

## Editorial for the Special ECIME Edition of EJISE – ECIME2014

It is tradition that the Electronic Journal of Information Systems Evaluation (EJISE) publish a special issue containing the full versions of the best papers that were presented in a preliminary version during the 8<sup>th</sup> European Conference on Information Management and Evaluation (ECIME 2014). The faculty of Economics and Business Administration of the Ghent University was host for this successful conference on 11-12<sup>th</sup> of September 2014. ECIME 2014 received a submission of 86 abstracts and after the double-blind peer review process, thirty one academic research papers, nine PhD research papers, one master research paper and four work-in-progress papers were accepted and selected for presentation. ECIME 2014 hosted academics from twenty-two nationalities, amongst them: Australia, Belgium, Bosnia and Herzegovina, Brazil, Finland, France, Greece, Ireland, Lebanon, Lithuania, Macedonia (FYROM), Norway, Portugal, Romania, Russia, South Africa, South Korea, Spain, Sweden, The Netherlands, Turkey and the UK. From the thirty-one academic papers presented during the conference nine papers were selected for inclusion in this special issue of EJISE. The selected papers represent empirical work as well as theoretical research on the broad topic of management and evaluation of information systems. The papers show a wide variety of perspectives to deal with the problem.

Devos and Van De Ginste work on the COBIT 5 framework released in 2012 by ISACA. COBIT 5 can be seen as a de facto framework for IT governance. Although COBIT 5 is well accepted in a broad range of IS communities, it is created by practitioners and holds only a minor amount of theoretical supported claims. The authors try to offer theoretical fundamentals for this framework. The authors followed a qualitative research method to develop inductively derived theoretical statements. Their findings indicate that COBIT 5 holds theoretical supported claims, but only lower theory types such as Principal Agent Theory and Stakeholder Theory contribute the most. The Technological Acceptance Model contributes lesser than the previous ones as a theoretical fundament for the framework.

Dobrev and Hart deal with real-time BI systems (RTBI) and try to shed light on the technological components and the organizational changes surrounding RTBI systems. They used a qualitative thematic analysis based on data obtained through semi-structured in-depth interviews in organisations in several industries. They found that RTBI can offer significant and measurable improvements, help organizations remain competitive, and in de long run drive strategic business objectives. A roadmap for RTBI justification and implementation is suggested.

Myreteg conducted a literature overview on organizational learning in the context of ERP systems. The author gives an answer to what extent and how do research conceptualize organizational learning and its interactions and involvement with the ERP system. The analysis shows that overall there is a lack of definitions and stringency in the research on organizational learning in an ERP systems context in the post implementation phase.

Nechkoska et al. present a study on the Tactical Management as a distinctive managerial function in information systems. They conducted a research of the literature and investigated current types of managerial information systems in order to evaluate the various manners tactical management is addressed. The purpose of the research is to attract attention to tactical management, its importance that it can bring substantial competitive advantage to the businesses, and the incremental potential that tactical management will realize when being accordingly supported by the information systems of tomorrow.

Nicolian et al. conducted structured interviews with the CIOs of 36 medium and large size Lebanese organisation to discover the perceived value of IT and the organisational competencies needed to deliver that value. They discovered challenges that point the need of process orientated competencies and challenges that are variance oriented and point to the factors that inhibit or enable deriving IT value. The authors have chosen for a Hybrid model for explaining the IT value proposition.

Serova and Krichevsky provides theoretical foundations of information systems architecture of management systems in the context of spatial economics. The paper is devoted to the study of issues of stability of architecture of spatial information systems.

Thomson and van Belle identify the antecedents for the adoption of Green IT in South African higher education institutions, namely which drivers and readiness factors influence Green IT adoption. Also they investigated the role of the following Green IT readiness factors: institutional, organisational and value network Green IT. All Green IT drivers were found to be significant antecedents in the adoption of green IT, although the overall adoption of green IT is relatively low. They condensed these antecedents into a revised Green IT adoption model.

Van Bussel et al. has developed a Green Archiving Model to reduce the amount of stored data and records in organizations based on the 'value' of information. The model can not only be used to reduce the amount of data, but also the electricity consumption for data storage, resulting in a cost reduction of 35 percent.

Van de Pas and van Bussel present an explorative study of the extent to which privacy enhancing technologies could be effective in providing privacy to citizens. They conclude that privacy compliance in the 'technological' sense cannot meet citizens' concerns completely, and should therefore be augmented by a conceptual model to make privacy impact assessments at the level of citizens' lives possible.

**Prof. dr. ir. J.G. Devos**

Ghent University

Faculty of Architecture and Engineering, and Faculty of Economics and Business Administration

Belgium



# Towards a Theoretical Foundation of IT Governance – The COBIT 5 case

Jan Devos and Kevin Van de Ginste  
Ghent University, Campus Kortrijk, Belgium

[jang.devos@ugent.be](mailto:jang.devos@ugent.be)

[kevin.vandeginste@ugent.be](mailto:kevin.vandeginste@ugent.be)

**Abstract:** COBIT, (Control Objectives for Information and Information related Technologies) as an IT governance framework is well-known in IS practitioners communities. It would impair the virtues of COBIT to present it only as an IT governance framework. COBIT analyses the complete IS function and offers descriptive and normative support to manage, govern and audit IT in organizations. Although the framework is well accepted in a broad range of IS communities, it is created by practitioners and therefore it holds only a minor amount of theoretical supported claims. Thus critic rises from the academic community. This work contains research focusing on the theoretical fundamentals of the ISACA framework, COBIT 5 released in 2012. We implemented a reverse engineering work and tried to elucidate as much as possible propositions from COBIT 5 as an empiricism. We followed a qualitative research method to develop inductively derived theoretical statements. However our approach differs from the original work on grounded theory by Glaser and Strauss (1967) since we started from a general idea where to begin and we made conceptual descriptions of the empirical statements. So our data was only restructured to reveal theoretical findings. We looked at three candidate theories: 1) Stakeholder Theory (SHT), 2) Principal Agent Theory (PAT), and 3) Technology Acceptance Model (TAM). These three theories are categorized and from each theory, several testable propositions were deduced. We considered the five COBIT 5 principles, five processes (APO13, BAI06, DSS05, MEA03 and EDM03) mainly situated in the area of IS security and four IT-related goals (IT01, IT07, IT10 and IT16). The choice of the processes and IT-related goals are based on an experienced knowledge of COBIT as well of the theories. We constructed a mapping table to find matching patterns. The mapping was done separately by several individuals to increase the internal validity. Our findings indicate that COBIT 5 holds theoretical supported claims. The lower theory types such as PAT and SHT contribute the most. The presence and contribution of a theory is significantly constituted by IT-related goals as compared to the processes. We also make some suggestions for further research. First of all, the work has to be extended to all COBIT 5 processes and IT-related goals. This effort is currently going on. Next we ponder the question what other theories could be considered as candidates for this theoretical reverse engineering labour? During our work we listed already some theories with good potential. Our used pattern matching process can also be refined by bringing in other assessment models. Finally an alternative and more theoretic framework could be designed by using design science research methods and starting with the most relevant IS theories. That could lead to a new IT artefact that eventually could be reconciled with COBIT 5.

**Keywords:** IT governance, COBIT 5, stakeholder theory, principal agent theory, TAM

## 1. Introduction

It has been found that firms with effective IT governance generate 40% higher returns on their IT investments than their competitors (Weill and Ross, 2004). Weill and Ross (2004) define IT governance as specifying the decision rights and accountability framework to encourage desirable behaviour in using IT. IT governance is to distinguished from IT management, in that IT management is the daily decision making and implementation activities around the firm's use of IT. Governance identifies who will make key IT decisions and how will they be held accountable. Good governance is enabling and reduces bureaucracy and dysfunctional politics by formalizing organizational learning and thus avoiding the trap of making the same mistakes over and over again. In that perspective IT governance is also strongly related to the well-researched domain of IT/IS failures.

According to the IT Governance Institute, IT governance is the responsibility of the board of directors and executive management. It is an integral part of enterprise governance and consists of the leadership and organizational structures and processes that ensure that the organization's IT sustains and extends the organization's strategies and objectives. IT governance is a concept that has been evolving rapidly over the last few years, especially in practitioners' communities. The IT Governance Institute is taking a leading role in the debate (ISACA, 2012a). Practitioners tend to see value of IT governance as the contribution to business performance and try to measure this contribution in terms of firm profitability, since this can be easily expressed in monetary units. Large public enterprises, with their natural propensity to control all business processes and to reduce risks and costs, heavily support this governance approach.

COBIT, as an IT governance, management and audit framework is well-known in IS practitioners communities (ISACA 2012a). It would impair the virtues of COBIT to present it as a framework as such. COBIT analyses and describes the complete IS function and offers normative support to manage, govern and audit IT in organizations (Kerr and Murthy 2013). COBIT is even used in academic programs for learning graduate students the principles of governing IT in organisations (Alves et al. 2012, Cabukovski and Tusevski 2011).

This may sound a bit awkward, but IT academics often lag behind IT practitioners with the description, explanation and predicting of IT phenomenon's. The latter cannot always wait for good normative theories to build IT artefact's. Both communities have of course their own objectives and ways of working. Working with IT to build and implement information systems (IS) however is certainly not straightforward and a lot failures often darkens the blue skies predicted by IT suppliers and vendors (Avison et al. 2006, Conboy 2010, Dwivedi et al. 2013). On the other hand information systems are enablers for conducting a business today. In many industries, survival and even existence is challenging without extensive use of information and communication technology. No longer can we imagine going to work and conducting businesses without IT/IS (Laudon et al. 2012). In a world of cutting-edge product development, the struggle between speed and quality is over. Speed has won decisively. In today's highly competitive global markets, getting innovations out quickly can mean the difference between success and failure (Cross 2011).

Although the COBIT framework is well accepted in a broad range of IS communities, it is created by and for practitioners and therefore it holds only a minor amount of firm theoretical supported claims. Thus critic rises from the academic community (Ridley et al. 2008, Goldschmidt et al. 2009, Choi and Yoo 2009, Chen and Shen 2010). The quest for theoretical underpinnings is not only a pure academic matter or an art pour l'art exercise, but can contribute to problems also raised by IT practitioners about COBIT. The main critic coming from this front is the huge amount of very complex descriptive guidelines and the strong accent on conceptual objectives. The 'what' is clearly specified but not so much the 'how'. This is good for IT auditors and risk managers, but clearly not so for IT managers and consultants. The authors of COBIT are well aware of these issues and have already anticipated within COBIT with the implementation of the Single Integrated Framework concept.

We agree with King and Lyytinen (2004) that theory is an input to a process of getting strong results, not an outcome. However the importance of IT/IS for organisations and society and the ever larger growing group of IS practitioners has much to gain in researched based educational programs strongly grounded in theoretical foundations. We asked ourselves if COBIT does have clearly theoretical foundations that can support some of the claims made in the framework. We focused on the process model of COBIT as well as on the principles and IT-related goals. This work is of value to strengthen a well spread practitioners framework with the rigor of a scholarly work albeit that the course of the trajectory, first the theory and then the practice is here just the opposite. However, there is no evidence that the large group of COBIT authors, reviewers and contributors should not have done an excellent job and certainly made a practical and pragmatic contribution to the IT/IS field.

So to say, we implemented a reverse engineering work and try to elucidate as much as possible propositions from COBIT as an empiricism. We followed a qualitative research method to develop an inductively derived theoretical framework. However our approach differs from the originally work on grounded theory by Glaser and Strauss (1967) since we have a general idea of where to begin and we made conceptual descriptions of the empirical statements in COBIT. So our data was only restructured to reveal theoretical findings.

The paper proceeds as follows: in section two we elaborate on the COBIT framework. In section three we make a suggestion of candidate theories and give a classification of the chosen theories according to the method of Gregor (2006). Section four describes our research method and in section five we bring a discussion of our findings. In section six we make our conclusion and give some recommendations for further research and some suggestions for refining our method of investigation.

## **2. The COBIT 5 framework**

COBIT dates back to 1996 and was originated as an IT audit framework. In 2012 a new version of COBIT 5 was released (ISACA 2012a). In the rest of the paper we will use COBIT, however we did our investigation entirely with COBIT 5. As stated before COBIT is a business framework for the governance and management of

enterprise IT and is almost entirely made by IT practitioners with an appetite for IT in larger organisations, mostly in banking, insurance and consultancy. COBIT is not a scholarly work. There were academics involved in the work of establishing the framework, but there is to the best of my knowledge no theoretical work done on the many claims in COBIT.

COBIT provides a framework that supports enterprises in achieving their objectives for the governance and management of enterprise IT. COBIT is based on five key principles that embodies these objectives and enables the enterprise to build an effective governance and management framework that optimises IT investments and use for the benefit of stakeholders (ISACA 2012a). Table 1 gives an overview of the five key principles of COBIT.

**Table 1:** The five key principles of COBIT

1: Meeting Stakeholder Needs
2. Covering the Enterprise End-to-end
3. Applying a Single, Integrated Framework
4. Enabling a Holistic Approach
5. Separating Governance From Management

Although the authors of COBIT posit that COBIT is not prescriptive, it suggest a process approach for the implementation of the framework, the COBIT Process Model (ISACA 2012b). Processes are seen as enablers or factors that, individually and collectively, influence whether something will work for IT governance or management. COBIT suggests that enablers (and thus processes) are driven by a goal cascade, i.e. higher-level IT-related goals define what the different enablers should achieve (ISACA 2012b). There are seven categories of enablers in COBIT: 1) principles, policies and frameworks, 2) processes, 3) organizational structures, 4) culture, ethics and behaviour, 5) information, 6) services, infrastructure and applications, and 7) people, skills and competencies. In this work we limited our investigation to the processes. COBIT defines a process as ‘a collection of practices influenced by the enterprise’s policies and procedures that takes inputs from a number of sources (including other processes), manipulates the inputs and produces outputs (e.g. products, services)’ (ISACA 2012a).

There are generic processes for IT governance as well as for IT management. The structural overview and consistency of the processes aims at an alignment between the business and IT (De Haes and Van Grembergen 2010). COBIT is a structure of 37 processes divided in five domains. One domain is IT governance, the other four domains are IT management domains. Each process of COBIT has input, output, goals, key process activities, metrics, sub processes and related references. Table 2 gives the five domains of the COBIT processes.

**Table 2:** Overview of the COBIT domains

Domain	Type of Domain	Number of processes
Evaluate, Direct and Monitor (EDM)	Governance	5
Align, Plan and Organize (APO)	Management	13
Build, Acquire and Implement (BAI)	Management	10
Deliver, Service and Support (DSS)	Management	6
Monitor, Evaluate and Assess (MEA)	Management	3

### 3. The chosen IS theories

The choice for candidate theories was based on the work of Truex et al. (2006) that gives four recommendations: 1) considering the fit between selected theory and phenomenon of interest, 2) considering the historical context of the theory, 3) considering how the theory impacts the choice of research method, and 4) considering the contribution of theorizing to cumulative theory (Truex et al. 2006).

First we selected three theories from a long list of theories used in IS research (Larsen et al. 2014) and checked for the Truex criteria. The chosen theories are: Stakeholder Theory (SHT), Principal Agent Theory (PAT) and Technology Acceptance Model (TAM). In Table 3 shows an overview of the selected theories and the fulfilled recommendations of Truex. We added the seminal papers or the theories in the bottom row of table 3.

In this work we only choose three theories, but it is should be clear this can certainly not be a complete situation. There are so many explaining, describing and predicting IS theories. During discussion with academics active in the field of IT governance we were attended on the Contingency Theory (CT) and the theory of the Resource-based view (RBV) of the firm (Fiedler, 1964; Penrose, 1959). Historically, CT has sought to formulate broad generalizations about the formal organizational structures that are typically associated with or best fit the use of different technologies. According to CT, business value is contingent to (i.e. dependent on) organizational factors, such as structure and environment (e.g. size). CT is an organizational theory and encompassed the idea that there is no best way of organizing. RBV is grounded in the economic work on firm heterogeneity (as against market structure) in conferring above normal profits and in driving imperfect competition. According to RBV heterogeneous firm resources are a basic for competitive advantage (i.e. differing resources, such as financial, people, know-how, etc.). RBV argues that firms possess resources, which enable them to achieve competitive advantage, and lead to superior long-term performance. RBV contributes to an organizational theory.

**Table 3:** The chosen theories according to the Truex criteria (Truex et al. 2006)

Truex criteria	Theories		
	SHT	PAT	TAM
Fit between theory and phenomenon	SHT fits very well with facts in COBIT. The first key principle of COBIT refers already to the broad phenomenon of stakeholders.	PAT focussed on a fundamental relation between two actors. An information system is a nexus of principal-agent relations: e.g. owner-manager, user-developer, auditor-CIO, ...	A substantial critic to COBIT is the 'mechanical' way the framework is constructed and the ignorance of the user as reflective human actor (Hoogervorst 2008). It makes it challenging to investigate how TAM could fit or not with the propositions of COBIT.
Historical context of theory	The concept of stakeholder has gradually grown from shareholder to a general concept of all actors that could have a stake in an artefact or organisation.	PAT is one of the cornerstone theories of organisations.	TAM is one of the only successful IS theories designed from within the IS discipline. Although the theory has been criticized by many, current relevant IS research is still using TAM.
Impact on the research method	SHT is a process theory which is compliant with the basic perspective of our research method (qualitative and a mixture of positivism and interpretivism).	PAT has two streams: positivistic agent theory and principal agent theory. We conducted the last stream (Eisenhardt 1989)	TAM is constructed as a variance theory. However the operationalization of the constructs (acceptance perceived ease of use and usefulness) can be also assessed from a process perspective.
Contribution to cumulative theory	SHT has been used in ten previous works in IS research (Larsen et al. 2014)	PAT has been used in 24 previous works in IS research and has links with other theories used in IS research (Larsen et al. 2014)	TAM is one of the few genuine IS theories, in the sense that the theory is not borrowed from other disciplines. TAM has been used in 64 previous works in IS research and has a profound link with the DeLone & McLean Success Model (Larsen et al. 2014)
Seminal paper	(Frooman 1999)	(Jensen and Meckling 1976)	(Davis 1986)

SHT is a management theory that identifies groups and individuals that have a stake in an organisation (Frooman 1999). The theory helps to identify, understand and use in a strategic way stakeholders in an organisation. Traditionally stakeholders were stockholders or owners of an enterprise. PAT is one of the cornerstone theories of the firm. The theory is well developed as a variance as well as a process theory. The theory is very well related to the theory of Transaction Cost Economics (TCE). TAM is one of most developed IS theories and brings the human interactions and perceptions in the middle. It is a theory which has his roots in psychology but it is actually a genuine IS theory.

For each of the three theories we made an analysis and a classification according to Gregor (2006) and we developed a summary of components. In table 4 we show the fiche of the SHT component as an example. Similar fiches were made for PAT and TAM.

**Table 4:** Overview of stakeholder theory

Overview of Stakeholder Theory (SHT)	
SHT is a management theory that identifies groups and individuals that have a stake in an organisation (Frooman 1999). The theory helps to identify, understand and use in a strategic way stakeholders in an organisation. SHT explains how stakeholders can affect the organization. SHT gives answers to three key questions: 1) Who are the stakeholders (Mitchell et al. 1997), 2) What do the stakeholders want? and 3) How do stakeholders influence?	
Theory Component	Instantiation
Means of representation	Words, lists, tables and diagrams
Primary constructs	Questions, groups and individuals
Statements of relationships	Relations between the stakeholders and the organization
Scope	The relations of an organization
Causal explanations	SHT explains the relation between stakeholders and organization by stating how stakeholders will impose their will.
Testable propositions	Questions can be composed and tested by interviews
Prescriptive statements	Only for the questions 1 and 3

In summary we can consider SHT and PAT as theories for explaining, and TAM as a theory for explaining and predicting (Gregor, 2006).

#### 4. The research method

To assess the degree of presence of any of the three selected theories in COBIT we designed a mapping tool. This tool is based on the ideas in ISO/IEC 15504-2 (ISO/IEC 2003). We do not use the tool as an capability determination instrument but as an assessment instrument. We developed a four layered scale to score the matching of a COBIT statement, keyword or proposition with theoretical components related to the three theories. The scale was constructed as follows

- Score N: (Not Present) There are no propositions, keywords or statements in COBIT that can be matched with components of one of the selected theories.
- Score P: (Present) There is a least one proposition, keyword or statement in COBIT that can be matched with one components of one or more of the selected theories.
- Score L: (Largely present) There is more than one proposition, keyword or statement in COBIT that can be matched with one theory.
- Score F: (Fully present) There is a strong match of several (more than two) COBIT propositions, keywords or statements with one theory.

We derived the propositions and keywords as suggested by Gregor (2006) from COBIT from three sources: 1) the five COBIT principles, 2) five selected COBIT processes (APO13, BAI06, DSS05, and MEA03) and 3) four selected IT-related goals (goal 02 'IT compliance and support for business compliance with external laws and regulations', goal 07 'Delivery of IT services in line with business requirements, goal 10 'Security of information, processing infrastructure and applications', goal 16 'Competent and motivated business and IT personnel'). We selected one IT-related goal from each dimension of the BSC (ISACA 2012b). In table 5 we give the pattern mapping for the five selected COBIT processes, principles and IT-related goals.



