deliver. The impact on institutional logic is in forms such as necessary strategic changes pertaining to previous failures, and the impact on technology heritage is in forms such as increases in complexity of the installed base.

We use the example of an ERP investment decision by a medium-sized enterprise, guided by previous findings from research. The Institutional heritage consists of a perception of IT as a supporting function, and a discontent with the existing quality of service of IT. The institutional logic consists of a strategic intent of standardization and consolidation, and the technology heritage consists of a highly pluralistic flora of internally developed systems. The investment decision may have effects that both increases and decreases the maneuverability of the organization. The increase in maneuverability (‘Amortization’) consists of e.g. replacing a substantial portion of the existing systems with one new ERP. The decrease in maneuverability (‘Loan’) consists of e.g. the lock-in effects from going with one particular ERP vendor, the substantial size of the investment, and the strain that the implementation is expected to have on the organization. Evaluating the increase versus decrease in maneuverability for said organization means to assess the effects for the technology debt balance, i.e. a cost of decreased maneuverability (‘cost of interest’). At the same time, the technology debt is allocated back to the three pre-requisites for the investment decision itself. Institutional heritage now encompasses a first experience of ERP implementation, along with experiences of vendor lock-in and the perception of IT.
as costly. Institutional logic shifts to pluralism and freedom of choice, and, technology heritage experiences an increase in complexity through the investment not succeeding in replacing the existing systems but merely adding an additional system. All of these factors influence the prospective investment decisions.

4.3 Enter the Typology of Technology Debt

We will now devote attention to addressing the different types of technology debt found in literature in order to create a structure of different types. Given the abstract notions of the various forms of debt, we present a typology of the types of debt found in previous research in Figure 2.

As seen in Figure 2, there are three areas of technology debt as identified in the literature. ‘Staff’ refers to debt directly related to the workers of the IT function. ‘Users’ refers to debt directly related to the customers and/or users of the IT function, i.e. both firm internal and potential inter-organizational partners provisioned by the IT function. ‘Systems’ refer to debt directly related to the technological content and its governance context.

To summarize, the proposed theory of technology heritage consists of a definition of the concept of Technology Debt, a process model, and, a typology. This theory will now be explored through the case presented below.

<table>
<thead>
<tr>
<th>Technology Debt</th>
<th>Ideology</th>
<th>Staff</th>
<th>IT staff pro-adoption bias for particular brands/types of technology, e.g. Microsoft versus Linux/Unix, resulting in sub-optimal path dependencies in technology options.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Competence</td>
<td>Users</td>
<td>Detrimental patterns in the competence profiles of the IT staff, resulting in sub-optimal path dependencies in recruitment.</td>
</tr>
<tr>
<td></td>
<td>Working environment</td>
<td>Users</td>
<td>Sub-optimal working environment for IT staff, resulting in increased difficulty in attracting new competence and an increased staff turnover.</td>
</tr>
<tr>
<td></td>
<td>User satisfaction</td>
<td>Users</td>
<td>Negative perceptions among the users in terms of actual and expected usability of current/future systems, resulting in low level of usage.</td>
</tr>
<tr>
<td></td>
<td>Reputation</td>
<td>Users</td>
<td>Negative perceptions among the internal customers/users related to fulfillment of service levels for IT, resulting in low level of trust and requests/demands.</td>
</tr>
<tr>
<td></td>
<td>Infrastructure</td>
<td>Systems</td>
<td>Negative implications of current infrastructure in terms of quality, redundancy, adaptability, interoperability and safety. Resulting in lock in and redundant costs.</td>
</tr>
<tr>
<td></td>
<td>Shadow IT</td>
<td>Systems</td>
<td>Negative aspects of decentralized investments and user-driven innovation handled as operating expense, resulting in loss of synergies and control.</td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td>Systems</td>
<td>Amassed code that is detrimental for future development through high levels of errors and low degree of documentation, resulting in high maintenance costs.</td>
</tr>
<tr>
<td></td>
<td>Governance</td>
<td>Systems</td>
<td>Bias in existing versus optimal governance: structures, compliance, processes and relational mechanisms, resulting in sub-optimal governance.</td>
</tr>
</tbody>
</table>

Figure 2. The typology of Technology Debt
5 Theory exploration: Technology Debt at a Large Public University

The University (henceforth referred to as ‘University X’) is one of northern Europe’s largest universities with over 40,000 students and a faculty of 6,000. University X was founded in the beginning of the 20th century, making it fairly young in relation to Sweden’s other major universities. The Swedish university system is highly regulated, with the bulk of funding coming directly from the state. The annual turnover is €550 Million.