**Table 5:** Pattern mapping for five COBIT principles, selected processes and IT-related goals

	Theories																				
	SHT							PAT							TAM						
COBIT Principles	Representation	Constructs	Relationships	Scope	Explanations	Propositions	Statements	Representation	Constructs	Relationships	Scope	Explanations	Propositions	Statements	Representation	Constructs	Relationships	Scope	Explanations	Propositions	Statements
MSHN (1)	F	F	F	L	F	L	L	L	L	L	L	N	P	N	P	N	P	N	N	N	N
CE-to-E (2)	L	L	F	L	F	L	P	F	F	L	L	N	P	N	N	N	N	N	N	N	N
SIF (3)	L	L	L	P	P	P	P	P	P	P	P	N	P	N	P	N	P	N	N	N	N
EHA (4)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
SGFM (5)	L	F	F	L	F	F	P	F	F	F	F	N	L	N	N	N	N	N	N	N	N
COBIT Processes																					
APO13	F	F	L	L	P	P	P	L	L	F	L	N	P	N	P	P	P	P	N	L	N
BAI06	P	P	L	P	P	N	L	P	P	P	P	N	N	N	P	P	P	P	N	L	N
DSS05	L	L	L	L	L	P	F	L	L	P	L	N	L	N	P	P	N	N	N	N	N
MEA03	L	L	L	L	P	P	F	L	F	L	L	N	L	N	N	N	N	N	N	N	N
EDM03	L	L	L	L	P	P	P	F	F	L	L	N	L	N	P	P	P	P	N	P	N
IT-related Goals																					
02	P	P	N	P	P	P	L	P	L	P	L	N	F	N	N	N	N	N	N	N	N
07	P	N	P	N	N	N	N	N	N	N	N	N	N	N	P	P	P	P	P	L	N
10	P	P	N	P	P	P	P	P	L	P	L	N	L	N	N	N	N	N	N	N	N
16	P	P	N	N	N	N	N	N	N	N	N	N	N	N	P	P	P	P	P	L	N

(1) Meeting Stakeholder Needs, (2) Covering the Enterprise End-to-End, (3) Applying a Single Integrated Framework, (4) Enabling a Holistic Approach, (5) Separating Governance From Management.

## 5. Findings and discussion

Based on the pattern mapping as shown in table 5 we brought all the mappings together in overall overview which is presented in table 6. The scores are now cumulated from the previous detailed scores as shown in table 5. The scores can now be read as follows:

- Score N: The theory is not present.
- Score LP: The theory is only partly present. Only three base components of the theory are present.
- Score P: The theory is present and the empirical findings are within the scope of the theory and there are causal explanations found.
- Score F: The theory is strongly present. There are testable propositions that can be derived or prescriptive statements present.

**Table 6:** Overview of IS theories presence in COBIT

	SHT	PAT	TAM
Meeting Stakeholder Needs	LP	LP	N
Covering the enterprise End-to-End	LP	LP	N
Applying a Single Integrated Framework	P	P	N
Enabling a Holistic Approach	N	N	N
Separating Governance From Management	LP	F	N
APO13 Manage Security	LP	LP	P
BAI06 Manage Change	P	LP	P
DSS05 Manage Security Services	LP	LP	N
MEA03 Monitor, Evaluate and Assess Compliance with external Requirements	LP	LP	N
EDM03 Ensure Risk Optimisation	LP	F	P
IT-related Goal 02	P	LP	N
IT-related Goal 07	N	N	P
IT-related Goal 10	P	LP	N
IT-related Goal 16	N	N	P

The strongest theoretical foundations in COBIT are coming for PAT. This will come as no surprise since PAT is theory that is often used to explain the elements of control in a governance versus management setting. There is also coupling in appearance between PAT and SHT. The dual appearance of PAT and SHT is remarkable in the COBIT principles. TAM is less present in COBIT. This can be due to the fact that TAM is a higher type of theory, with strong causal relations.

What we have noticed during our enquiry is that the IT-related goals can strongly determine the presence of a theory. This is the way around, a framework should be designed with a theoretical stance in the first place. As an example: IT-related goal 07 suggest to be based on TAM and brings the theory into the process BAI06. The same goes for the IT-related goals 02 and 10 that bring in PAT in APO13 and DSS05. A possible explanation can be given that when a goal is present in a process, the process is likely to be shaped to meet the goal. In that way a possible 'hidden' theory is unveiled in the process. In table 7 we combined the IT-related goals with the five selected processes. We did not go further in that direction, but this suggests a deeper investigation.

**Table 7:** Presence of IT-related goals in the selected processes (yes=present / no= not present)

	IT-related goal 02	IT-related goal 07	IT-related goal 10	IT-related goal 16
APO10	YES	NO	YES	NO
BAI06	NO	YES	YES	NO
DSS05	YES	NO	YES	NO
EDM03	NO	NO	YES	NO
MEA03	YES	NO	NO	NO

## 6. Conclusions

The classification of IS theories and the matching with the COBIT principles, processes and IT-related goals have shown that COBIT did not take off from a clear theoretical starting position. However the derived theoretical propositions from the selected theories were surprisingly present in the framework, albeit not always completely. The primary constructs, scope and statements of relationship of the theories are often found, but causal explanations are often absent. Some theories do not have very clear causal explanations, so type I and type II theories have a higher likelihood to be supportive for COBIT. This is the case for PAT.

As for the SHT we see that prescriptive statements are only limited present in COBIT. To fully implement SHT one could use the findings of Mitchell et al. (1997) to assess the influence of each stakeholder. Together with the findings of Froomean (1999) the framework could be enriched with the way how stakeholders try to execute their influence. This could lead to better or more fine-tuned metrics.

The strong appearance of PAT and SHT in COBIT is probably due to the fact that both theories are lower types of theories according to the classification of Gregor (2006). Also COBIT was originally built as an IT audit guideline, so control and stakeholders are key elements there.

TAM is the less present theory of the selected theories in COBIT. To act according to TAM large changes will be necessary. We suggest a more intensified application of TAM into the COBIT processes. The ease of use and the usefulness are such important constructs for the acceptance of technology, and this should be noticeable in COBIT. We consider it as a drawback that COBIT does not take TAM more into account. This high level theory has yet proved to be very valuable.

IT-related goals always suggest the presence of an IS theory. But this touches the fundamental problem of COBIT: what is the initiator of a descriptive or normative statement? For us, academics it should be a theory and not a set of well agreed practical statements. However the goals cascade mechanism in COBIT forces the authors to make causal statements, derived from the principles down to the IT-related goals. Although this a common research practice, it is in no way supported by a theoretical context delivering theoretical propositions to support the deduced steps.

The implicit presence of a theory in an IT-related goals, makes that the framework cannot be forced into favourable statements. So the normative character of COBIT should come from the theories in the first place. However this means that deducing practical propositions from theories can lead to complete other goals. It is not impossible that the stakeholders from an organization put goals in place that cannot be reached. As an example we can take IT projects that in a traditional perspective should be managed according the old-style trinity of constraints in budget, time and quality. However we see in reality that more than 50% of all IT projects do not fit in such a pre-designed management model. Other theories, such as sense making (Cicmil and Hodgson 2006) and real option management (Benaroch 2002) are popping up to counter this dark side of IT management. These theories should be much more embraced by IT practitioners communities.

The generalization of our results can be an issue. We think we made a generalization from empirical statements to theoretical statements or a ET-generalization according to Lee and Baskerville (2003). (Lee and Baskerville 2003). This is a type of generalisation in the sense of the analytical or theoretical generalisation of Yin (2003). (Yin 2003, Dube and Pare 2003)

This research has offered a positive answer to our research question if COBIT could be more founded with IS theories. However the quest to these theoretical foundations have raised a multitude of new questions. First of all we could ask what other theories are present in COBIT? When we disseminated this work to a limited group of peers some suggestions of candidate theories pop up, such as Resource Based Theory, Transaction Economics, and Structuration Theory. These theories, who have been used many times in IS research should be researched to see if they can contribute to this work or to a more general contribution of a cumulative theory. Second we can pose some questions to our assessment model of scoring the presence of a theory in COBIT. We believe that this model can be fine-tuned. Third, it is not impossible that our research method can be of use for other practitioners frameworks which are also created without a firm theoretical foundation (e.g. ITIL).

Finally we must think about the managerial contribution of doing this sort of theoretical work. This brings us to the question if COBIT should not be adapted to a more intensive use of IS theories and thereby gain a stronger validity. It is our believe that IS scholars and practitioners should try to work more closely together. After all, our discipline of information systems is still shaped by a very practical kernel of IT artefacts and systems and is still in an urgent need for good describing, predicting and explaining theories.

## References

- Alves, V., Ribeiro, J. and Castro, P. (2012) Information Technology Governance - A Case Study of the Applicability of ITIL and COBIT in a Portuguese Private School, translated by Madrid, SPAIN.
- Avison, D., Gregor, S. and Wilson, D. (2006) 'Managerial IT unconsciousness', *Communications of the Acm*, 49(7), 89-93.
- Benaroch, M. (2002) 'Managing information technology investment risk: A real options perspective', *Journal of Management Information Systems*, 19(2), 43-84.
- Cabukovski, V. and Tusevski, V. (2011) 'Introducing the COBIT Framework into a IT Academic Education', *Education and Education Management*, 1, 167-170.
- Chen, J. and Shen, L. (2010) 'Assessment Model of Corporate Governance with COBIT-Based IT Governance', *Nanotechnology and Computer Engineering*, 121-122, 550-557.
- Choi, W. and Yoo, D. (2009) 'Assessment of IT Governance of COBIT Framework', *U- and E-Service, Science and Technology*, 62, 82-89.

- Cicmil, S. and Hodgson, D. (2006) 'New Possibilities for Project Management Theory: A Critical Engagement', *Project Management Journal*, 32(3), 111-122.
- Conboy, K. (2010) 'Project failure en masse: a study of loose budgetary control in ISD projects', *European Journal of Information Systems*, 19(3), 273-287.
- Cross, T. (2011) 'A Rush To Failure?', *Harvard Business Review*, 89(4), 127-131.
- Davis (1986) 'A technology acceptance model for empirically testing new end-user information systems: Theory and results', MIT, Doctoral Dissertation.
- De Haes, S. and Van Grembergen, W. (2010) 'Analysing the Impact of Enterprise Governance of IT Practices on Business Performance', *International Journal of IT/Business Alignment and Governance*, 1(1), 14-3838.
- Dube, L. and Pare, G. (2003) 'Rigor in information systems positivist case research: Current practices, trends, and recommendations', *Mis Quarterly*, 27(4), 597-635.
- Dwivedi, Y. K., Zinner Henriksen, H., Wastell, D. and De, R. (2013) *Grand Successes and Failures in IT: Public and Private Sectors - IFIP WG 8.6 International Conference*, Springer.
- Eisenhardt, K. M. (1989) 'Agency Theory: An Assessment and Review', *Academy of Management Review*, 14(1), 57-74.
- Fiedler, F. E. 1964. A Contingency-Model of Leadership Effectiveness. *Advances in Experimental Social Psychology*, 1, 149-190.
- Frooman, J. (1999) 'Stakeholder influence strategies', *Academy of Management Review*, 24(2), 191-205.
- Goldschmidt, T., Dittrich, A., Malek, M. and Ieee Computer, S. O. C. (2009) 'Quantifying Criticality of Dependability-Related IT Organization Processes in Cobit', *Ieee 15th Pacific Rim International Symposium on Dependable Computing*, Proceedings, 336-341.
- Hoogervorst, J. (2008) 'De ongemakkelijke waarheid omtrent IT-governance', *Informatie*, 03/2008.
- ISACA (2012a) *COBIT 5 - A Business Framework for the Governance and Management of Enterprise IT*, Rolling Meadows, IL, USA: ISACA.
- ISACA (2012b) *Cobit 5 - Enabling Processes*, Rolling Meadows, ISACA.
- ISO/IEC (2003) 'ISO/IEC 15504-2-2003 - Information technology -- Proces Assessment -- Part 2: performing an assessment', 16p.
- Jensen, M. C. and Meckling, W. H. (1976) 'Theory Of Firm - Managerial Behavior, Agency Costs And Ownership STRUCTURE', *Journal of Financial Economics*, 3(4), 305-360.
- Kerr, D. S. and Murthy, U. S. (2013) 'The importance of the CobiT framework IT processes for effective internal control over financial reporting in organizations: An international survey', *Information & Management*, 50(7), 590-597.
- Larsen, K. R., Allen, G., Vance, A. and Eargle, D. (2014) 'Theories Used in IS Research Wiki', [online], available: <http://istheory.byu.edu> [accessed: 9/04/2014]
- Laudon, K. C., Laudon, J. P. and Brabston, M. E. (2012) *Management Information Systems: Managing the Digital Firm*, Pearson Education Canada.
- Lee, A. S. and Baskerville, R. L. (2003) 'Generalizing generalizability in information systems research', *Information Systems Research*, 14(3), 221-243.
- Mitchell, R. K., Agle, B. R. and Wood, D. J. (1997) 'Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts', *Academy of Management Review*, 22(4), 853-886.
- Penrose, E. 1959. *The theory of the growth of the firm*, New York, Oxford University Press.
- Ridley, G., Young, J. and Carroll, P. (2008) 'COBIT 3rd Edition Executive Summary', *Australian Accounting Review*, 18(4), 334-342.
- Truex, D., Holmstrom, J. and Keil, M. (2006) 'Theorizing in information systems research: A reflexive analysis of the adaptation of theory in information systems research', *Journal of the Association for Information Systems*, 7(12), 797-U26.
- Weill, P. & Ross, J. 2004. *IT Governance: How Top Performers Manage IT Decision Rights for Superior Results*, Harvard Business Press.
- Yin, R. K. (2003) *Case Study Research: Design and Methods*, Applied Social Research Methods Series, Third Edition ed., Thousand Oaks, London, New Delhi: Sage Publications, Inc.

# Benefits, Justification and Implementation Planning of Real-Time Business Intelligence Systems

Kiril Dobrev and Mike Hart

University of Cape Town, Cape Town, South Africa

[kirildobrev@gmail.com](mailto:kirildobrev@gmail.com)

[mike.hart@uct.ac.za](mailto:mike.hart@uct.ac.za)

**Abstract:** While traditional Business Intelligence (BI) environments have for some time assisted organizations with their information requirements, they have become increasingly incompatible with the pressures of current business environments. They are geared towards analysis of historical information, and limited in their ability to close the latency gap between information and action. This has encouraged a movement towards real-time BI (RTBI) systems. Although these overcome latency aspects of traditional BI, and offer many value-adding benefits to organizations, their implementation has been hampered by technological complexities, and has required changes to the business environment, and high costs to put them in place. Justification of such IT investments remains a problem as they provide many intangible benefits incompatible with traditional (financial) IT benefits measurement models. For these reasons, the research set out to investigate and understand the technological components and organizational changes surrounding RTBI implementation. To further facilitate justification, application areas and benefits of RTBI were also explored. Data was collected through semi-structured in-depth interviews in organizations across several industries that had implemented or were implementing RTBI systems. A qualitative thematic analysis was then used to investigate the issues further. The study confirmed that RTBI is likely to require major changes to technical architecture, which may involve acquisition of new tools and technologies. Several issues at the organisational level also need to be addressed, and the research uncovered a wide range of practical RTBI applications and analytics applied across industries; process intelligence was found to play a fundamental role in many of these. The study reveals that RTBI can offer significant and measurable improvements, help organizations remain competitive, and in the long run, drive strategic business objectives from a grass roots level. To assist organisations to take advantage of this, a roadmap for RTBI justification and implementation planning is suggested.

**Keywords:** business intelligence, real-time BI, BI maturity, analytics, process intelligence, operational BI, justification

## 1. Introduction

For the sixth successive year, Business Intelligence (BI) and Analytics was rated the most important technology and application issue for CIOs (Kappelman, McLean, Johnson, & Gerhart 2014). In this survey Big Data is the 10<sup>th</sup> most significant IT investment, with data velocity comprising one of its “three Vs” (Pedersen, Castellanos & Dayal 2014; Villars, Olofson & Eastwood 2011). BI and Analytics (BI&A) has consistently been the top IT application and technology investment in Europe, and is globally the “top IT trend keeping the CIO awake at night” (Derksen & Luftman 2014).

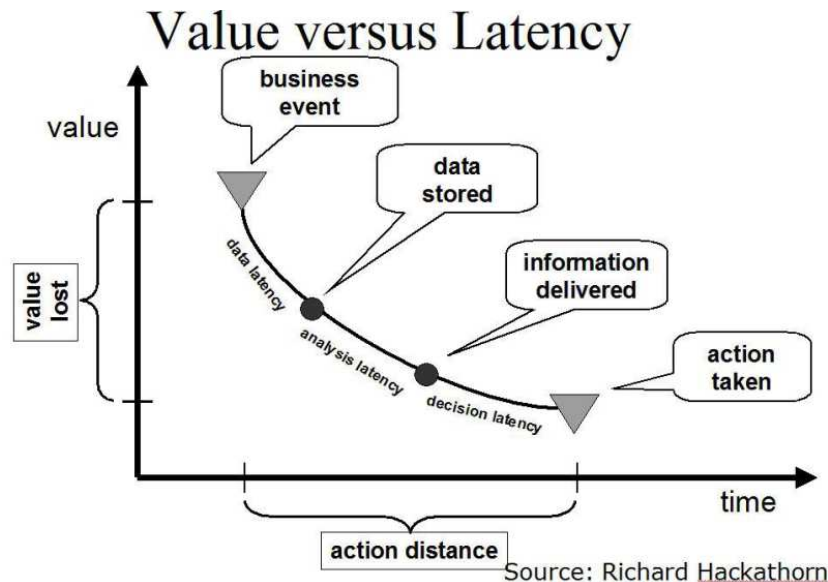
Initially storage and processing constraints meant that data for BI was typically kept at a summary level (daily, weekly, monthly etc), and there was a significant time delay (latency) in creating and using these summaries. Transaction-based analytics or data mining was generally not done on real-time data, other than for areas like fraud detection. BI was typically at a strategic or tactical level. Cost-effective advances in storage and processing have now facilitated BI at operational and process levels, with increased interest in real-time BI (RTBI) and analytics. This research aims to uncover many of the issues involved in planning implementations of RTBI systems, by interviewing key people involved in such implementations across a range of organisations.

A brief literature review next summarises key aspects of real-time implementation of BI. Details of the research methodology used then follow. Analysis of the interviews then exposes pertinent issues surrounding justification and implementation of RTBI. After discussion and summarisation of these, a roadmap to help organisations with RTBI justification and implementation planning is developed, and the paper concludes.

## 2. Background

Figure 1 illustrates the motivation for an organisation to move towards RTBI, suggesting that three different latencies reduce the business value of information (Hackathorn 2004). For example, ETL (extract, transform and load) processing often occurs in overnight batch runs (Seufert & Schiefer 2005). This means that the results of BI and analytics cannot link back into business processes immediately or automatically (Azvine, Cui &

Nauck 2005; Sahay & Ranjan 2008), and provide timely action. Andriole (2012) stresses the need for real-time analytics, while Korotina, Mueller and Debortoli (2015) note the value of real-time business process intelligence, but suggest that understanding of this concept by businesses is limited. When analytical processes are linked in real time to business activity monitoring (BAM), it is possible to take corrective action before problems materialize (Seufert & Schiefer 2005). Reducing action time in order to increase business value is therefore the critical objective for RTBI (Eckerson 2004; Tank 2015). Ioana (2008) sees RTBI as an evolutionary process towards operational BI using process intelligence.



**Figure 1:** Business value vs latency (Hackathorn 2004)

Watson, Wixom, Hoffer, Anderson-Lehman and Reynolds (2006) note the business-driven purpose of RTBI is to increase revenues and decrease costs. Advances in RTBI applications have also helped to manage, automate and synchronize many of the business processes of customer relationship management (CRM) (Goldenberg 2008; Grigori *et al.* 2004). However, data will only need to be as fresh as its respective business requirements (Ioana 2008; Watson *et al.* 2006). Consequently the terms "right-time" or "near real-time" may be more appropriate than real-time (Pedersen, Castellanos, & Dayal 2014).

Implementing a RTBI system may require several additional components to a typical BI architecture (Acker, Gröne, Blockus, & Bange 2011; Hang & Fong 2010; Tank 2012) such as in-memory analytics and service-oriented architecture (SOA). Agrawal (2009) suggests that adoption of RTBI is hindered because of lack of clarity on technology requirements, and the substantial costs. Schneider (2006) stresses that benefits of business decisions made under low latency must outweigh the significant investment in achieving RTBI (Ward, Daniel & Peppard 2008), and Seufert and Schiefer (2005) list seven ways in which RTBI can generate value. Chan, Tan, Lau and Yeoh (2013) quote research that indicates that strong demand for mobile BI will increase incidence of real-time BI, because of the many applications that could benefit mobile workers (Andriole 2012). RTBI implementation is unlikely to be successful unless the organisation has reached a relatively high level of BI maturity (Rajterič 2010).