In terms of IT, the total spending in 2011 was €16 Million (an increase from €4M in 2000), and the university organizes its IT resources in two main sections. First, there is the ‘Strategic IT Department’, with responsibility for the strategic planning of operations. This section employs some 10 individuals in roles such as CIO, Enterprise Architect et cetera. Second, the ‘IT Delivery Department’ has responsibility over the operational work related to IT, such as end-user support, software development, integration and database maintenance. This section employs some 120 individuals in roles such as Key Account Manager, CTO, Solution Architect etc. The set-up follows a centralized, demand-supply model of operations with a portfolio of services, and the key elements of the IT strategy are currently consolidation and standardization. IT is funded through overhead allocations, yet there is a strive towards the use of direct charge-back per service.

This current IT organization at the University has been in place following a major re-organization in 2008. Before that, the organization was highly decentralized, with each university section and department having their own systems, IT employees et cetera. Moving back even further, the university had attempted and failed a major centralization initiative during the 1980’s. The case below depicts the evolution from the year 2004 up until the current date. Through presenting the case, we aim at to analyse the initiatives, directions sought and effects in terms of technology debt that have surfaced throughout these years.

In 2000, information technology was almost entirely decentralized within the university. With eight geographically dispersed faculties, this implied that IT was organized on a central, faculty, and department level. The reason for this type of an organization was primarily based on negative perception towards central organization of support functions. Previous experience of centralized IT was highly negative, and there was also a discourse of consonance logic where the organization of supporting functions should match the overall organization.

Direct effects of this high level of decentralization could be seen in both systems such as e-mail, directories et cetera, and, infrastructure with e.g. an aversive attitude towards shielding the university network with one, centrally located firewall.

One direct consequence of this was, as previously noted, redundant full stacks for each faculty (and in some cases even departments), which resulted in both increased spending and high integration costs in cases where integrated solutions were sought between the organizational entities. To counteract these negative implications of the current organization and governance of IT, a chain of investment decisions were undertaken between 2003-2012, as seen below. These decisions will be used as the basic fundament for our exploration of the technology debt of University X.

**Investment decision 1: Standardization (2003)**

By 2003, there was a growing despair within both IT and the business side concerning costs and long development cycles. As a response to this, the central IT department (50 employees) developed an IT strategy based on standardization and consolidation. The aim was to select and adhere to one (or a few) standard platforms for the ‘bread and butter’ functionality that could be regarded as university wide, such as e-mail, extranet, collaboration portals et cetera. The decision to invest in a suite from Oracle was made on what would later be described as ‘rather shaky grounds’. Underlying this decision
was an explicit unwillingness to for instance considering Microsoft’s platform, which by many of the IT professionals was regarded as a ‘tenant of evil’.

**Investment decision 2: Centralization (2008)**

The new platform created quite a stir, and after four years it was finally abandoned due to high integration costs and issues related to severe downtime. During this period, the organization went through a strong centralization initiative (2008), once more creating a centralized IT function. This IT function was divided into two main organizations, one for IT strategy (Office of the CIO, 10 people) and one for IT delivery (Office of the CTO, 120 people). This massive increase in employees was facilitated through expropriating the systems, technology and people that were previously decentralized. The objective was to create a clear supplier-customer relationship, with formalized interfaces between the demand and supply through individuals assigned to roles of Key Account Managers, and transparent procedures and processes for handling the communication of demands.

**Investment decision 3: Externalization (2009)**

This strong centralization created the bedrock for a chiasm between the CIO and CTO functions, with both organizations and their respective managers being placed on the same hierarchic level. Without any clear definition of roles or responsibilities, and with equal authority, these two functions started to act independently. One of the consequences of this independence was seen in 2009 when a surge of outsourcing was initiated. After initially outsourcing the email system and storage facilities, it soon became clear that the relationship between the two functions was less than optimal, and detrimental coordination effects started to appear in the form of miscommunication and misdirection. Since the outsourcing initiatives were not communicated beforehand to the IT Delivery function by the IT strategy function, it added to the previously strained relationship, and created a feeling of peril for loosing their jobs among some of the IT Delivery staff.