### 3. Research objective, questions and approach

The primary objective of this research is to produce a roadmap or framework which serves as a guideline for organizations planning on moving into the RTBI sphere. In order to achieve this objective four research questions were investigated:

1. What are the challenges and considerations, both technological and organizational, which need to be addressed when planning for, or moving into RTBI?
2. What are the application areas and related analytics of RTBI, and how are they enabled in this environment?
3. What goes into planning and approval of a RTBI investment and how is it justified?
4. How does the introduction of RTBI affect its users, and how does it influence decision-making at different levels of the organization?

Because of the lack of published information on local RTBI implementations, the study was exploratory, interpretive and inductive, aiming to uncover and understand the key issues involved (Klein & Myers 1999). A purposive sample of organisations with involvement in the RTBI area was therefore chosen. Seven senior business and IT management staff were interviewed from South African companies in financial services, retail, energy, transport and IT consulting. Respondents were given advance information of the types of questions that would be asked, and ethical requirements and confidentiality were observed. Semi-structured in-depth interviews of an hour or more enabled most important areas to be covered, while enabling an open flow of conversation, and for respondents to volunteer points on areas not conceived of beforehand. Interviews were recorded digitally and then fully transcribed. A process of thematic analysis (Braun & Clarke 2006; Thomas 2006) was used to code segments of text, create categories, and iteratively combine and summarise these into themes. Thomas (2006 p5) states the importance of finishing with “three to eight summary categories”. The six themes that emerged were: technological considerations, organisational considerations, users, application areas and analytics, benefits, and the investment process. Each of these had a number of sub-themes.

#### **4. Analysis of themes and sub-themes**

The main emergent themes and their sub-themes are now discussed, with illustrative quotes.

##### **4.1 Technological considerations**

In this section, various fundamental technological elements of a RTBI system will be explored. Although it was found that BI architectures will vary depending on their context, their underlying technical structures share common components.

###### *4.1.1 Integration*

While it is common for organizations to run multiple systems to support their various business functions, they need to be integrated in a BI environment. Information can no longer be kept in isolated repositories but must be consolidated in order to provide a unified view. Integration is a key component in creating a technical landscape that supports RTBI.

*“... there’s been difficulty with getting information out based on non-integrated systems, and have therefore had people in the organization with different versions of the truth”*

The high dispersal of systems around the organization also made integration more difficult. For many large organizations, such as retailers and banks, legacy systems were found to still support many business functions. Some expressed difficulty in integrating them because they are not really designed for real-time.

*“...in a retail environment, your legacy stuff is all typically flat-file based. So it’s a bit more of a challenge moving retailers into real-time”*

###### *4.1.2 Message-bus or enterprise service bus (ESB)*

The message-bus is a key component of a RTBI architecture as it provides the means to integrate an organization’s systems and route their data into a repository. This addresses many of the challenges that come with the integration process, and includes integrating internal and external systems (including legacy systems) into one space in such a way that it does not impact business systems.

*“ESB is really the communications between the different ... systems, as a basis, so it’s an integration layer”*

*“So all of our 65 ERP systems speak through your central ESB”*

The implementation of a message-bus can be seen as one of the initial steps to configuring a RTBI architecture. The value of a message-bus comes not only from its ability to integrate systems, but because the real-time data flowing through it can be intercepted. While doing this, a host of analytics can be applied to it, but it also needs to be compared with historic data in order to contextualize it.

*“...it can get information, or transactional information, the moment something happens”*

*“The beauty of an ESB is that you can inspect that stuff as it flows through”*



#### 4.1.3 Data

All companies had large amounts of operational and transaction data, often using this for analytical purposes. The importance of a master data management environment was stressed.

*"There is also a lot of master data management implementation as well to normalize your master data across all the systems in order to move into real-time"*

Some were looking at combining their transaction data with social network data, but noted problems in dealing with the less-structured data analytically.

The frequency with which information is distributed should be aligned with how often that information is actually being used to make decisions. For instance, delivering information that is refreshed hourly when an organization only makes decisions once a day will be of no benefit. This may also result in additional costs incurred from making those load changes.

*"I can change something every 5 minutes, but if you're only using it to make decisions every 2 days then it doesn't make a difference"*

The ETL process is one of the major reasons for latency. In order to achieve a real-time environment it was noted that ETL processes should not be used to fix incomplete data. Instead, using business rules, data should be validated at its source (host systems).

*"You can't have these sophisticated ETL processes which are going to try and fix deficient information...your business rules should be on your systems and not on your ETL processes"*

#### 4.1.4 Architecture

The points and technologies mentioned above indicate different architectural requirements, with the use of the message-bus and an operational data store (ODS) being key.

*"you're creating a whole new level of aggregation which requires different technology"*

This can be described as a five stage process: data is created at its host system (1), it is then integrated and brought into the message-bus (2), it is intercepted at the message-bus for analysis (3), and it undergoes ETL processes (4) before it is consolidated into the DW (5). In order to harness real-time analytics, the ODS sits between the host systems and the DW and intercepts data flowing through the message-bus and then compares it in real-time against historic snapshots or target values from the DW.

*"... you can intercept information at the [message-bus] and compare it with historic data to start a business event or to alert a situation"*

Many organizations apply BAM analytics, where they can directly monitor business activities as they are executed at their host systems. In some cases, BAM was also applied to monitor integration and ETL processes to ensure that they are being executed correctly, and in-memory analytics was also being used, independently of the DW:

*"...looking at solutions that are sitting on top of your transactional systems with in-memory capabilities."*

The need for on-going flexibility was also mentioned:

*"So it's an ever-learning environment, and you grow on top of that"*

## 4.2 Organisational considerations

The following organisational issues were mentioned regularly during the interviews:

#### 4.2.1 BI / DW maturity

Several organisations noted the importance of first evaluating their maturity in the BI and DW space. If not mature here, they were more likely to run into obstacles when attempting RTBI. Mature organisations were also likely to have more historic information in their DW, useful for analytics and comparing with real-time data.



#### 4.2.2 Business process re-engineering (BPR) and change management

In a real-time environment, where data can drive business processes, the need for configuration and re-engineering of processes is a likely requirement.

*"... first of all it's going to change a bit of our business processes"*

This may become a major task, and change management may be needed for two things: to facilitate business process reengineering and also to help individuals accept changes in their business environment. In one organisation this was needed when a policy holding users responsible for data quality was introduced.

*"master data management ... is very change-management oriented because ... [you're] pushing the responsibility of the quality of the data into the organization, they're often quite resistant to that because you're making them responsible for the quality of data"*

#### 4.2.3 Skills and support

RTBI implementation will require the skills to put it in place and also to support it. In addition, it may require that IT staff become more knowledgeable of the business itself.

*"The people implementing it also need to understand the business"*

It may be challenging to actually bring those skills together and manage them.

*"... if you're going to move into real-time BI, in a large environment / corporate, you're going to have to have the integration teams, the guys who put in integration and ESB etc., they have to work very closely with the BI guys. You've got to mesh those skills, which itself, internally in an IT department, is a big challenge"*

#### 4.2.4 Business rule definitions

As one respondent commented:

*"... if your definitions (your golden standards) aren't defined, you're going to have a serious problem about even getting to the single version of the truth because no one has defined [those] business rules"*

This can be a challenging task because business rules are context-specific, and every organization needs to assess its own requirements and objectives first, e.g.

*"... on-time flights; where do you start to measure it? Is that when the last passenger is on the plane, or from the time you're given permission to take off etc"*

#### 4.2.5 Requirements and driving force

One of the organisational aspects mentioned most was the driving force behind going real-time – either addressing business problems, or harnessing opportunities. One organisation wanted to have real-time metrics on employee work satisfaction. Another wanted to take a proactive approach towards fraud. A retailer wanted real-time visibility at the point of sale (POS), and to integrate information silos in service level areas. In all cases these need to contribute to a business plan to justify the investment.

#### 4.2.6 "Build or buy" and costs

Decisions whether to build or buy solutions featured strongly in the interviews. The general view, from organizations that are not in the software development industry, is that

*"...we try and buy everything; it's just a lot less expensive for us"*

Some, however, had to tailor a solution by purchasing several components and integrating them.

*"... there are situations where there is nothing on the market; ... that allows us to do it in the fashion we wanted to do it in"*

*"... aren't vendors out there that have got to that level of sophistication"*

This will require the appropriate skills needed to then configure the solution.

*"so [often] there is no one vendor that has everything"*

*"Sometimes the solution becomes purchasing one or two items and plugging them together and coming up with a solution"*

Vendor research and assessment is an important part of this process. Notable factors included vendor maturity, skills, and availability of support.

*"[do they have the] skills available to support it?"*

Apart from the build or buy decision, common costs include investment in infrastructure and architecture, as well as resources that are spent on consulting, training, and support.

*"There are a lot of initial investments before you can reap the benefits"*

This supports the need to identify feasible realization of measurable business benefits from real-time BI that can justify the costs involved.

### 4.3 Application areas and analytics

This summarises some areas in which RTBI and analytics were found to be applied.

#### 4.3.1 Process intelligence

This proved to be a significant value-generating aspect. Having visibility at the lowest (transaction) levels allows organizations to garner important knowledge and can also help them to understand, monitor, and control their business processes, leading to process improvements.

*"At our operational [process] level is where we have a need for real-time BI, and that is really where it is valuable for us."*

Typically, systems that produce data must be integrated and consolidated into the message-bus. It is at the message-bus where real-time data can be intercepted and analyzed.

*"... we had to kind of build a pick-up service that runs on the tills and intercepts the transactions to bring them down"*

Monitoring this real-time data on its own however, provides little insight. As mentioned earlier, it needs to be combined with historic or projected data, targets or indicators to put it in context.

Through business activity monitoring (BAM) users can make informed and timely decisions at the operational level, and subsequently help to improve tactical and strategic performance measures. In the airline industry for example:

*"You may have revenue guys wanting to know sales figures, profit, and number of seats available, the load factor (how busy the flight is), and the IT department will want to know if the systems are up etc."*

This includes key performance indicators (KPIs), which may be dynamic:

*"You see it needs to be a dynamic KPI so that the threshold is ... continuously updated based on your history. e.g.: refreshed each day based on the last 12 weeks"*

Dashboards are used extensively.

*"[we have an] executive-level dashboard, a holistic view, and then breaking that down into different divisions and departments and things like that"*

The detection of anomalies is highly advantageous because it provides organizations with actionable information in a timely manner, and can be applied in numerous places.

*"We're also able now ... to create alerts when x or y happens; they will send an email or they can do certain things [like] send it out and alert the person"*

Anomaly detection was applied for fraud detection at two organisations. When potentially malicious activity is detected, it can be addressed in a timely manner and, ideally, resolved proactively.

*"... if an address change was affected in the last month and there is a withdrawal of money, we want an alert raised"*

#### 4.3.2 Predictive analytics

This predicts trends and future behaviour by deriving patterns from a mix of historic and live data. All organisations were using it to some extent in different applications such as sales and demand forecasting. Some related applications follow.

#### 4.3.3 Fraud detection and forensics

Because fraud is a time sensitive issue, if it can be detected early enough, it can be prevented.

*"So now obviously going into the more proactive mode, we can stop the money from leaving the building, which is a different ball game then"*

RTBI only enables this kind of environment; finding the fraudulent transactions however, is based on learned business rules.

*So it's very easy to run through a set of transactions and look at authorizing and initiator; if somewhere it's the same person, and that's your exception that you would follow up on. So we've got a team that sort of builds these things"*

#### 4.3.4 Dynamic pricing and yield management

These dynamic pricing decisions are often quite complex because they have to factor many variables to determine an optimum price. The airline industry respondent explained:

*"Airlines are generally dynamically priced. For example, our booking systems are intelligent in that they can sense if the demand for a flight increases; so should the price. And it can dynamically adjust that"*

A retailer also included price comparisons as part of their pricing decision process, thus ensuring that they stay competitively priced.

*"... we monitor our competitors and we receive those prices which we store and do price comparisons". "... you can adjust them [price] in the store"*

#### 4.3.5 Demand monitoring and forecasting

This uses mathematical techniques on historic data and real-time information from the supply chain.

*"With real-time on our till, we've been able to do things like shelf-gap monitoring, so you can monitor stock-out situations"*

*"they can receive their stock within a 24hour period instead of a 48hour period and keep the in-stock situation higher. So the bottom line is we would be that much more profitable"*

#### 4.3.6 Supply chain improvement

The petroleum supplier's logistics management is a complex task. Many of these processes however, can be improved in a real-time environment.

*"... a big focus in our supply chain into Africa, so we're looking at moving of product from South Africa into [Country A] for example, wanting to understand what is our transport time by boat from here to the harbour in [Country A], what is our delay time, their harbour time, offloading, transporting ..."*

#### 4.3.7 Customer relationship management (CRM)

Although this was in use by all organisations in a general sense, they were still starting to explore its use in a real-time environment, and mentioned future possibilities rather than current applications.

### 4.4 Users

RTBI users at different levels of the organization are likely to have different information requirements as well as different data latency demands, and it is important to understand these. At strategic and tactical levels data latency required is generally similar to that of traditional BI. But operational managers and users need low latency transaction data, as for the financial forensic analysts:

*"Typically you need the transaction data (the payment transaction) and something about the policy, the policy owner ... at times you need inception data"*

User training was also needed as data was different to that of traditional BI, and to make sure:

*"...that people understand what it is they're looking at and to make sure they are truly ready to receive what they're looking for"*

Change management may be required to overcome resistance and assist cultural change:

*"It's been a process of getting them to accept looking at a screen when they assess the situation in terms of their business; it hasn't been their culture"*

RTBI offers users most value at the operational level, in terms of decision-making. Further, decisions can be taken faster without having to refer every decision to a superior.

*"... there was very little micro decision-making on stock and replenishment [before real-time BI]. So the last 7 or 8 years has completely been turned on its head. There's a lot more responsibility at lower levels"*

#### 4.5 Benefits

Many of these have already been alluded to, and others will be briefly mentioned, such as visibility:

*"... they're able to see what's happening in the business long before they get the financials at the end of the month or year"*

With the new information available, learning and discovery has increased.

*"... there's lots to learn, I mean as you move, and are now receiving information you can monitor with real-time, you start to learn more about the business because you get different visibility on the business"*

Prediction has increased and the impact of different possible scenarios is being assessed.

*"... reporting has also changed from being backward-facing to being a whole lot more forward-facing ... saying what is going to happen"*

Similarly there has been a move from being reactive to proactive:

*"At our operational level is where we have a need for real-time business intelligence.... For example we want to see if a flight is delayed so we can react immediately"*

There has also been an increase in adaptive, automated decisions in the operational systems, e.g.

*"...our booking systems are intelligent in that they can sense if the demand for a flight increases; so should the price. And it can dynamically adjust that"*

#### 4.6 Investment Process

This describes the steps necessary to justify and obtain approval and budget for a RTBI implementation. As a starting point it is vital to first identify measurable business problem(s) or opportunities which real-time BI can address. These form the crux of the business case and ultimately drive the proposal. In a situation like this, technical approval is also usually required.

*"Whenever any IS investment decision [is made], like ... an investment into a specific project that will bring new functionality on board for example, all of that gets placed in the business case, before the decisions are made around whether to proceed or not"*

*"... you need to have a strategy and your budget, what you're going to spend on infrastructure (which they might not understand), and then there's got to be real benefits from that"*

Some organizations started off with smaller investments, with business cases which subsequently evolved and iteratively matured into real-time BI.

*"... [we] started off with something small, which is easy to invest in, to something much larger with a more formal business case"*

#### 4.6.1 Stakeholders

While a proposal is normally triggered by a business problem or opportunity and business stakeholders, IT departments were also found to contribute strongly to the innovation.

*"... whoever's going to benefit from it. In [our] case, it [was] in the space of operations; so in this case, your Chief Operating Officer (COO) is your main component behind it, going through to your CEO"*

*"... we continuously try to innovate, it's one of the biggest things we try to do internally in IT"  
..... "a combination of ideas from the business ... and also the technology team; the software development team"*

Directors such as the CEO, CFO, CIO, and COO, are typically present for such a proposal. It is important to foster an environment in which multiple stakeholder input is encouraged because one needs to ensure that there are people that understand the business, and also how technology can support the business's needs. There are however often communication difficulties between the two parties (IT and business).

*"... a lot of IT departments where the IT individuals are not business-oriented at all, they are very technical; they struggle to put forward a strategy and they don't understand the business well enough"*

Some organizations were found to have established investment committees dedicated to reviewing and approving investment proposals.

*"... we have what we call an IS investment committee that your CIO, the financial director, and one or two other directors sit on"*

Multiple stakeholder input is also particularly important when it comes to the decision to build or buy (see 4.2.6), and especially in justifying the technology. This decision does not only involve IT, but requires a strategic and financial assessment as well.

#### 4.6.2 Trust

It is common for an IT project to require a change in architecture, especially for enabling real-time BI; justifying these components however, is not an easy task. For instance, a message-bus, in isolation, does not demonstrate financial value. In the grand scheme of a real-time BI architecture however, it plays a fundamental role. Business therefore, needs to be trusting of IT decisions, especially when they are technical in nature and may not necessarily be understood.

*"... like architecture, it's quite difficult to put forward and say what ROI [will be] on ESB"*

On the other hand, IT needs to earn trust from the business by consistently demonstrating value from its investments. This will also help business to be more trusting of future IT proposals.

*"...[we've] really shown a lot of value to the business, from what we take and what we give"*

One way in which they can gain trust is by being conservative in their ROI projections. This is to minimize the risk of failing to reach those targets, as this could also be detrimental to building trust.

*"... [if you are] conservative about the impact of IT, they become more trusting on your submissions of expenditure when you have your ROI calculation"*

While trust plays a role in investment approval, it ultimately rests on whether the proposed benefits, financial or non-financial, can outweigh the cost.

#### 4.6.3 Quantifying Benefits

Identifying measurable benefits of the proposed RTBI system is one of the most crucial components for building a credible business case for the investment. Those that are measurable are quantified and used to calculate a ROI estimate, and an investment must first demonstrate that it is financially prudent. Some organizations also applied hurdle rates (a minimum acceptable rate of return) in their calculations.

*"... because we were using our own skills to develop the system, [we had to look at] the cost of those skills in developing the system versus working on a client project and earning revenue"*

Real-time BI systems also provide many intangible benefits; these however are difficult to measure because they are non-monetary in nature. For this reason, some organizations follow a balanced scorecard approach (Kaplan & Norton 2008) which extends benefits realization beyond financial dimensions. These kinds of benefits are difficult to measure, and there is often uncertainty as to how these should be used in a business case.

*“... you obviously list all of your intangible benefits, but no one is going to sit there and try measure those” (I62)*

Some organizations did attempt to quantify these softer benefits by using estimations. For instance, a financial services company calculated their softer benefits based on “assumptions and history”.

#### 4.6.4 System Growth Planning and Scalability

The choice of technology and environment should be scalable and flexible to allow it to adapt to changing business needs. One organisation noted:

*“...we’ve had it going since 2007 and it’s constantly evolving”*

This can be seen as increasing the amount of an already existing investment simply by supplementing or configuring the technology. Organizations who followed this approach normally adopted multiple business cases. By continuously demonstrating value through these iterations, business is more likely to be supportive and trusting of the proposals.

*“... [it] started off with something small, which is easy to invest in, to something much larger with a more formal business case”*

## 5. Discussion and Summary

This summarises some of the issues that emerged from the analysis, and later leads to development of a roadmap for RTBI justification and implementation planning.

The Technological theme (See Table 1) revealed a few key aspects for RTBI. Integration of systems assumed an even greater role, with unsuitability of some legacy systems being noted. Apart from the increased velocity of the BI data, variety that included unstructured and social media data would add to the difficulties of management and metadata. In order to achieve RTBI, a new flexible architecture was needed, which could accommodate concepts of BAM, an ODS and the important message-bus.

**Table 1:** Summary of technological considerations

Theme	Issue(s)
<i>Integration</i>	Multiple systems
	Distributed systems
	Difficult to change infrastructure
	Integrate without impact
	Legacy systems integration
	Migration
	Data consolidation
<i>Message-bus</i>	
<i>Data</i>	Structured & unstructured
	ETL Process
	Master data
	Historic data
	Data latency
	Data management
<i>Architecture</i>	New tools & technologies
	Flexibility

As with any BI implementation, Organisational issues proved highly significant (See Table 2). Up front, detailed requirements had to drive a sound business case that would justify the investment. Sensible decisions on build versus buy were needed. BPR with clearly defined business rules and change management would probably be required, as would a new set of skills for both IT and users.