**Investment decision 4: Concentration (2012)**

By 2012, the CIO left the organization as a result of the conflict between the IT strategy and the IT delivery functions. In conjunction with this, a previously conceived but not effectuated initiative to supply the organization with standardized workstations was implemented. This initiative involved the creation of a totally new environment, acting in parallel with the existing environment but built primarily on open standards (moving away from the previous tendency for choosing proprietary solutions). At the same time, the decision was made to move towards a ‘Competence Center’ approach of organizing critical competencies related to the new environment, integration and a new business intelligence solution that was being implemented.

Shifting the focus from the previous pluralistic environment to the new, homogenized environment together with a pooling of resources into competence centres is seen as an act of concentration. By 2013, a total of 50% of all the users had been moved to the new environment, and the competence centres were becoming operational.

**Summary of Technology Debt at University X**

On the basis of these four initiatives, we have utilized the technology debt typology to identify technology debt categories in the case, along with the impact on the level of debt (loans versus amortizations). This is presented in Table 1, with the identified instances of changes in the particular type of debt for each investment decision. Increases in debt (loans) are marked as bold and the cells filled, whereas decreases in debt (amortization) are in regular text and not filled cells.
6 Discussion

In this paper, we have proposed a new theory for increasing our understanding of the constraining aspects of technology heritage, and how past decisions related to technology investments impact the maneuverability of future decisions. We have done so through developing the theory of Technology Debt, through a definition of the concept, a process model and a typology, and then exploring it through a case study of a large, public university’s past investment decisions.

As seen in Table 1, certain patterns of debt acquisition become visible when the theory is applied to the case. First, we see that since 2004, two types of technology debt stand out in terms of consequently involving loans or amortizations. In terms of loans, the four investment decisions have all involved loans related to the working environment for the IT workers of the university. At the other end of this spectrum, the reputation of the IT organization has solely included amortizations of debt. To put it bluntly, this could be seen as an indication of the IT organization borrowing from itself, in order to decrease the level of debt to the overarching organization. The choices of technology have since 2004 all been considered legitimate through being in tune with the surrounding norms and practices (Ashforth and Gibbs, 1990). Despite this acceptance from the users (or perhaps as a result of it), there was an increase in shadow IT through cloud services for e.g. storage and collaboration, a debt that is manifested in the Systems category.

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</thead>
<tbody>
<tr>
<td>Ideology</td>
<td>Open Source Software bias</td>
<td>Pooling of staff created increased interaction</td>
<td>Split between supporters and non-supporters</td>
<td>Split between supporters and non-supporters</td>
<td></td>
</tr>
<tr>
<td>Competence</td>
<td>Lack of competence</td>
<td>Pooling of staff created overview</td>
<td>Lack of competence on procurement</td>
<td>Difficulty in attracting niche competence</td>
<td></td>
</tr>
<tr>
<td>Working environment</td>
<td>Loss of control due to lack of competence</td>
<td>Re-organization and forced move of employees</td>
<td>Fear of downsizing</td>
<td>Creation of an A and B team</td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Reduced up-time</td>
<td>New systems replaced old without quality assurance</td>
<td>Increased quality of service</td>
<td>High Quality of Service in new environment</td>
<td></td>
</tr>
<tr>
<td>Reputation</td>
<td>Single solution was perceived as legitimate</td>
<td>Centralization was perceived as legitimate</td>
<td>Outsourcing perceived as legitimate</td>
<td>New environment perceived as legitimate</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Single instance on standardized platform</td>
<td>Increased complexity</td>
<td>Increased complexity due to inability to cater to external providers requirements</td>
<td>Decreased complexity due to functional separation and loose-coupling</td>
<td></td>
</tr>
<tr>
<td>Shadow IT</td>
<td>Envelopment of existing solutions, single system policy</td>
<td>Un-acceptance of central investment routines</td>
<td>Increase of use of cloud services as complements</td>
<td>New environment does not provide full support for research</td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td>Low quality in integrations</td>
<td>Control</td>
<td>Adoption to external parties resulting in inter-dependencies</td>
<td>Strong focus on control and order in development</td>
<td></td>
</tr>
<tr>
<td>Governance</td>
<td>Bias between policy and practice</td>
<td>New policy of centralization in place</td>
<td>No clear policy in place</td>
<td>No clear policy in place</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Changes (amortizations and loans, loans embossed) in technology debt

Simplifying the analysis into the three categories of debt (Staff, Users and Systems) along with the assessment of amortization and loans using Boolean logic (Amortization/Loan = 1 or 0), we see the distribution of debt in a new light. Staff has a balance of 4 loans, Users a balance of 4 amortizations and Systems a balance of 4 loans, implying that Users and Systems display a net increase in debt during the analysed time-frame. This creates a total of 14 amortizations versus 22 loans, a balance of 8
loans, i.e. an increase of technology debt between 2004 and 2011. Despite the obvious shortcomings of such an over-simplification, it raises questions into how technology debt may be employed in the management of IT. Given the assumed impact of past decisions on future decisions, each decision holds with it the possibility of either increasing or decreasing technology debt. At the same time, IT Management should be aware of who the creditor actually is. In terms of increasing the technology debt in the category of Staff, this would likely correspond to a particular decrease in manoeuvrability related to instances where Staff is a key resource. At the same time, an increase in technology debt in the categories Users and Systems would imply a particular decrease in manoeuvrability where Users and Systems are a key resource. Hence, managers are likely to have to manage the distribution of debt between the different categories and types, so as to avoid unbalanced distribution detrimental to future performance.

6.1 Contribution and future research

Our study offers three main contributions for research. First, the proposed theory adds to the current body of theories addressing issues related to technology heritage. In line with previous research within information infrastructures (Hughes, 1983; Hanseth and Lyttinen, 2010; Kallinikos, 2006), network economics (Arthur, 1994; Shapiro and Varian, 1999; Liebowitz, and Margolis, 1995) and institutional theory (DiMaggio and Powell, 1983; Sahlin-Andersson, 1996), this proposed theory offers the possibility of a complement to the existing theories. Issues that fall within the realm of the feasible areas of application for the theory include investment patterns, technological shifts in the installed base, predictions of implementation success, shifts in investment behaviour et cetera. Second, through both the process model and the typology, the proposed theory helps us to better understand the attributes of technology debt itself. Provided that technology debt is coupled with negative consequences for the organization and/or manager, the amassment of debt becomes a process that should be better understood and focused on within research.

Albeit being in an early stage of theory development, we see three central contributions for practice. First, the typology of technological debt offers the CIO (or equivalent) a practical method for assessing the consequences of a given decision. In line with developments within real-options theory, the typology could serve as a method for decomposing the negative implications of various technology options. Second, with the CIO being under current pressure of a rapid return on investment, the concept of technology debt form a valuable means for raising and communicating questions related the negative impacts of particular choices in technology. Hence, the theory could aid CIOs in situations where they are pushed to promote a project with swifter payback despite obvious (to the CIO) drawbacks in the long-term. Third, the typology offers managers involved in investment decisions related to IT a possible means for assessing the consequences of an uneven distribution of debt, something that over time may prove detrimental to the power-distribution between business and IT.

Forth, with the theory focusing on the relationship between past and future decisions, this could be utilized for purposes where the current status of IT in a particular firm needs to be assessed. Involving aspects of technology debt could hence support both IT audit work related to due diligence in mergers and acquisitions, as well as offering CIOs considering taking a new position with a practical means of assessing the situation.

We see three future projects as viable given this first proposal of the concept of technology debt. First, with this being the first study focusing on developing a theory of Technology Debt, we see the necessity of a more thorough and rigid testing of the theory as directly necessary. The exploration provided in this paper is a first step towards a full test of the theory. At present, we are conducting four more case studies within varying settings in both the public- and private sector. Second, we see the need for studies directed towards establishing calculative practices associated with the monetary cost of technology debt, operationalizing the different types of technology debt, together with visualizations that support decision-making. This also includes studies of optimal capital structures
given Technology debt. A third valuable project would be an investigation into coping strategies among CIOs and other IT executives.

References