**Table 2:** Summary of organisational considerations

Theme	Issue(s)
<i>Requirements</i>	Need to be defined
	Incorporated into business case
<i>Cost</i>	Technological
	Organizational
<i>BI / DW Maturity</i>	Maturity assessment
	Phased development
	Data
<i>Business Rules</i>	Need to be defined
	Monitoring data
	Golden standard of information
<i>Bus. Process Re-engineering</i>	Enterprise-wide
	Planned change
<i>IT Skills &amp; Support</i>	New tools & technologies
	Management of skills
	Training
<i>Build versus Buy</i>	Build : skills; justification; maturity
	Buy : configuration; vendor assessment
<i>Change Management</i>	BPR management
	User resistance

A varied range of RTBI applications was mentioned (See Table 3), with process intelligence generating many analytics applications and capabilities.

**Table 3:** Summary of application areas and related analytics

Application Area	Analytics
<i>Process intelligence</i>	Analysis and visibility
	Business activity monitoring
	Situation and anomaly detection
	Prediction
	Business process improvement
	Automation
<i>Fraud detection</i>	
<i>Supply chain optimization</i>	
<i>Dynamic pricing &amp; yield management</i>	
<i>Customer relationship management</i>	
<i>Demand monitoring &amp; forecasting</i>	

Differences in requirements of users at different organizational levels were assessed in terms of objectives, types of users, and data latency requirements. At strategic and tactical levels, information requirements were found to be typical of traditional BI. The former focus on long-term objectives (strategic goals), and analysis is on data with a high temporal window, such as weeks or even months, mainly historic data. The latter focus on tactical objectives and users typically include financial analysts, and business managers; here the data latency is normally within weeks or days.

In contrast, operational / real-time BI seeks to provide visibility into the current state of operations; therefore the required latency of data is much lower, often in terms of minutes or even seconds. Furthermore, requirements vary not only across organizational levels, but across different types of users. For this reason, it is important to assess the users of the system, prior to implementation, so as to understand how their data requirements vary. With real-time BI, decision-making is also becoming increasingly automated, especially at the operational level where common and repetitive decisions are frequent. Decision-making is now more embedded into the normal business workflow whereby systems are able to automatically sense conditions or identify problems. The deployment of a real-time BI system will therefore impact users in a variety of ways, and this change will need to be managed so as to avoid potential resistance to the system, and more training is required. (See Table 4).

**Table 4:** Summary of user-related aspects



Theme	Outcome
<i>Data Requirements</i>	Low latency + historic data (Operational)
	Historic data (Strategic and Tactical)
	Vary with types of users
	Context-specific dashboards
<i>Training</i>	Operational users lack BI skills
<i>Resistance, Participation, and Adoption</i>	Operational users not accustomed
	System design
	Change management
<i>Decision-making</i>	↑ Operational users
	↓ Decision & Action latency
	Decentralized
	Proactive
	Optimized

According to those interviewed, RTBI provided a solid list of benefits, as shown in Table 5.

**Table 5:** Summary of real-time BI benefits

Theme	Outcome
<i>Real-time Business Information</i>	Increase visibility
	Deliver actionable information
	Improved decision-making
	Decentralized decision-making
<i>Learning and Discovery</i>	New information
<i>Prediction</i>	Accurate forecasting
	What-if scenarios
<i>Proactive Responses</i>	Proactive alerting
	Proactive decision-making
	Lower risk, Maximize opportunity
<i>Automation &amp; Adaption</i>	Information into action
	Anomaly detection & automated alerts
<i>Business Process Improvement</i>	Adapt to changes in business environment
	Better use of resources

Many of these could be classed as intangible, but they increased organisational ability to improve profit and decision making and reduce risk in various ways. The main impact of these benefits on the business user was at the operational level, requiring in many ways a different mind-set, training and change management.

## 6. A suggested roadmap for planning RBTI

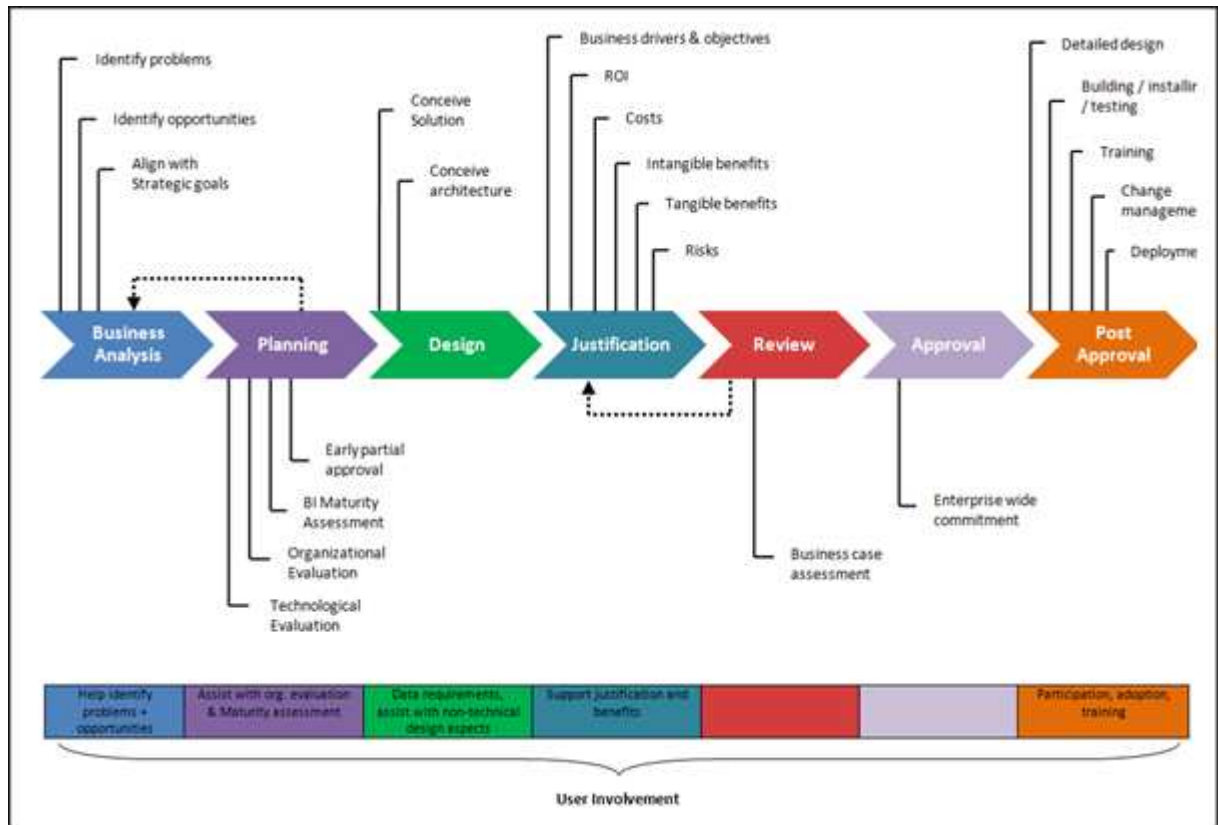
The information that was gathered through answering the four research questions was also used to suggest a roadmap that aims to assist organizations in producing meaningful and insightful justification for real-time BI. The conceptual model in Figure 2 (A roadmap for RTBI justification and implementation planning) aims to provide an answer to the primary research objective:

*“...to produce a roadmap or framework which serves as a guideline for organizations planning on moving into the RTBI sphere.”*

The purpose of the roadmap would be to inform and equip organizations with the necessary information they should know before pursuing such an investment.

A few points are now made about each of the seven phases (Business Analysis to Approval and Post Approval).





**Figure 2:** A roadmap for RTBI justification and implementation planning

**Business Analysis:** The business analysis phase is the first and possibly the most important step in building a successful case for real-time BI. In essence, this is what will drive the investment proposal throughout the entirety of this process. As a starting point, it is vital to identify a business problem that can be overcome, or an opportunity that can be exploited, through the implementation of a real-time BI system.

**Planning:** After completion of the business analysis phase, organizations need to identify what changes will be required in moving forward with the proposal. In doing so, organizations need to assess their own readiness, from a technological and organizational perspective, to move into real-time BI.

A proposal may require partial approval in this phase; so it is important that the business analysis has been conducted in detail, the status quo has been evaluated, and requirements for achieving the desired real-time environment have been understood. At this stage of the process, a preliminary budget may be required, and both IT and business users will be needed to take the proposal forward. If there are concerns regarding the proposal at this stage, organizations may need to return to the Business Analysis phase (illustrated by the dotted line in Figure 2).

**Design:** The Design phase is primarily centred on conceiving solutions for the identified business problem / opportunity, and for the required architecture. For the former, a build or buy analysis may need to be conducted. If, however, the solution is being developed in house, further financial analysis, such as cost-benefit analysis, should be carried out, as well as an assessment of the existing level of internal IT skills and support.

The research found that a suitable architecture is likely to require systems integration, a change in ETL processes, master data management environments, as well as possible deployment of components such as a message-bus and an ODS.

**Justification:** At this stage of the process organizations need to deliver a comprehensive business case that addresses the specifics of the proposed investment. This is a critical component in the process because it

needs to demonstrate, with substantial evidence, what kinds of benefits the investment will yield, and how they will cover the costs of putting the solution in place.

It is critical for practitioners to understand that the justification should be business-driven and not IT-driven.

**Review:** After the business case has been submitted to the relevant stakeholders / investment committee, it will be reviewed for validity of the problems / opportunities being addressed, and for financial and organisational viability. Practitioners, however, also need to bear in mind that the proposal is likely to be competing for resources with other bids. Therefore, if it is not approved at this stage, the business case may need to be re-worked (as indicated by the feedback link in Figure 2).

**Approval and Post Approval:** After successful buy-in has been achieved, including both business and technical approval, several issues still lie ahead. While these are out of the scope of this research, they will briefly be mentioned. First, it is likely that a more detailed and specific design plan will need to be put together. The building / installing and testing phase is expected to be a major task for IT, and will therefore require additional planning, management and coordination. Preparation for implementation may require training and change management practices, particularly at lower levels where users are not accustomed to using analytical environments for decision-making. Deployment of the system will also require significant planning, and it is advised that a staged approach be adopted where possible. Promotion of the right-time or real-time BI concept and the benefits already (being) achieved should be carried out across the organization. At the same time, existing applications should be monitored and feedback obtained to ensure ongoing improvement in real-time BI organizational deployment.

## 7. Conclusion

The research aimed to uncover and understand the key issues involved in RTBI implementation, using a purposive sample of South African companies in different industries. Results clearly cannot be generalised to all companies, South African or otherwise, but hopefully create a greater understanding of many of the factors that should be borne in mind when embarking on RTBI. As with the currently much-hyped theme of big data analytics, careful attention should be paid to the real benefits that might be achievable with RTBI, in relation to the current BI maturity of the organisation, and the costs involved. Companies should also consider carefully whether “near real-time” or “right-time” is appropriate for them and their business environment.

Taking cognisance of these key issues, a roadmap for RTBI justification and implementation planning was also proposed, and it is hoped that this will give a holistic picture of the process that could be followed in creating an appropriate justification for RTBI, and for planning its successful implementation.

Further research could be carried out to examine how the availability of RTBI has impacted on the decision processes of a wider set of organisations. It could also look specifically at organisations that are seriously attempting to apply RTBI to the “big data” situation of expanded velocity, volume and variety, using machine-generated and unstructured and semi-structured data as well as structured data.

## Acknowledgements

This work is based on research partly supported by the National Research Foundation. Any opinion, finding or conclusion or recommendation expressed in this material is that of the authors, and the NRF does not accept any liability in this regard.

## References

- Acker, O., Gröne, F., Blockus, A. and Bange, C. (2011) “In-memory analytics—strategies for real-time CRM”, *Journal of Database Marketing & Customer Strategy Management*, 18(2), 129-136.
- Agrawal, D. (2009) “The Reality of Real-time Business Intelligence” [PowerPoint slides]. Retrieved from <http://birte08.stanford.edu/ppts/08-agrawal.pdf> [Accessed April 2010]
- Andriole, S. J. (2012) “Seven Indisputable Technology Trends That Will Define 2015,” *Communications of the Association for Information Systems*, 30(4). Retrieved from: <http://aisel.aisnet.org/cais/vol30/iss1/4>
- Azvine, B., Cui, Z. and Nauck, D.D. (2005) “Towards real-time business intelligence”, *BT Technology Journal*, 23(3), 214-225.
- Braun, V. and Clarke, V. (2006) “Using thematic analysis in psychology”, *Qualitative Research in Psychology*, 3, 77-101.
- Chan, L-K., Tan, H-K., Lau, P-Y., and Yeoh, W. (2013) “State-of-the-art review and critical success factors for mobile business intelligence”, *Communications of the IBIMA*, Article ID 246123, 1-10.
- Derksen, B. and Luftman, J. (2014) “European Key IT and Management Issues & Trends for 2014”, CIONET Europe.

- Eckerson, W.W. (2004) "The "soft side" of real-time BI", *DM Review*, 14(8), 30-67.
- Goldenberg, B.J. (2008) *CRM in Real Time - Empowering Customer Relationships*. Medford, New Jersey: Information Today, Inc.
- Grigori, D., Casati, F., Castellanos, M., Dayal, U., Sayal, M. and Shan, M.C. (2004) "Business Process Intelligence", *Computers in Industry*, 53(3), 321-343.
- Hackathorn, R. (2004) "The BI Watch: Real-Time to Real Value", *DM Review*, 14(1), 24-43.
- Hang, Y. and Fong, S. (2010) "Real-time Business Intelligence System Architecture with Stream Mining", Paper presented at the 5th International Conference on Digital Information Management (ICDIM), Thunder Bay, Canada.
- Ioana, D. (2008) "Operational and Real-time Business Intelligence", *Informatica Economică*, 3(47), 33-36.
- Kaplan, R. S., and Norton, D. P. (2008) "Using the Balanced Scorecard as a Strategic Management System", *Harvard Business Review*, July-August 2007, 150-161.
- Kappelman, L., McLean, E., Johnson, V., and Gerhart, N. (2014) "The 2014 SIM IT Key Issues and Trends Study", *MIS Quarterly Executive*, December 2014 (13:4), 237-263
- Klein, H.K. and Myers, M.D. (1999) "A set of principles for conducting and evaluating interpretive field studies in information systems", *MIS Quarterly*, 23(1), 67-93.
- Korotina, A., Mueller, O.; and Debortoli, S. (2015) "Real-time Business Process Intelligence. Comparison of different architectural approaches using the example of the order-to-cash process", *Wirtschaftsinformatik Proceedings 2015*, Paper 114. Retrieved from <http://aisel.aisnet.org/wi2015/114>
- Pedersen, T.B., Castellanos, M., and Dayal, U. (2014) "Report on the Seventh International Workshop on Business Intelligence for the Real Time Enterprise (BIRTE 2013)", *SIGMOD Record*, December 2014, 43(4), 55-58.
- Rajterič, H.I. (2010) "Overview of Business Intelligence Maturity Models", *International Journal of Human Science*, 15(1), 47-67.
- Sahay, B.S. and Ranjan, J. (2008) "Real time business intelligence in supply chain analytics", *Information Management Computer Security*, 16(1), 28-47.
- Schneider, D. A. (2006). "Practical Considerations for Real-Time Business Intelligence", In BIRTE Workshop, *Business Intelligence for the Real-Time Enterprises* (1-3). Seoul, Korea: Springer.
- Seufert, A. and Schiefer, J. (2005) "Enhanced Business Intelligence – Supporting Business Processes with Real-Time Business Analytics", In Proceedings of the 16th International Workshop on Database and Expert Systems Applications, (919-925). Copenhagen, Denmark.
- Tank, D.M. (2012) "Reducing ETL Load Times by a New Data Integration Approach for Real-time Business Intelligence", *IJEIR*, 1(2), 1-5.
- Tank, D.M. (2015) "Enable Better and Timelier Decision-Making Using Real-Time Business Intelligence System", *I.J. Information Engineering and Electronic Business*, 1, 43-48.
- Thomas, D.R. (2006) "A general inductive approach for analyzing qualitative evaluation data", *The American Journal of Evaluation*, 27(2), 237.
- Villars, R.L., Olofson, C.W. and Eastwood, M. (2011) "Big Data: What It Is and Why You Should Care", *IDC #228827*, June 2011, 1-14
- Ward, J., Daniel, E. and Peppard, J. (2008) "Building better business cases for IT investments", *MIS Quarterly Executive*, 7(1), 1-15.
- Watson, H. J., Wixom, B. H., Hoffer, J. A., Anderson-Lehman, R. and Reynolds, A. M. (2006) "Real-time Business Intelligence: Best Practices at Continental Airlines", *Information Systems Management*, 23(1), 1-16.

# Organizational Learning and ERP Systems in the post-implementation phase: Where do we Stand? A Literature Review

Gunilla Myreteg

Department of Business Studies, Uppsala University, Uppsala, Sweden

[gunilla.myreteg@fek.uu.se](mailto:gunilla.myreteg@fek.uu.se)

**Abstract:** ERP systems are today implemented in a great number of organizations. Research has invested much energy and time to make descriptions and recommendations regarding how the implementation should best be managed. The next step in practice as well as in research is how to continue to develop the business processes and ERP systems in order to take advantage of all their promises, and to refine how ERP systems are used in day-to-day activities. A starting point for the present study is that organizations today are characterized by strong external and internal pressure. In order to respond to and deal with these, organizations strive to balance demands regarding stability and change. This implies that organizations put effort into designing and maintaining or changing practices, rules and routines. Within the general fields of organization theory and management accounting/control the ambition to create deliberate change is often conceptualized as processes of organizational learning (OL). This concept has also been used in the context of ERP systems. The research field is however heterogeneous and findings are scattered and inconsistent. There is a need for further development of our knowledge about the role of ERP systems in processes of organizational learning after the implementation phase. The present paper strives to consolidate and synthesize the current knowledge. The research question is to what extent and how do research conceptualize organizational learning and its interactions and involvement with the ERP system? The paper is a literature review of research on OL in the context of ERP systems in the post-implementation phase between the years 2005-2015. A total number of 18 research articles were identified. The aim is to analyze and classify previous research, and also to give suggestions for avenues suitable and fruitful for future research. The review compares and contrasts approaches in order to analyze similarities and dissimilarities and to investigate what topics or issues have been addressed by previous research. The analysis shows that overall there is a lack of definitions and stringency in research on OL in an ERP systems context in the post-implementation phase. The final section also forwards some suggestions for future research.

**Keywords:** ERP systems, organizational learning, stability, change, literature review

---

## 1. Introduction

Research on ERP systems has grown over the years. The research topics are several, as is the theoretical foundations of research. The growing numbers of research articles however make our knowledge limited as to how far our knowledge has evolved. Already several years ago research pointed out the need to focus on the post-implementation phase of the projects (for example, Botta-Genoulaz et al. 2005; Gattiker & Goodhue 2005; Shang & Seddon 2002) which is still considered to be a current research topic (Law et al. 2010). There is need of a synthesis of post-implementation research in order to establish what achievements has been accomplished so far, and what studies would need to be further carried out. The phases of an ERP project can be described in different manners, for example as the five phases of design, implementation, stabilization (also called the shake-down phase), continuous improvement, and transformation (Ross & Vitale 2000). In the current paper the three last phases are regarded as post-implementation. A starting point for the present article is that the use of an ERP system implies a continuous change process, where people interact with the technology in every day practice. At the same time the organization is exposed to strong external and internal pressure in a globalized world, which can be characterized as competitive and institutional pressures (cf. Benders et al. 2006). Due to the complexity in these pressures the deployment of an ERP system also may lead to standardization within and between organizations (ibid.). There is thus a need for organizations to balance demands regarding stability and change.

The deployment of ERP systems increases the need for organizations to adjust, to learn to do things in new ways, and even to think in a new manner (Myreteg 2007). The expected benefits of ERP systems can be located in several dimensions: operational, managerial, strategic, IT infrastructure, and organizational, where organizational learning is included as a benefit (Shang & Seddon 2002). The concept of organizational learning (OL) is based on the works of Bateson (1972) and furthered by Hedberg (1981), Argyris and Schön (1978) and Argyris (1977). OL comes about when individuals that acts as agents for the organization are involved in learning activities (Argyris 1977). The use of an ERP system need to be regarded as part of a total organizational development program in order to facilitate learning (ibid., p. 121) which corresponds to a

holistic view of the relationship between IT and the social organizational life (ensemble view; embedded technology; Orlikowski & Iacono 2001).

The dynamic concept of OL is a possible and fruitful starting point for evaluating and synthesizing research regarding the post-implementation phase. The concept holds a broad analytical value and is used in several academic disciplines, such as organization theory and management. We need to further its application in the area of ERP systems. The question in this article is to what extent and how does research conceptualize organizational learning and its interactions and involvement with the ERP system?

The following method was adopted: The review was restricted to the period from years 2005 unto 2015. Articles published in academic journals were searched using web search facilities on the keywords enterprise resource planning and organizational learning, in IS and management research. Based on the abstracts, a further selection eliminated articles about the early phases of ERP projects. A total of 18 articles were selected and analyzed. It is difficult to find agreement on OL and its definitions. Different classifications have been developed, which in the present study are regarded to be complementary rather than exclusive. The paper is structured as follows. The sections below have the ambition to model OL, followed by an analysis and classification on previous research on OL and ERP systems in the post-implementation phase. The review compares and contrasts approaches, striving to identify similarities and dissimilarities, and to investigate what topics or issues have been addressed. Based on this analysis an assessment is made on the standings of research in the field. Conclusions are drawn, and finally some suggestions are made for future research.

## **2. The concept of organizational learning**

The idea of organizations as learning systems is developed from an interest of how information processing is carried out within the organization. Early on, comparison was made with the human brain and important contributions were made by Simon and March as they challenged the assumptions made about the optimizing behavior of individuals (cf the notion of the “economic man”) and concluded that individuals, and organizations, settle for good enough, and thus satisfy needs rather than optimize. Argyris and Schön (1974, 1978) and Argyris (1977) made the distinction between single-loop and double-loop learning. In a single loop, the learning is restricted to an ability to detect and correct errors in accordance to the operating norms that were previously set up (using budgets, performance reports, and deviation analyses). In double-loop learning the set objectives and basic norms need to be repeatedly challenged over time. Instead of being occupied with “keeping the course”, goals and norms are reviewed and changed as needed (Argyris 1977). Many organizations’ control systems are based upon the idea of single-loop learning (using budgets, performance reports, and deviation analyses). More difficult is to achieve double-loop learning, where the set objectives and basic norms need to be repeatedly challenged over time. As the situation and its conditions change the operating norms may become obsolete. Double-loop learning involves understanding this, and having an ability to detect and correct errors that are related to the design of operating norms. Instead of only being occupied with “keeping the course”, the goals and norms are thus reviewed and changed as needed (Argyris & Schön 1974; 1978; Argyris, 1977).

Another approach to organizational learning can be found in organizational research and the concept of organizational memory (e.g. Stein 1995, Stein & Zwass 1995, Walsh & Ungson 1991, Wang 1999). Here, what people learn is collected and saved within a storage device (i.e. the ERP system; cf. Wang 1999) in the organization; the organizational memory. This notion resembles of how Morgan (2006) uses the brain metaphor to discuss learning: the image of the organization as a brain may help us explain how the same process can combine logical reduction and creative expansiveness, or use a parallel high degree of specialization and distributed function. By the use of IT, such as ERP systems, we may process vast amounts of data that is needed in large and complex organizations, and the uncertainty of tasks may be reduced. The concept of OL has found its way into IS research (see for example Martins & Kambil 1999, Robey & Newman 1996, Salaway 1987).

## **3. Organizational learning in previous studies**

Robey et al. (2000) carried out an early review of OL in IS research. They found research either be occupied with OL *about* IT, or with IT designed to *support* OL in practice. With the first is meant studies that investigate the implementation and use of IT itself as learning. Here, studies are occupied with questions regarding the role of experience, how to overcome knowledge barriers, and the dynamics of learning (Robey et al 2000:



128). The other group consists of studies that are concerned with how to design and use IT to achieve learning. Here, IT can be the enabler or a disabler of OL while it supports (or not) organizational memory, communication and discourse (Robey et al 2000: 128). It is thus of interest to separate research into two tracks: one who considers how actors get to learn how to use ERP systems, and another who investigates how ERP systems may be used to support learning. As previously mentioned, the expected benefits of ERP systems may occur in different aspects. Shang and Seddon (2002) distinguish between five groups of expected benefits of ERP systems: operational (tangible benefits linked to business value chain processes and end-results, such as quality), managerial (intangible benefits regarding resource management, planning and decision-making), strategic (mostly intangible issues related to business expansion, product and marketing competition), IT infrastructure (tangible as IT costs, indirect support for business changes), and organizational (mostly intangible benefits linked to work patterns, individual attitudes, interpersonal relations, facilitating OL, empowerment, and common vision). The present article makes use of these to identify what topics the reviewed articles are concerned with. The analysis spurred the need for a sixth group to be added: fit. With fit is meant a fit between the ERP system and the internal environment (the processes) or the external environment of the organization. Studies with this topic not so much investigated the benefits of ERP systems as of how ERP assimilation could be facilitated.

OL as a field can be sorted into different streams. One method of classifying OL research is to separate it by its conclusions into three groups (Dodgson 1993): i) the goals of learning (outcomes), ii) learning as a process or iii) the ways in which learning may be facilitated and impeded. According to a similar classification by Bapuji and Crossan the difference between studying the process of learning (ii) and studying the facilitators of learning (iii) is a difference in perspective. In the present study articles have been classified as a study of OL as a process if the learning was regarded as carried out over time, for example through interaction between different actors, or if the researcher investigated different learning strategies. If the reviewed article tested different types of factor models to investigate what factors were important or not for learning to occur it was classified to the group where facilitators and impediments are regarded as critical (OL as CSF).

Another classification of previous research was made by Lähteenmäki et al (2001). They examined OL research from a critical perspective with the aim to reveal knowledge gaps. They are very critical to the poor achievements in the field. They found that OL conceptualizations were vague, and that very little empirical research had been done. Bapuji and Crossan (2004) however note that empirical OL research has increased, and also judge that the field is maturing. An explanation to, and somewhat a support of, Lähteenmäki et al.'s critical judgment of OL research is given by the review of Shipton (2006). She claims that research with a prescriptive stance towards learning takes as a starting point that there is a positive relationship between learning and firm performance. When Lähteenmäki et al (2001) critically judge earlier research one understanding of this is that they observe, and react upon, this untested positive relationship within prescriptive research. In a critical research vein it would be suitable also to challenge the assumption that OL will lead to benefits; compare this to Argyris' (1977) difficulties to give recommendations of how to overcome the problems regarding how to design a management information system that stimulates learning, and especially a double-loop learning (ibid. p. 121). Shipton further confirms Lähteenmäki et al.'s estimation that there is a lack of empirical testing within this area of research (Shipton, 2006). The present article will in the review of the selected articles investigate whether they use an empirical material for the analysis or not.

The model developed by Shipton (2006) describes research approaches on a continuum from prescriptive/normative to explanatory/descriptive. Combined with the dimension individual or organizational learning, Shipton creates four areas of research with different key features (figure 1). Quadrant 1 represents an idealized view of learning. The other quadrants includes research that is, more or less, critical to the idealized vision. In quadrants 1 and 2 research deals with the anticipated outcomes by learning and with how to transfer learning from individuals to the organization. In quadrant 3 research focuses on identifying changes rather than the outcomes of learning. According to Shipton this perspective is especially concerned with dysfunctional aspects and less than optimum results by learning; these researchers regard learning as an imperfect process (Shipton 2006). In quadrant 4 research is descriptive, which difficulties to draw general conclusions and few practical implications (Shipton 2006).

In her article she describes the model as based on a "continuum". This means that a study can be more or less clearly positioned within a certain quadrant. The present article uses this framework, and the model displays four different positions (figure 1). The reader should thus keep in mind that the boundaries between the

positions are not as strict as the boxes may imply; the four areas are based on a continuum. Difficulties that was encountered in the present analysis was in some instances to separate between the normative and the explanatory perspective. It is possible for research to show traits of both. When conclusions were stated as that the "ERP must be managed" or that an effective ERP assimilation "requires" the organization to act in a specific manner (see Mu et al 2015: 366), or that it is "crucial to --- measure and maximise the ERP impact" (Chang & Chou 2011: 257) the research was classified as normative---even if it also showed signs of explanatory ambitions.

Another difficulty to classify the selected studies was to separate between an individual or an organizational level of learning. Often the research design forces the researcher to collect data on an individual level; for example by sending out questionnaires to a number of respondents. In the present analysis the choice was made to decide the level of analysis based on the discussion and conclusion sections and not on the mode for data collection. Thus, when an article discusses "human agency", "social actors", "individuals", "user", and "users" (see for example Boudreau & Robey 2005; Nwankpa & Roumani, 2014) it was classified as dealing with learning on an individual level. If the article referred to "groups" or "networks" (such as van Fenema et al 2007), or a specific department (for example the IT function; Mu et al 2015) it was marked as treating learning on an organizational level. If discussion and conclusions were made regarding both individuals and groups (see for example Wagner & Newell 2007), or concerns the relationship between managers and users (Boudreau & Seligman 2005), the present analysis has marked the study as taking an interest in organizational level learning.

<p>Quadrant 1</p> <p>The prescriptive perspective</p> <p>Individual learning</p>	<p>Quadrant 2</p> <p>The normative perspective</p> <p>Organizational learning</p>
<p>Quadrant 4</p> <p>The descriptive perspective</p> <p>Individual learning</p>	<p>Quadrant 3</p> <p>The explanatory perspective</p> <p>Organizational learning</p>

**Figure 1:** OL research as four different areas (based on Shipton 2006)

The present study includes the following aspects in the review process: **topic** (six dimensions of benefits with ERP systems), **method** (theoretical, survey, field or case study), **research approach** (prescriptive, normative, explanatory or descriptive), **relationship between ERP and OL** (how users learn about the ERP system, or how ERP can support learning), **level of learning** (individual or organizational learning), and **view of learning** (OL as a process, as related to critical success factors (CSF), or OL as an effect of using ERP).

#### 4. Advances so far: Organizational learning and ERP systems

Research on IT and OL is a growing field, which only some years ago was described as being in its early history (Robey et al 2000). Since ERP systems today are very commonly used in organizations of all sizes, it is important that we increase our knowledge on every aspect of how these systems are used within organizations. In a previous review of articles treating the selection, implementation and use of ERP systems OL as a theoretical concept was found to be little used (Myreteg 2009).

##### 4.1 Classification of research on OL and ERP systems in the post-implementation phase

The literature about ERP and OL in the post-implementation phase is heterogeneous (table 1). 12 treated the relationship between OL and ERP as an issue on group, network, or organizational level of how actors learn how to use ERP (6 kept the discussion on an individual level). Only three studied how ERP systems can be used to support OL. Two of these were empirical, one was theoretical. This is an imbalanced state; research neglects issues concerning how information technology may support OL.

Six articles defined learning as a process, and nine viewed learning as a CSF. Only three studied the implication the ERP system had on OL. Of these, only one took an interest in how ERP, by supporting learning, gave benefits to business operations. The other two studied organizational benefits. Almost all of the identified articles were empirical studies: only two were theoretical. Of the rest, six were case studies (one or several cases), two were field studies, and eight were surveys.

The complete set of articles were analyzed to reveal patterns or trends that could show development of the research area over time (change of interest regarding topic, definition of OL, choice of method, *et cetera*). Two such patterns were possible to spot (table 2). Due to the small number of total articles it is impossible to confirm or corroborate that the patterns reveal a trend, however it is an interesting observation that should be noticed. One pattern is that case and field studies as methods dominated research between the years 2005-2010, while the survey has dominated the last five years of the literature review (N.B.: by the time of writing the year 2015 has not come to an end). The second pattern concerns the view of OL. Research that regards learning as a process or as an effect of the ERP use were carried out in the years 2005-2010. From 2011 and onwards, OL was treated as a CSF in order for OL to come about.

**Table 1:** Analysis of ERP and OL research in the post-implementation phase during 2005 - 2015

Author/-s and year	Topic	Method	Research approach	Relationship ERP-OL and level of learning		View of OL		
				Learn ERP	ERP to learn	process	CSF	effect
Boudreau & Robey 2005	ORGANIZ.	CASE	EXPLANATORY	INDIVID		X		
van Fenema et al 2007	ORGANIZ.	CASE	DESCRIPTIVE	ORG		X		
Graville & Compeau 2008	ORGANIZ.	FIELD	NORMATIVE	INDIVID		X		
Wagner & Newell 2007	ORGANIZ.	CASE	EXPLANATORY	ORG		X		
Boudreau & Seligman 2005	ORGANIZ.	CASE	EXPLANATORY	ORG		X		
Ettlie et al 2005	ORGANIZ.	SURVEY	EXPLANATORY	ORG		X		
Wang et al 2007	FIT	SURVEY	NORMATIVE	ORG			X	
Saraf et al 2013	FIT	SURVEY	EXPLANATORY	ORG			X	
Mu et al 2015	FIT	SURVEY	NORMATIVE	ORG			X	
Chang & Chou 2011	ORGANIZ.	SURVEY	NORMATIVE	INDIVID			X	
Wang et al 2006	ORGANIZ.	SURVEY	EXPLANATORY	ORG			X	
Chou et al 2014	ORGANIZ.	SURVEY	EXPLANATORY	INDIVID			X	
Nwankpa & Roumani 2014	ORGANIZ.	SURVEY	EXPLANATORY	INDIVID			X	
Chen et al 2009	MAN.	CASE	EXPLANATORY	ORG			X	
Wang & Ramiller 2009	IT- infrastr.	FIELD	EXPLANATORY	ORG			X	
Ryu et al 2005	ORGANIZ.	THEOR	NORMATIVE		INDIVID			X
Cotteleer & Bendoly 2006	OPERAT.	CASE	EXPLANATORY		ORG			X
Tomblin 2010	ORGANIZ.	THEOR	EXPLANATORY		ORG			X

#### 4.2 Illustration of the reviewed research by research approach

In the present review, no article was prescriptive research but as many as five were normative (figure 2). Within quadrants 3 and 4 there are a great variety of research approaches (figure 3). Case studies are found in both. Only one article was considered more of a descriptive kind. The biggest share of articles is found in quadrant 3, where researchers explain OL as a problematic process or explain the importance of factors involved in learning. Researchers seem to have listened to the previous calls for more explanatory research about OL as a process (i.e. Robey et al 2002). That this research would be especially concerned with dysfunctional aspects, which Shipton (2006) claims, is however not supported by the present analysis.



**Table 2:** Analysis of articles in order to investigate possible trends over time during 2005-2015

Period	Author/-s	Year	Method	View of OL		
				process	CSF	effect
2005 - 2010	Boudreau & Robey	2005	CASE	X		
	Boudreau & Seligman	2005	CASE	X		
	Ettlie et al	2005	SURVEY	X		
	Ryu et al	2005	THEORETIC			X
	Wang et al	2006	SURVEY		X	
	Cotteleer & Bendoly	2006	CASE			X
	van Fenema et al	2007	CASE	X		
	Wagner & Newell	2007	CASE	X		
	Wang et al	2007	SURVEY		X	
	Graville & Compeau	2008	FIELD	X		
	Chen et al	2009	CASE		X	
	Wang & Ramiller	2009	FIELD		X	
	Tomblin	2010	THEORETIC			X
	Chang & Chou	2011	SURVEY		X	
2011 - 2015	Saraf et al	2013	SURVEY		X	
	Chou et al	2014	SURVEY		X	
	Nwankpa & Roumani	2014	SURVEY		X	
	Mu et al	2015	SURVEY		X	

Quadrant 1	Quadrant 2
The prescriptive perspective	The normative perspective
	Ryu et al 2005 T (three different learning processes)
	Wang et al 2007 S (learning as a knowledge transfer)
	Graville & Compeau 2008 F (software training, learning strategies)
	Chang & Chou 2011 S (learning is a critical factor)
	Mu et al 2015 S (learning as requirement for ERP assimilation)

C: case study

F: field study

S: survey

T: theoretical study

**Figure 2:** Classification of ERP and OL research in full text during 2005 – 2013, based on research perspective: the prescriptive and the normative perspectives.

Quadrant 4	Quadrant 3
The descriptive perspective	The explanatory perspective
van Fenema et al 2007 C (necessitates OL, learning increase)	Boudreau & Robey 2005 C (improvised learning)
	Boudreau & Seligman 2005 C (quality of use)
	Ettlie et al 2005 S (strategic predictors)
	Wang et al 2006 S (knowledge transfer, fit)
	Cotteleer & Bendoly 2006 C (order lead-time improvement)
	Wagner & Newell 2007 C (participation, post-implementation)
	Chen et al 2009 C (project management)
	Wang & Ramiller 2009 F (innovation, community)
	Tomblin 2010 T (theory development)
	Saraf et al 2013 S (absorptive capacity)
	Chou et al 2014 S (post-training self-efficacy needed)
	Nwankpa & Roumani 2014..... S (learning as a capability; user satisfaction)

C: case study

F: field study

S: survey

T: theoretical study

**Figure 3:** Classification of ERP and OL research in full text during 2005 – 2013, based on research perspective: the descriptive and the explanatory perspectives.

## 5. Conclusion and issues for future research

The present article investigated research on OL in the context of ERP systems in the post-implementation phase. The aim was to analyze and classify previous research compare and contrast approaches in order to analyze similarities and dissimilarities and to investigate what topics or issues have been addressed by previous research. A framework for the analysis was constructed based on research on OL in the organization and management fields. 18 research articles were identified and reviewed. They were classified based on what topics were addressed, what methods were used, view of OL, how they constructed the relationship between OL and ERP system, level of analysis, and research approach. The analysis shows great variety in research and the overall impression is a lack of definitions and stringency in the field.

Topics varied from some focusing on management activity, IT-infrastructure, and operational effects, or the importance of fit between ERP and institutional pressures. Mostly they addressed organizational benefits of different kinds (i.e. individual attitudes, interpersonal relations, participation, general use, reinvention, avoidance, and resistance). The vast majority of the identified articles treated the relationship between OL and ERP as how users learn to use ERP, and disregarded how ERP can support OL. A conclusion is that it is truly problematic that we lack research concerning ERP as a support for OL. There is a heavy dominance of studies concerning how to use the ERP system itself, rather than investigating how IT can support learning processes that could have operational, managerial, strategic or organizational benefits. For the promised benefits of ERP

systems to be realized in practice we need to know more about how organizations can use them to support how to work and think in a new manner.

Two patterns over time were spotted: (1) a shift from the use of case or field studies to the use of survey as choice of research method, and (2) a shift from regarding OL as a process or as an effect of ERP system use to regarding OL as a CSF. The two patterns are possibly related: the use of survey as a method give foremost a snapshot imagery of actors and/or the organization---which makes it more appropriate to investigate OL as a CSF rather than to view it as a process. Survey data will be difficult to use in order to say anything about development over time (OL as a process). Because of the small number of articles, it is however difficult to corroborate that the observed patterns represent an actual trend.

The current article suggests future research to better state the topic under investigation: to avoid treating organizational benefits as unspecified, intangible benefits related to attitudes and general usage, and to particularly focus on managerial issues (such as resource management, planning and decision-making) and operational benefits (tangible benefits linked to business value chain processes and end results; quality). This together with the study of how ERP can support OL will make a fruitful avenue for future research. Bapuji and Crossan (2004) and Shipton (2006) concluded that empirical OL research has increased, which is supported by the present study: only two articles were theoretical and the rest used empirical material in some form for the analysis. This would mean that the situation is not as dark as Lähtenmäki et al (2001) feared it to be when they found that very little empirical work had been done.

Previous research has suggested that research should regard OL as a process and disregard critical success factors (Robey et al 2002). Of the reviewed articles six regarded OL as a process, and nine studied CSF. As was previously mentioned, to sort the articles on publishing year further revealed a pattern of that the view of OL as a CSF for OL to occur also is the dominating view from year 2011 up to now. Considering the suggestion made by Robey et al, the development of the research field would benefit if more research applied the view of OL as a process. Furthermore, few of the articles that regarded OL as a process succeeded in illustrating explicitly the relationship between OL and the ERP system. Mostly they discussed learning as an increased understanding of ERP systems. There is still a general lack of precision in accounts of who, when, how and what was learnt, and the role of the ERP system in this. In line with previous calls for research, the present analysis revealed that the majority of research was explanatory. However, the question still remains whether these articles explain the phenomena that are most important for us to understand in order to make sure the promised benefits of ERP systems are realized. The complexity of the ERP system and how that can be understood, how the artifact functions or interplays with the organization and the organizing process, is seldom discussed in greater detail. This can be compared to that Orlikowski and Iacono (2001) showed that studies of IT in organizations seldom make use of what they call the ensemble view, where the IT system is regarded to be developed and used in a complex, dynamic context. They suggested that more research should apply the ensemble view, which is what the present study also states. If learning in organizations, at least partially, depends on the use of enabling technologies (Robey et al 2000), it would be a worthwhile effort to analyze more closely how, when and why an ERP system can be used in this respect.

Further, few of the reviewed articles defined OL as an effect of the use of ERP systems, that is: focused on the role the ERP system played in the organization for its learning. A conclusion is that in order to investigate and reach a full understanding of ERP systems and their role in organizations, it is important that we set our mind at having them play an important role in processes of learning. If research assumes that ERP *contains* a structure that the user must apply, and that there is a “right” or “wrong” way to use the system (cf. Orlikowski & Robey 1991), this means it is sufficient that users learn to use ERP in a “proper way” to have desired results. If research however considers the ERP system to be an artefact that emanates in and is enacted by the actual usage – that is: the system does not contain structures, but users interact with the system and thus *invent and create* its possibilities and embed it into the socio-economic reality of the organization (Orlikowski & Iacono 2001) – it is important that research acknowledges that users and the organization hold the keys to how ERP systems should be designed and used in the specific situation in order to achieve and support OL. Then it is not enough to focus on getting users to learn “how to use the system”, the issue of achieving OL – and especially double-loop learning – runs deeper than that. The definition of the ERP system as an artifact is thus of great importance, just as Orlikowski and Iacono (2001) argues, and needs to receive more attention in future research.

Finally, an observation should be made of the difficulty of carrying out the classification of the investigated articles. The borderlines between the four perspectives, for example, are not obvious. Shipton's (2006) framework is not unambiguous and could be improved. The interpretation of whether the level of analysis is at the individual or at a group or organizational level is difficult to make; organizational learning deals with a situation when individuals acts as agents for the organization and are involved in learning activities (Argyris 1977). This is also one of the strongest critiques to the concept of OL that it is problematic to talk about an organization learning when it is *de facto* the individuals belonging to the organization that learn (see for example Huber 1991). If a broad definition of OL is selected this would imply that all articles that analyze individuals as members of an organization (as separated from individuals as private persons) are investigating learning at an organizational level. Thus, the distinction in the present article between organizational and individual analysis should be regarded as suggestive.

To sum up, the review of research in the field of OL and ERP systems in the post-implementation phase shows a need for further research. It is of great importance that research defines what is meant by OL and how the ERP artifact is defined. Analyses should be more explicitly engaged with the relationship of how ERP systems may support OL, especially focusing on areas of ERP benefits such as operational, managerial, strategic, and organizational benefits. These benefits need to be well defined so that research may contribute with specific theoretical knowledge as well as practically relevant and realizable knowledge. Questions of what role or function ERP systems may or should have in the OL process has so far not been advanced in research. Future research need to be more specific regarding what OL involves. As long ago as 1991 Huber noted the lack of cumulative work and lack of synthesis of work from different research groups in the area of organizational learning. It seems much remains to be done in research in order to correct these deficiencies.

## References

- Argyris, C. (1977) "Organizational learning and management information systems", *Accounting, Organizations and Society*, Vol. 2, No. 2, pp. 113-123.
- Argyris, C. and D.A. Schön (1978) *Organizational learning: A theory of action perspective*. MA: Addison-Wesley.
- Babaian, T and W. Lucas (2013) "Modeling data for enterprise systems with memories." *Journal of Database Management*, Vol. 24, Issue 2, pp. 1-12.
- Bapuji, H. and M. Crossan (2004) "From Questions to Answers: Reviewing Organizational Learning Research", *Management Learning*, Vol 35, No 4, pp 397-417.
- Bateson, G. (1972) *Steps to an ecology of mind*. New York: Ballantine Books.
- Benders, J, R. Batenburg and H. van der Blonk (2006), "Sticking to standards; technical and other isomorphic pressures in deploying ERP-systems", *Information and Management*, Vol. 43, pp. 194-203.
- Botta-Genoulaz, V., P.-A. Millet, and B. Grabot (2005), "A survey on the recent research literature on ERP systems", *Computers in Industry*, Vol. 56, pp. 510-522.
- Boudreau, M.-C. and D. Robey (2005), "Enacting Integrated Information Technology: A Human Agency Perspective", *Organization Science*, Vol 16, No 1, pp 3-18.
- Boudreau, M.-C. and L. Seligman (2005), "Quality of Use of a Complex Technology: A Learning-Based Model", *Journal of Organizational and End User Computing*, Vol 17, No 4, pp 1-22.
- Chang, H.-H. and H.-W. Chou (2011) "Drivers and effects of enterprise resource planning post-implementation learning." *Behaviour & Information Technology*, Vol. 30, No. 2, pp. 251-259.
- Chen, C.C, C.C.H. Law and S.C. Yang (2009) "Managing ERP implementation failure: A project management perspective." *IEEE Transactions on Engineering Management*, Vol. 56, Issue 1, pp. 157-170.
- Chou, H.W., H.H. Chang, Y.H. Lin and S.B. Chou (2014) "Drivers and effects of post-implementation learning on ERP usage", *Computers in Human Behavior*, Vol 35, pp 267-277.
- Cotteleer, M.J. and E. Bendoly (2006) "Order lead-time improvement following enterprise information technology implementation: An empirical study." *MIS Quarterly*, Vol. 30, Issue 3, pp. 643-660.
- Dodgson, M. (1993). "Organizational Learning: A Review of Some Literatures", *Organization Studies*, Vol 14, No 3, pp 375-394.
- Ettlie, J.E., V.J. Perotti, D.A. Joseph and M.J. Cotteleer (2005) "Strategic predictors of successful enterprise system deployment." *International Journal of Operations & Production Management*, Vol. 25, Issues 9-10, pp. 953-972.
- Gattiker, T.F. and D.L. Goodhue (2005) "What happens after ERP implementation: Understanding the impact of interdependence and differentiation on plant-level outcomes." *MIS Quarterly*, Vol. 29, No. 3, pp. 559-585.
- Graville, J. and D. Compeau (2008), "Self-regulated learning strategies and software training", *Information & Management*, Vol 45, pp 288-296.
- Hedberg, B. (1981) "How organizations learn and unlearn", In P.C. Nystrom and W. H. Starbuck (eds.) *Handbook of organization design.*, Vol. 1. New York: Oxford University Press, pp. 3-27.
- Huber, G.P. (1991) "Organizational learning: The contributing process and the literatures." *Organization Science*, Vol. 2, No. 1, pp. 88-115.

- Law, C. C. H., C. C. Chen and B. J. P. Wu (2010) "Managing the full ERP life-cycle: Considerations of maintenance and support requirements and IT governance practice as integral elements of the formula for successful ERP adoption." *Computers in Industry*, Vol. 61, pp. 297-308.
- Lähteenmäki, S., J. Toivonen and M. Mattila (2001) "Critical Aspects of Organizational Learning Research and Proposals for Its Measurement", *British Journal of Management*, Vol 12, pp 113-129.
- Martins, L. L., & Kambil, A. (1999). Looking back and thinking ahead: effects of prior success on managers' interpretations of new information technologies. *Academy of Management Journal*, 42 (6), 652-661.
- Morgan, G. (2006) *Images of organization*. Thousand Oaks, CA.: Sage.
- Mu, E., L. J. Kirsch and B.S. Butler (2015) "The assimilation of enterprise information system: An interpretation systems perspective", *Information & Management*, Vol 52, pp 359-370.
- Myreteg, G. (2007) *Förändringens vindar (Winds of change: A study of actor groups and the art of choosing and implementing an ERP system.)*, dissertation (in Swedish), Department of Business Studies, Uppsala University: Uppsala.
- Myreteg, G. (2009) "Learning to understand what the ERP system is all about: A literature review." The 3rd European Conference on Information Management and Evaluation, Gothenburg, Sweden, 17-18 September 2009.
- Nwankpa, J. and Y. Roumani (2014) "Understanding the link between organizational learning capacity and ERP usage: An empirical explanation", *Computers in Human Behavior*, Vol 33, pp 224-234.
- Orlikowski, W.J. and C.S. Iacono (2001) "Research Commentary: Desperately seeking the "IT" in IT research - A call to theorizing the IT artifact." *Information Systems Research*, Vol. 12, Issue 2, pp. 121-134
- Orlikowski, W.J. and D. Robey (1991) "Information technology and the structuring of organizations." *Information Systems Research*, Vol. 2, pp. 143-169.
- Robey, D., M.-C. Boudreau and G. M. Rose (2000) "Information technology and organizational learning: a review and assessment of research", *Accounting, Management and Information Technologies*, Vol 10, No 2, pp 125-155.
- Robey, D., & Newman, M. (1996). Sequential patterns in information systems development: an application of a social process model. *ACM Transactions on Information Systems*, 14 (1), 30-63.
- Ross, J.W. & M.R. Vitale (2000) "The ERP revolution: surviving vs. thriving", *Information Systems Frontiers*, Vol. 2, No. 2, pp. 233-241.
- Ryu, C., Y.J. Kim, A. Chaudhury and H.R. Rao (2005) "Knowledge acquisition via three learning processes in enterprise information portals: Learning-by-investing, learning-by-doing, and learning-from-others." *MIS Quarterly*, Vol. 29, Issue 2, pp. 245-278.
- Salaway, G. (1987). An organizational learning approach to information systems development. *MIS Quarterly*,
- Saraf, N., H. Liang, Y. Xue and Q. Hu (2013) "How does organisational absorptive capacity matter in the assimilation of enterprise information systems?" *Information Systems Journal*, Vol. 23, Issue 3, pp. 245-267.
- Schön, D.A. (1983) *The reflective practitioner*. New York: Basic Books.
- Shang, S. & P.B. Seddon (2002) "Assessing and managing the benefits of enterprise systems: the business manager's perspective", *Information Systems Journal*, Vol. 12, pp. 271-299.
- Shipton, H. (2006) "Cohesion or confusion? Towards a typology for organizational learning research", *International Journal of Management Reviews*, Vol 8, Issue 4, pp 233-252.
- Stein, E. W. (1995) "Organization memory: Review of concepts and recommendations for management", *International Journal of Information Management*, Vol 15, No 1, pp 17-32.
- Stein, E. W. and V. Zwass (1995) "Actualizing Organizational Memory with Information Systems", *Information Systems Research*, Vol 6, No 2, pp 85-117.
- Tomblin, M.S. (2010) "theory development in enterprise systems and organizational learning." *Journal of Organizational Computing and Electronic Commerce*, Vol. 20, Issue 4, pp. 398-416.
- van Fenema, P. C., O. R. Koppius and P. J. van Baalen (2007), "Implementing packaged enterprise software in multi-site firms: intensification of organizing and learning", *European Journal of Information Systems*, Vol 16, pp 584-598.
- Wagner, E. L. and S. Newell (2007), "Exploring the Importance of Participation in the Post-Implementation Period of an ES Project: A Neglected Area", *Journal of the Association for Information Systems*, Vol 8, Issue 10, pp 508-524.
- Walsh, J. P. and G. R. Ungson (1991) "Organizational memory", *Academy of Management Review*, Vol 16, No 1, pp 57-91.
- Wang, E.T.G., T.C. Ying, J.J. Jiang and G. Klein (2006) "Group cohesion in an organizational innovation: An empirical examination of ERP implementation." *Information and Software Technology*, Vol. 48, Issue 4, pp. 235-244.
- Wang, E.T.G., C. Chia-Lin Lin, J.J. Jiang and G. Klein (2007) "Improving enterprise resource planning (ERP) fit to organizational processes through knowledge transfer." *International Journal of Information Management*, Vol. 27, Issue 3, pp. 200-212.
- Wang, P. and N.C. Ramiller (2009) "Community learning in information technology innovation", *MIS Quarterly*, Vol. 33, Issue 4, pp. 709-734.
- Wang, S. (1999) "Organizational memory information systems: A domain analysis in the object-oriented paradigm", *Information Resources Management Journal*, Vol 12, No 2, pp 26-35.

# Critical Organizational Challenges in Delivering Business Value from IT: In Search of Hybrid IT Value Models

Nazareth Nicolian<sup>1</sup>, Christine Welch<sup>2</sup>, Martin Read<sup>2</sup> and Martyn Roberts<sup>2</sup>

<sup>1</sup>Faculty of Business and Economics, Department of MIS, American University of Science and Technology, Beirut, Lebanon

<sup>2</sup>Portsmouth Business School, Operations and Systems Management Group, University of Portsmouth, UK

[nnicolian@aust.edu.lb](mailto:nnicolian@aust.edu.lb)

[Christine.Welch@port.ac.uk](mailto:Christine.Welch@port.ac.uk)

[Martin.Read@port.ac.uk](mailto:Martin.Read@port.ac.uk)

[Martyn.Roberts@port.ac.uk](mailto:Martyn.Roberts@port.ac.uk)

**Abstract:** This study forms part of a larger research project to explore and analyze the perceived value of IT and the organizational competencies needed to deliver that value. By identifying and evaluating the challenges faced by Lebanese organizations, this paper provides empirical evidence in support of hybrid models of IT value. While process-based IT value models provide an explanation for “how” IT value is created, and what steps occur to create that outcome, they lack the contingency theory found in variance models, which explain “why” IT value is realized, and what variable moderate that outcome. On the other hand, variance models alone are also ill-equipped to explain the greater scope and impacts of IT investments. Hybrid models combine both process and variance perspectives to provide a more comprehensive theory of IT value realization. Structured interviews are conducted with the Chief Information Officers (CIO) of 36 medium and large size Lebanese organizations to discover the challenges faced in delivering value from IT investments. Of the 14 challenges discovered, seven point to the need for process orientated competencies and these include “Change Management”, “Organizational Readiness”, “Relationship Management”, “Benefits Management”, “IT Governance”, “IT Architecture Management”, and “IT Talent Management”. The other seven challenges are variance oriented and point to the factors that inhibit or enable deriving IT value, and these include internal factors, such as: “Family Business Ownership”, and “Budgetary Constraints”, and other external factors, such as: “Political/Social/Economic Instability”, “Telecommunications/Bandwidth Issues”, “Lack of Governmental IT Laws”, “Local Cultural Issues”, and “Immature Local Suppliers/Vendors”.

Rather than continuing an already-saturated research conversation about the dependent variable, “IT Value” and whether IT creates business value, this study contributes to the independent variable research stream - the investigation of “how to derive value from IT, and “when and under which conditions” value is realized, and for conceiving a Hybrid model explaining the IT value proposition.

**Keywords:** IT value Models; Organizational IT competencies and IT challenges; ERP CSFs; CIO

## 1. Introduction

While the predominant source of Information Systems (IS) research comes from the West, there is emerging IS research in developing countries and in the Middle East region. Although the IS literature coming out of Europe and the USA is relevant to the global community of academics and practitioners, valuable insights could be gained from the experiences of companies in other countries and continents. This paper reports the first part of a larger research project to explore and develop theories explaining how organizations derive business value from their investments in IS, and what competencies are critical to sustain that value, within the context of Lebanon. The aim of this paper is to develop a general baseline of the IS landscape in Lebanon, and to explore and assess the key challenges Lebanese organizations face in delivering business value from Information Technology (IT) and to suggest how these challenges point to the need for conceptualizing “hybrid” models of IT value which better inform the IT value proposition. It is important to note that the terms IT and IS are not necessarily synonymous. The former is commonly regarded as a wider term, encompassing human and procedural, as well as technical elements. However, these terms are used interchangeably throughout the literature of value creation, and that is how they are used in this paper also.



## **2. Literature review**

### **2.1 The dependent variable “IT Value”**

Although the focus of this paper is to identify and assess the key factors, and the “independent variables” that affect an organization’s ability to derive business value from IT, it is imperative to begin that quest with a brief review of the “dependent variable” literature. To understand the factors that enable or inhibit getting business value from IT investments, one must understand the value being sought. Although well over 1000 journal articles, conference papers, books, technical notes have been written on the subject of IT evaluation (Bannister and Remenyi 2000), only a relatively small subset of this literature has been concerned with the core issues of what precisely is meant by the term “value”. Bannister and Remeny, (2000) argued that a weakness in much of the current research is the fact that the definition of value is usually unclear, frequently inadequate, often partisan and sometimes completely absent from the discussion.

In answering Keen’s (1980) call for defining the IS dependent variable, and in seeing so much diversity and inconsistency in the definition of that variable, Delone and McLean (1992) (DandM) developed a comprehensive model of that dependent variable, which they called, “*IS success*”. The authors evaluated over 180 references to one or more aspect of IS success to develop a taxonomy which involved the following categories of IS success – System Quality, Information Quality, Use, User Satisfaction, Individual Impact, and Organizational Impact. The significance of the DandM model is twofold: by abstracting the various attributes of IS success, the model confirms the complexity and elusiveness of IS success; and by grouping the various attributes of success, the model facilitates definition, measurement, and ultimate attainment of IS success. The model also implies that IS success is a multi-dimensional construct and that it should be measured as such.

In their updated paper, DandM (2003) evaluated over 300 IS success research efforts that applied, validated, challenged, and proposed enhancements to their original model. One of their key findings is that IS researchers are confused between the independent and dependent variables. They used as examples, “User Involvement” and “Top Management Support” as independent variables affecting the outcome of the dependent variable, “*IS success*”. Based on their evaluation of those contributions, they proposed a minor refinement to the original model, adding the concept of service quality and net benefits. Service quality was added to measure the quality of the service provided by the IT function, or the IT provider. Individual and Organizational Impact were replaced by the concept of net benefits which reflected the positive or negative impact of IS on customers, suppliers, employees, organizations, markets, industries, economies or even society.

Additionally, the term IT business value has been commonly used to refer to the organizational performance impacts of IT, including productivity enhancement, profitability improvement, cost reduction, competitive advantage, inventory reduction, and other measures of performance (Devaraj and Kohli, 2003; Hitt and Brynjolfsson, 1996). General expectations are that IT provides services with better quality at a low cost and low business risk with increased agility (Govekar and Adams, 2010). Kohli and Grover (2008) have defined value as the ability to improve access to information, and the ability to generate value from information, and improving the quality and abundance of information.

The extant “dependent variable” literature alludes to the fact that there isn’t a single agreed upon measure of the impact and value of IT, and there are many stakeholders involved in the IT value proposition, each having different and often competing needs. The business executive’s view of IT value may be different than the view of the corporate IT function, and this in turn, may be different than the view of the actual users of IT, and the view of the other organizational stakeholders, such as customers, partners, and suppliers. While there’s general agreement on the overall expectations, benefits, and resulting business value from IT, there continues to be challenges in delivering that value.

### **2.2 The Independent Variables**

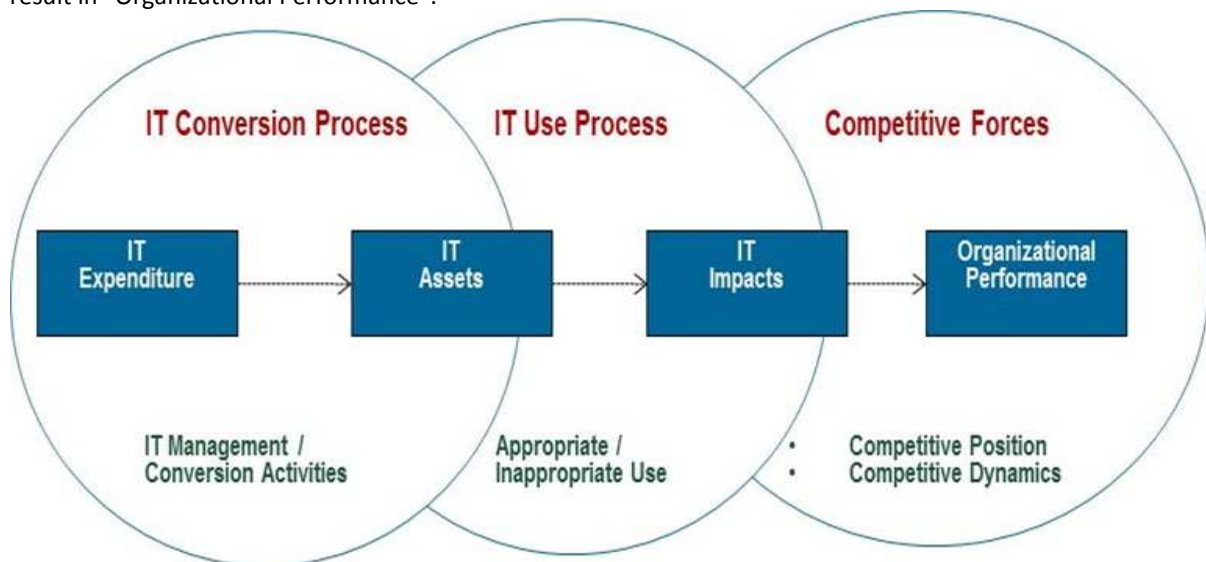
The difficulty in defining the business value of IT, and the multiplicity of meanings associated with the concept of IT value are not the only challenges in the IT value proposition. Agreement on the various factors that impact deriving that value is just as problematic. In order to understand and improve IT value derivation, many authors have developed theoretical models that trace the path from IT investments to business value (Lucas

1993; Sambamurthy and Zmud 1999; Markus and Soh, 1995; Peppard and Ward 2004; Melville *et al.*, 2004; Marshall *et al.*, 2007; Ashurst *et al.*, 2008; Ward and Daniel, 2012). These models provide an explanation of the IT value proposition, in terms of how IT value is created, and what factors contribute to maximizing that value.

The majority of such theories fall under one of three possible categories:

### 2.2.1 Process theories

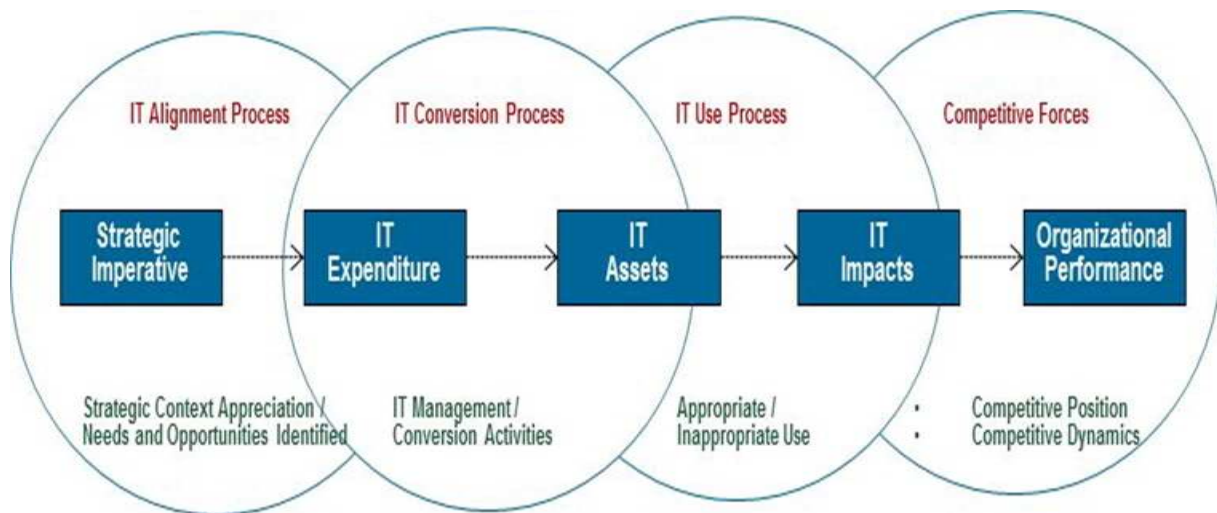
These theories provide an explanation for 'how' something happens, and what steps occur to create that outcome. In a seminal research paper, Markus and Soh (1995) developed a pure process theory of how IT creates business value. The authors move away from earlier research focused on whether IT creates business value, to the question of how, when and why benefits in IT investments occur or fail to do so. The authors conduct a comprehensive literature review of IT value, and synthesize five previously-developed process models to derive at their own process model. The authors claim that IT value, the dependent variable, is delivered in increments, and that each phase of the IT value proposition creates an intermediate outcome. As depicted in Figure 1, the IT value journey is comprised of 3 major processes, and it begins with the “*IT Conversion process*”, converting “IT Expenditures” to “IT Assets”, and is followed by the “*IT Use Process*”, where “IT Assets” are turned into “IT Impacts”, and finally to “*Competitive Forces Process*”, where “IT Impacts” result in “Organizational Performance”.



**Figure 1:** Markus and Soh (1995) – IT Value Model

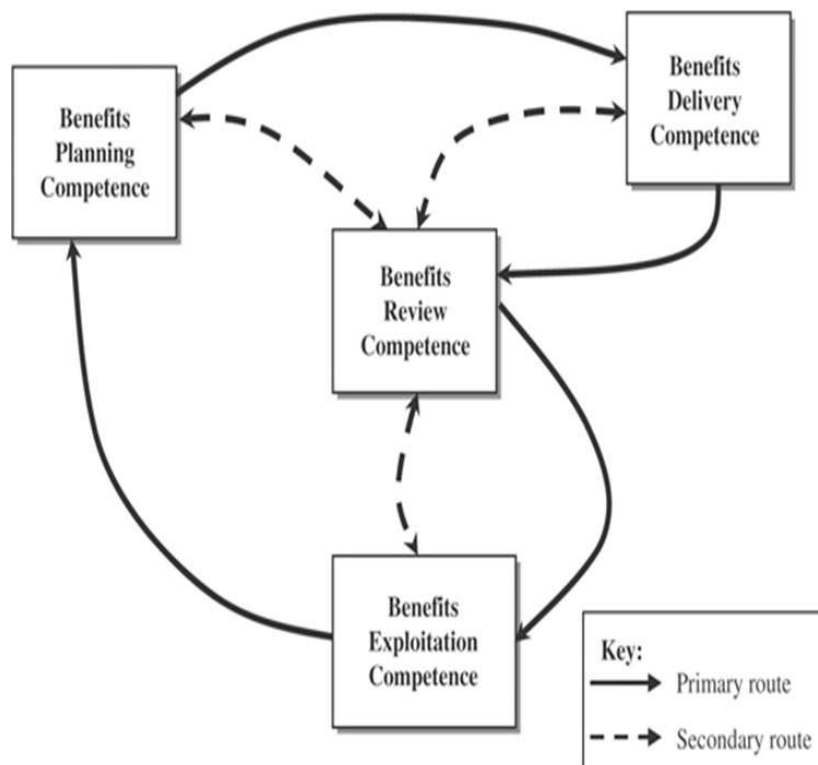
Marshall *et al.*, (2007) analyzed the process model developed by Markus and Soh (1995) and proposed revisions to make the model more comprehensive. The authors added a key process in the beginning of the lifecycle which they called “*IT Alignment Process*”, arguing that “*IT expenditure*” alone cannot give rise to business benefits, and that expenditures need to be linked back to business strategy and business requirements. Therefore, to ensure that the business focus of IT expenditures is both explicitly-recognized and featured in the model, they add the “*Alignment Process*”. The new model is depicted in Figure 2.





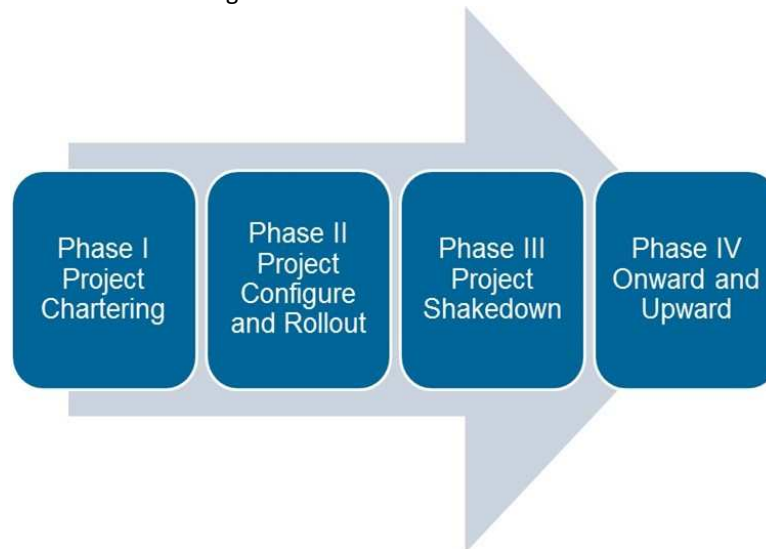
**Figure 2:** Marshall et al., (2007) – IT Value Model

In search for competencies that explicitly contribute to the realization of benefits from IT projects, and heeding the call to develop benefits management practices from Peppard and Ward, (2000), Ashurst *et al.* (2008) developed a benefits realization competence framework that conceptualizes the lifecycle of IT projects as comprising the following key phases: “Benefits planning”, where the planned outcomes of an IT project are identified, and the means of means by which they will be achieved are stipulated; benefits delivery, where the actual design and execution of what they called the “*program of organizational change necessary to realize all of the benefits specified in the benefits realization plan*” takes place. “Benefits review”, where the assessment of the success of an IT project takes place, and where the identification of the ways and means by which further benefits might be realized takes place. “Benefits exploitation”, where what they called ‘*the adoption of the portfolio of practices required to realize the potential benefits from information, applications and IT services, over their operational life*’ take place. Their model is depicted in Figure 3.



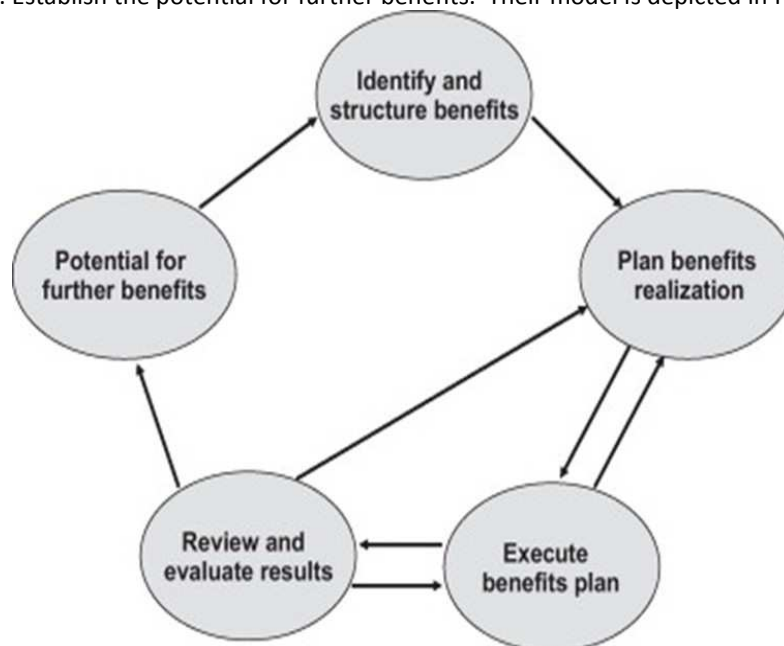
**Figure 3:** Benefits Realization Capability model - Ashurst et al., (2008)

As illustrated in Figure 4, Markus and Tanis (2000) identified four phases in the lifecycle of one of the most complex and potentially the most value-adding IS investment, ERP. The authors define the first phase as the “*chartering phase*”, comprising decisions leading to funding of the ERP project. They define the second phase of their lifecycle as the “*project phase*” comprising system configuration and rollout. The third phase in their lifecycle is called the “*shakedown phase*”, and they define it as the period of time from “going live” until “normal operation” or “routine use” has been achieved. They define the final phase of “*onward and upward phase*” as the on-going maintenance and enhancement of the ERP system and relevant business processes to fit the evolving business needs of the organization.



**Figure 4:** Markus and Tanis (2000) IT Value Model

Ward and Daniel (2012) incorporating their earlier research (2006), developed a process-driven model consisting of 5 major iterative steps: 1. Identify and structure the benefits, which results in developing a business case identifying the objectives for the investment and all potential benefits that could be obtained; 2. Plan the benefits realization containing a full benefits plan and a business case for the investment; 3. Execute the benefits plan, which includes the actual conversion and implementation of business process changes and information system implementation; 4. Review and evaluate the results, which takes place after the implementation is completed, as a post implementation review step, to assess performance and adjust accordingly; and 5. Establish the potential for further benefits. Their model is depicted in Figure 5.



**Figure 5:** The Benefits Management Process Model - Ward and Daniel (2006 2012)

### 2.2.2 Variance theories

Variance theories explain ‘why’ something happens, and what variables moderate that outcome. A major reason businesses fail to realize business value from their IS investments is their lack of appropriate individual and organizational competencies, and not exploiting certain contextual factors. Mohr (1982) coined the term “variance” to describe the way that researchers view the world when they see it comprised of independent and dependent variables. In terms of theoretical concepts, the variance approach focuses on properties of entities, often called variables or factors. It is assumed that these properties can have different values even though the property itself has a fixed meaning. For example, an IT system might have the property “system quality.” The meaning of system quality remains fixed over time even though the values for any given system could change over time (e.g., from high to low) and different systems could have different values at any point in time.

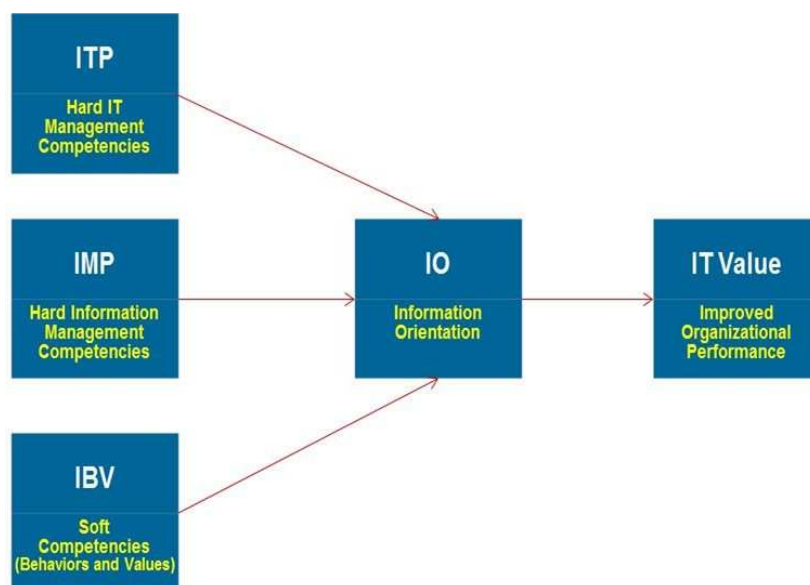
In 2000, Marchand *et al.*, surveyed over a thousand senior managers from 169 senior management teams in 98 companies operating in 22 countries and 25 industries to discover how the interaction of people, information and technology affect business performance. The authors proposed their model as a new instrument to measure the effectiveness of organizational information use, comprising the following three elements:

*Information technology practices (ITP)*, which describes the capabilities of a company to effectively manage IT applications and infrastructure to support their business operations, business processes, managerial decision making, and innovation.

*Information management practices (IMP)*, which describes the capabilities of a company to manage information effectively over the lifecycle of information use, this lifecycle includes sensing information, collecting information, organizing information, processing information, and maintaining information.

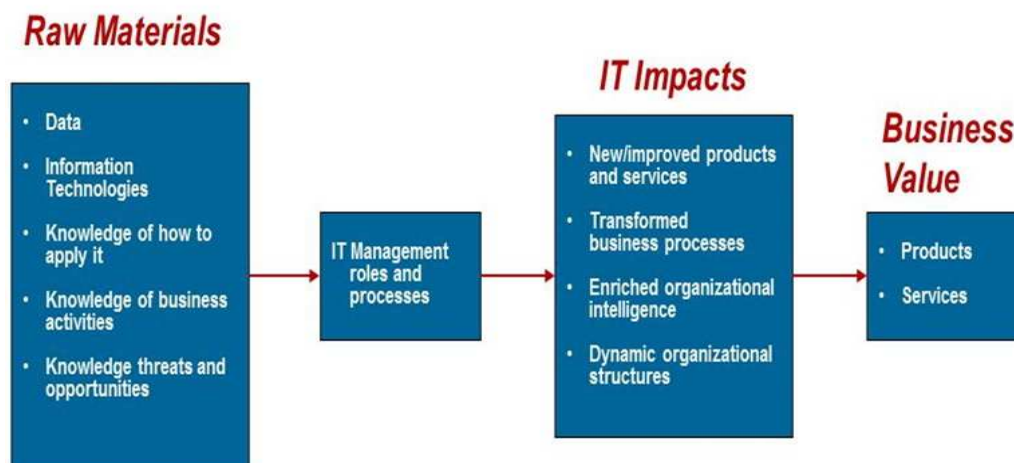
*Information behaviors and values (IBV)*, which describes the capabilities that promote behaviors and values (information culture) in its people for the effective use of information.

The Marchand *et al.* (2000) model is adjusted in Figure 6 to conceptualize the theoretical constructs of the model. The model is a variance theory linking certain organizational competencies - Hard IT Management (ITP), Hard Information Management (IMP), and Other Soft Behaviors and Values (IBV) - to organizational performance. In order to improve organizational performance (dependent variable), organizations must develop these organizational competencies.



**Figure 6:** The Marchand et al., (2000) Adjusted Information Orientation Model

As Figure 7 illustrates, in the Sambamurthy and Zmud, (1999) model, raw materials (technology, knowledge, data), as well as resource competencies (knowledge of how to apply IT, and knowledge of business activities) enable the creation of intermediate “IT impacts” (new/improved products and services, transformed business processes, enriched organizational intelligence, and dynamic organizational structures. This implies a necessary and sufficient relationship between IT management competencies and “IT impacts”: the greater the competencies, the greater the impact. According to the authors, “IT impacts” eventually lead to business value and improved organizational products and services, but the authors do not elaborate on how “IT impacts” create ultimate business value, and what processes or conditions are necessary to create that final outcome. Although the authors mention the need for IT management processes as a condition to create “IT impacts”, they do not elaborate on such processes, and therefore, the model appears to be a variance theory of IT management competencies and “IT impacts”.

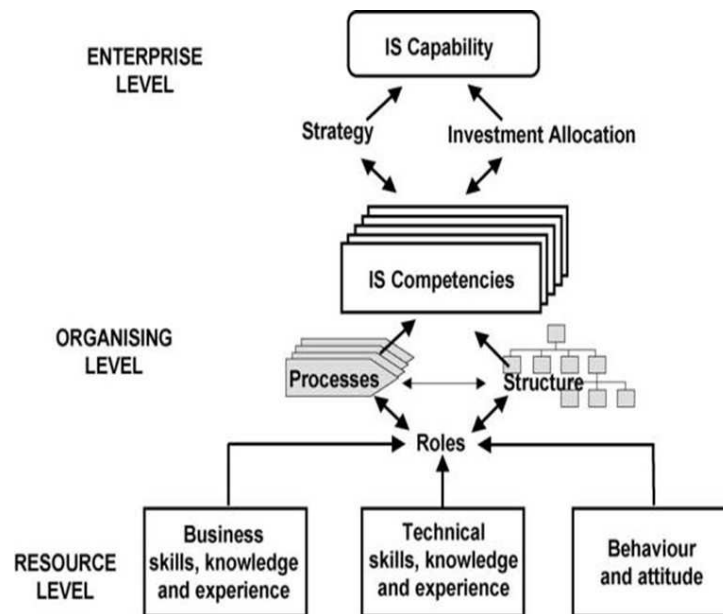


**Figure 7:** Sambamurthy and Zmud (1999) model of IT Impacts

Peppard and Ward (2004) used the Resource-Based-View (RBV) theory of the firm and grounding their research with the prior work done by Peppard *et al.* (2000) developed a model representing the components of what they called “The IT Capability”. The model has three levels: the resource level, the organizing level and the enterprise level (see Figure 8). The resource level denotes the resource components that are the key ingredients of the IS competencies. In managing IS, these resources are the skills, knowledge and behavioral attributes of both employees and external providers. The organizing level is concerned with how these resources are mobilized and marshaled via structures, processes and roles to create IS competencies. It is, however, only at the enterprise level the authors contend that the capability actually manifests itself and is ultimately recognized in the performance of the organization.

Compared to the earlier model of IS competencies developed by Peppard *et al.* (2000), this model presents a notable improvement. The “IS capability” in their model is the dependent variable, and all the other factors listed are the independent variables. Organizations mobilize resources and arm these with the proper organizational processes and structures to create an intermediate outcome - IS capability - which in turn may be used by firms to improve their performance.

At first glance, the model appears to be a hybrid model, combining both process and variance orientation. However, a closer look reveals that the process component does not really address how IT value is created, and does not offer a recipe-like sequential process of how value is created. Although the authors allude to a process construct, they use that more as a factor or variable, and therefore, their model appears to be more of a variance theory, linking various factors, such as individual resource competencies, organizational competencies, and organizational structures as key variables affecting IT value generation (in their case leading to an IT capability).

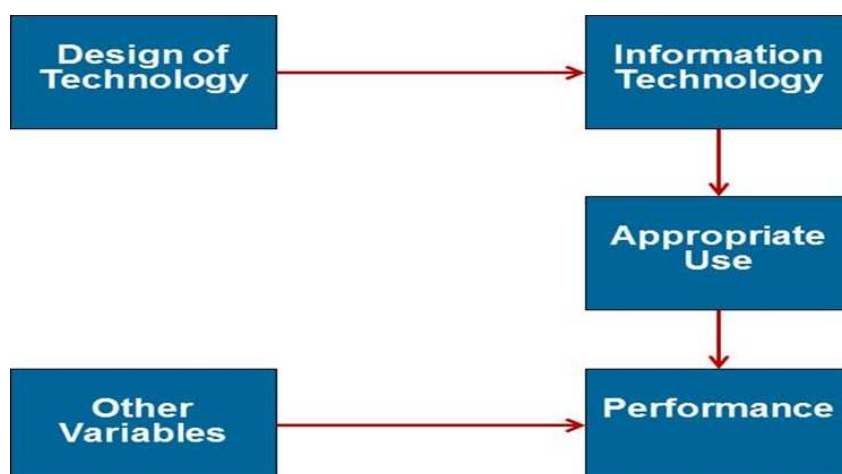


**Figure 8:** A model of the IS capability adapted from Peppard and Ward (2004)

### 2.2.3 Hybrid theories

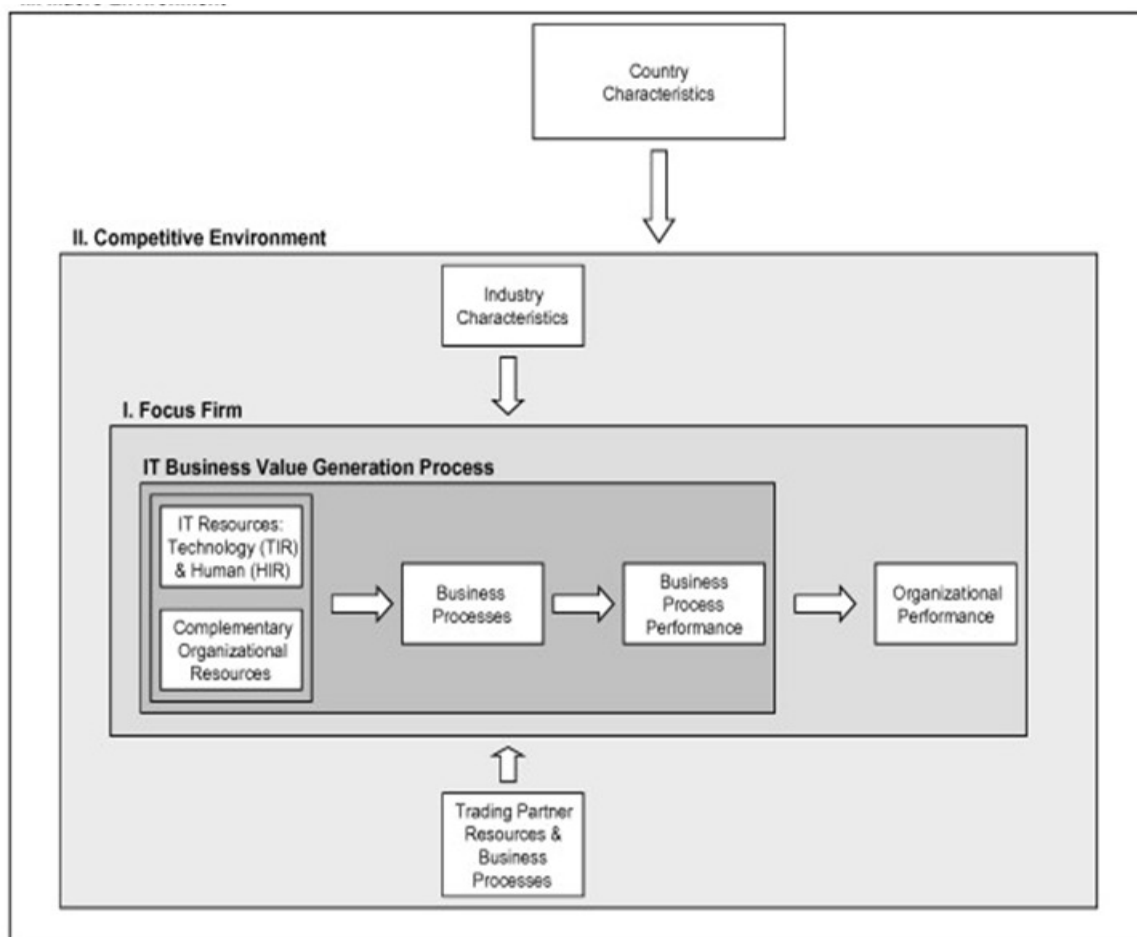
In order to provide a more comprehensive explanation of the IT value proposition, in terms of the processes, as well as the factors that enable and maximize business value, a few authors have developed hybrid IT value models (Lucas, 1993; Melville *et al.*, 2004). Burton-Jones *et al.*, (2011) elaborate the many benefits that hybrid approaches provide to theory-building in IS research, and these include: improving understanding of concepts (whether the state of an entity is affected by events or processes), and improving understanding of relationships (the process by which a relationship among properties occurs).

As Figure 9 illustrates, Lucas (1993) is concerned with how (process) IT increases firm performance. He proposes two conditions, occurring in sequence, leading to the performance outcome. The first, necessary but not sufficient, condition is that IT be designed in such a way that it fits the firm's task effectively. An effective IT design is not, however, sufficient for organizational performance improvement, because technology cannot improve organizational performance unless the technology is used. Therefore, appropriate use of an effectively designed technology is also a necessary condition for improved organizational performance in Lucas' model. Lucas acknowledges that factors other than appropriate use of an effectively designed technology may influence firm performance (e.g., competitor's reactions).



**Figure 9:** IT Value Model – Adapted from Lucas (1993)

In one of the most-cited IT value research papers, Melville *et al.*, (2004) use the RBV of the firm to develop a descriptive model of the IT business value generating process integrating the previous strands of research into a single framework. One of their principal findings is that IT is valuable, but the extent and dimensions are dependent upon internal and external factors, including complementary organizational resources of the firm and its trading partners, as well as the competitive and macro environment. The authors suggest that if the right IT is applied within the right business process, improved processes and organizational performance result, conditional upon appropriate complementary investments in workplace practices and organizational structure and shaped by the competitive environment. The authors' IT Value model comprises three domains. The first of these is the "focal firm", which is the organization acquiring and deploying the IT resource firm. Within the focal firm, IT business value is generated by the deployment of IT and complementary organizational resources such as policies and rules, organizational structure, workplace practices, organizational culture, non-IT physical capital resources, non-IT human capital resources, and what they call organizational capital, e.g., formal reporting structures and informal relationships within and among firms. The authors separate the second domain, "competitive environment" into two components: industry characteristics and trading partners. In industry characteristics, they include competitiveness, regulation, technological change, and other related factors. The authors suggest that when IT spans firm boundaries, the business processes, IT resources, and non-IT resources of trading partners play a role in the IT business value generation of the focal firm. According to the authors, the third domain, "macro environment", denotes country- and meta-country- specific factors, which include government promotion and regulation of technology development and information industries, IT talent, information infrastructure, as well as prevailing information and IT cultures. The model is depicted in Figure 10.



**Figure 10:** IT Business Value Model (Melville et. al 2004)

Schryen (2013) conducted a comprehensive review of the IS Value literature and found that the value creation process remain unclear in terms of how, why and when IS assets and organizational capabilities are transformed into business value. The author indicated that IS business value theory building and testing as one



of the key challenges of future research, and argued that the best theories of IS Value are “hybrids”, combining the best qualities of “Variance” and “Process” orientation.

### **2.3 Additional factors affecting IT Value Derivation**

In the quest to find the “silver bullet” for deriving business value from IT, scholars and researchers have prescribed a number of different cures. Some advocated the use of IT Governance (Marshall et al, 2007; Sambamurthy and Zmud, 1999; Peterson, 2004; Avison et al (2006); Weill and Ross, 2004). Others have suggested the use of formal benefits management processes to manage value throughout the lifecycle of the IT value proposition (Peppard, 2007; Ward and Daniel, 2008).

There is also a large body of research evaluating individual competencies needed by the Corporate IT function and the CIO. Periasamy and Seow (1998) identified five critical success factors for the CIO to deploy IT to deliver optimal value to his organisation promptly and successfully. Lane and Koronios (2007) found that the role of the modern CIO has become increasingly business focused and strategic, and that soft skills dominate the critical competencies. Polansky et al. (2004) presented a 10 Point Leadership Agenda for CIOs, which comprised IT strategy; IT governance; IT organisation and staffing; technology and architecture; technology awareness; corporate governance; business intelligence; business transformation; customer care; and Internet and e-business. CSC (1997) defined six leadership roles for the CIO (e.g. Chief Operating Strategist) and Remenyi et al. (2005) used the analogy of the Chameleon to describe the key characteristics of CIOs (e.g. the ability to change). Chun and Mooney (2009) found that much of CIO role has evolved to the executive-level management and is centered on working with other business executives inside and outside of the firm to change the firm’s strategy and processes.

A stream of research has looked beyond the individual competencies needed by CIOs and the corporate IT function, and stressed the importance of user-related and other contextual attributes as contributing factors to IS success. Sabherwal et al. (2006) developed and tested a comprehensive theoretical model linking IS success with four user constructs (user experience with IS, user attitude towards IS, user training in IS, and user participation in the development of IS), and two constructs representing the context (top-management support for ISs and facilitating conditions for ISs). Several authors (Armstrong and Sambamurthy, 1999; Feeney and Willcocks 1998; Sharma and Yetton, 2003; Salvage and Dhanda, 2007) emphasized the importance of non-CIO executives taking an active role in the planning of IS. Peppard and Ward (2004) argued that competence is an organizational concept that reflects a bundle of skills and technologies while capabilities are related to the strategic application of competencies in order to achieve business objectives.

Furthermore, a number of researchers have highlighted the impact of human/social factors within business organizations. Nissen (2002) points out that the concept of ‘user’ may not be a helpful one in the context of an IS value proposition, since it serves to insulate system developers from the needs of real business professionals. Few people, he suggests, would define themselves as users of IT, but as accountants, sales personnel, storemen, etc. Furthermore, they are not simply ‘consumers’ of information systems, but co-creators. As Ward and Peppard (2002) point out:

*As the benefits management process proceeds, it may cause revision to the specification, and it is assumed that effective change control processes can deal with this. The other related set of activities are organizational changes of many types that have to be made to deliver the benefits. The benefits management process should be the driving mechanism for these change activities. How to bring them about in detail is addressed in the wealth of change management and organizational development literature (2002, p.441).*

While most researchers have concentrated on rational choices involved in IT/IS deployment, this does not always reflect the whole picture. The affective zone can also have an impact on benefit realization, but this factor is often swept up into consideration of ‘change management practice’. Argyris (2004) describes how ‘defensive routines’ can arise in organizational behavior. When faced with the need to address uncomfortable choices or deliver ‘bad news’, people may wish to avoid awkwardness or confrontation, and thus become quite skilled in what Argyris calls ‘skilled incompetence’. In a magazine article, Williams (2007) reported on research commissioned by the IT Governance Institute. 52% of the projects sampled were expected to lead to negative returns, while 31% actually destroyed value for the companies concerned, yet only 3% of projects were



abandoned before completion. This suggests that managers were continuing to preside over projects knowing that they would destroy, rather than create business value. Williams reflects that this cannot be accounted for through rational management decision-making, but suggests reluctance by managers to cancel when this might be seen as a sign of weakness and failure.

## 2.4 The country-specific CIO experience

A number of other authors have explored the challenges faced and competencies needed by CIOs within the context of a particular country. For example, to understand the individual competencies required of CIOs in Brazil, Vreuls and Joai (2011) evaluated seven competency models found in literature and used a pure quantitative approach to identify CIO competencies from the perspective of Brazilian CIOs. They concluded that CIOs should possess/develop knowledge of the business; understanding of the organizational context; the ability to influence the organization; technical expertise; external networking; management of the information technology operation and the capacity to innovate using new information technologies. Reviewing 3 large Australian IS projects and their failures, Avison et al (2006) found that managerial IS unconsciousness and failure in IS governance, defined as patterns of authority for key IS activities in firms, including IS infrastructure, IS use and project management can even lead to the bankruptcy of private companies and the waste of millions of dollars of taxpayers' money. The authors also argued that the importance of IS governance is largely ignored in the failure literature (Avison and Wilson, 2002).

Zuo and Maou (2005), carried out the first academic study in China with regard to CIO state and impact. The Chief Executive Officer's (CEO) perspective in that study was that CIOs need to be more business-oriented, requiring soft skills and relationship management skills. Using a different approach, Gottschalk (2000) looked at CIO roles in Norway, which led to the identification of required competencies. Oracle conducted a study in 2011 and included information from a number of regional CIOs/organizations (e.g. Saudi Arabia, Emirates, Jordan, Dubai, India and other emerging markets). They found that the IT knowledge and competency of non-IT people (general Management and the users) is weak and that CIOs are surrounded by executives who have an inadequate awareness of IT capacity.

## 3. Data collection

The data in this paper has been collected from interviews with the CIOs of the participating organisations. Two interviews with each of the participating CIOs were conducted, followed by an offline collaboration process, using email as the platform to confirm and to prioritize the challenges raised during the interviews. Next, a one day forum was organized allowing the CIOs to meet each other and to collaborate real-time on the key challenges. The forum was also used as an opportunity to plant the seeds for a more permanent platform for CIO collaboration and for future research, which ultimately resulted in the formation of the "*CIO Lebanon Association*" officially approved by the Lebanese Ministry of Interior.

Data from Kompas (2009) was initially used to identify the total population of industries and organizations. Subsequently, a sample was selected to include organizations that represented the four key industries in Lebanon: Banking, Healthcare, Higher Education, and Retail (77% of the sample included such companies). It was also important to choose organizations that had significant experience in IT/IS, and with no prior IS studies to reveal that population, organization size (no. of employees) was used as a substitute to select the participants (35% of large organizations and 8% of medium size organizations in Lebanon were included in the sample), (See Tables 1 & 2):

**Table 1:** Lebanese organizations and sample used

	Total for Lebanon	Sample
No of Organisations > 500 employees	78	26
No of Organisations 250 - 500 employees	122	10

**Table 2:** Participating organizations

Sector	Sample
Banking	11
Healthcare/Hospitals	6
Higher Education	6
Airline carrier	1
Post office	1
Retail	5
Telecommunications	1
Printing	1
Logistics	1
Pharmaceuticals	1
Food & Beverage	1

## 4. Results

A total of 14 key challenges were identified and categorized as either “process-related”, i.e. ways and means of deriving value from IT investments, or “variance-related”, i.e. factors that affect getting maximum value from IT. Process-oriented challenges included:

### 4.1 Change resistance and the need to manage change

The majority of CIOs indicated that it was very difficult, costly and time consuming to implement business process changes and related behavioral changes in their organizations. This was by far one the most important challenge raised. The CIOs attributed this challenge to a number of factors, including: ownership of IT projects resting upon the IT function; not adopting formal change management processes; lack of IT literacy of users and management; having powerful users with self-serving and hidden agendas; lack of having change champions, and the lack of CIO empowerment.

### 4.2 IT illiteracy of management and users and the need for organizational readiness

While this was generally less of an issue in some sectors (e.g Higher Education), this was a major issue preventing the majority of participating organizations in getting maximum value from IT. The CIOs of organizations that had this issue attributed it to a “*generational gap*” claiming IT illiteracy among their older employees who were still in charge of key management positions. Other CIOs blamed the Higher Education sector in Lebanon for not preparing future managers adequately in the use and exploitation of IT. While most of the participating organizations had developed employee training programs, the training was more oriented to developing general IT literacy competencies, rather than developing IT planning, exploitation, and value extraction competencies.

### 4.3 Inadequate CIO to CxO relations and the need for better relationship management processes

The title of CIO was only given to four of the participants, while others held a number of other titles, including Director of IT, Head of IT, and IT Manager. Three of the CIO positions were in the Banking sector, and one in Higher Education. More than half of the participants reported directly to the top executive. 80% of the CIOs in the Banking sector reported to the Chief Operations Officer (COO), and only one of the CIOs in the Higher Education industry reported directly to the President, the rest reporting to the VP of administration position. In other sectors, it was a mixed bag, with some CIOs having direct access and strong relationships with their CEOs, and others reporting to lower level executives and therefore lesser potential impact on their organizations. Where the relationship was direct, the CIOs enjoyed a strong and productive relationship, resulting in an equal seat at the executive table and a direct involvement and impact to their organization's strategy. Many of the CIOs who did not hold that title, or did not report directly to their CEOs expressed a deep concern and attributed this issue to the lack of appreciation of the strategic value of IT within their organizations.

### 4.4 Lack of formal and comprehensive benefits management processes

None of the participants had implemented a comprehensive benefits management program. While some (25%) had developed formal processes at the early stage of planning IS investments (by using business cases),

and others (50%) had formal project management practices during the implementation stage of IS projects, none had any meaningful management practices at the post implementation stage. It also seemed that the majority of companies and their management were not interested or capable of accurately measuring the value of their IS investments. Of those companies that were measuring, the focus was either on project efficiency measures (in-flight, or during IT project implementation metrics) such as: delivery of projects on time, on budget, and according to customer scope and requirements; or the focus was more on IT operational measures (availability, throughput, and response time).

The majority of CIOs were also struggling to convince their users to own or at least co-own the responsibility of deploying information systems and more importantly the responsibility of reaping the benefits from such investments. In addition, the business value of IT was poorly defined and vaguely understood and not common to all stakeholders within the organization. More than 40% of organizations viewed IT as a cost center, rather than as a partner in generating value.

#### **4.5 Lack of formal IT governance**

While a number of organizations, especially the ones in the Banking sector have instituted structural forms of governance, in the forms of organization-wide IT steering committees to approve and manage enterprise IT projects, IT decision rights were, in the majority of organizations, owned and exercised by the Corporate IT function. Many of the CIOs attributed this to the lack of technology literacy of their Management and users. There was also an emergence of enterprise-wide Project Management Office (PMO) structures in a few organizations, but these were in their very early stages. The PMO function either did not exist (75% of cases), or was just being implemented.

#### **4.6 Complex IT applications architectures and the need for IT Architecture Management**

The applications architecture (AA) construct is a conceptual model representing departmental and enterprise information systems in support of operational business processes and analytical decision-making. The challenge as described by the CIOs was that their AA was very complex, difficult to support, did not fully support their business strategy, and was not flexible. The most significant issues include:

- Legacy information systems built with antiquated ICT technologies.
- ERP systems that have been heavily customized and no-longer supported by ERP vendors. Almost every CIO indicated at one time or another having difficulty and/or failing to implement enterprise applications. Two of the major retail organizations had customized their ERPs to the point where it was impossible for them to upgrade to a new version of the ERP.
- The majority of CIOs did not have a clear AA roadmap or strategy, and even if such a roadmap existed, it was not a formal planning process linked with their overall business planning process.

#### **4.7 IT talent management issues and the need to have better IT Management**

This was mentioned as a key issue by more than 70% of the participants, and it was a more acute issue when it came to finding senior level people. A number of the CIOs felt that this was a much bigger issue 5 years ago when talent was being lost to higher-paying markets outside of Lebanon. However, due to the economic problems in the Gulf, and the relative stability in Lebanon, CIOs felt that this issue was more under control.

The list of other “variance-related” challenges included:

#### **4.8 Family business ownership**

With the exception of organizations that were owned by religious entities (three Hospitals and three Universities), or public organizations (two were involved in this study), or organizations that weren’t family owned (two Universities, and two other organizations), all remaining 26 organizations were family-owned, which constituted 72% of the participating organizations.

The predominance of family business ownership is one of the characteristics of the Lebanese economy. In family firms, property and control are so firmly entwined that family members are involved in both strategic and day-to-day decision making, and the firm is shaped by dynastic motive. As evidenced by this research, the

family impact extends to large organizations, and many organizations in the thriving banking industry, for example, were closely held by extended families. Five of the family-owned organization felt that family-ownership was a positive situation because it involved leaders who were also owners that cared about the longevity and long-term viability of their firms, as opposed to leaders that were only in these positions to establish short term gains. All remaining family-owned organization CIOs indicated serious disadvantages arising from family ownership, such as unfair and inconsistent human resource policies in the recruitment, selection, and promotion of employees.

#### **4.9 Budgetary constraints**

This was more of a challenge in the Healthcare sector, as most of the organizations in this sector had cash flow issues due to significant delays in receiving remittances from the Government. The CIOs in the Healthcare sector indicated that the biggest share of their revenues came from government-insured patients (75%), and only 25% of their patients had private insurance. This was also a challenge in smaller organizations.

#### **4.10 Political, economic, and social instability**

Lebanon has witnessed many devastating wars before and after its independence from France in 1943. The most devastating recent war lasted for over fifteen years beginning in 1975. Another recent war in 2006 resulted in the destruction of the majority of the country's infrastructure. Since 2006, the country continued to experience many additional conflicts inside the country and throughout its surrounding neighboring countries. Many of the CIOs expressed total frustration and lack of control over these issues and found this to be the most serious challenge they faced.

#### **4.11 Telecommunications issues**

During the initial interviewing process, this challenge clearly emerged as the top challenge among most CIOs. Issues related to the reliability, availability, and cost of Internet bandwidth was a key concern. This even resulted in three of the organizations having to compromise the architecture of their core ERP system. The affected organizations had several branches in the region, and have deployed an ERP product in a totally decentralized architecture/approach. Had they had more reliable and affordable Internet access, they would have chosen to deploy these ERPs using a centralized architecture/approach.

#### **4.12 Lack of Governmental IT laws**

One of the key issues raised by the majority of CIOs is the lack of any governmental ICT legislation regulating and protecting the electronic rights of organizations and consumers.

#### **4.13 Local culture issues**

This was mentioned by the majority of CIOs as a key and possibly detrimental factor in not only getting business value from IT, but in getting any value from the business. Three of the CIOs that are currently engaged in re-engineering their entire organization spend the majority of their time (one CIO indicated that it is as high as 70% of their time) dealing with and managing cultural transformation. The issue of "entitlement" was dominant in larger organizations, and in organizations that were family-owned.

#### **4.14 Immaturity of local suppliers, vendors, and partners**

All CIOs indicated their dissatisfaction with local professional services organizations, and expressed a need and commitment to help improve these vendors' service levels. Also of deep concern in the Hospital sector was the lack of ICT competence in doctors, which created a key challenge in rolling out IT applications and services. In the Higher Education sector, there were similar issues with Faculty members who did not want to be involved in the planning, implementation or roll-out of applications, and when it came to using such applications, they abdicated that responsibility to their assistants.

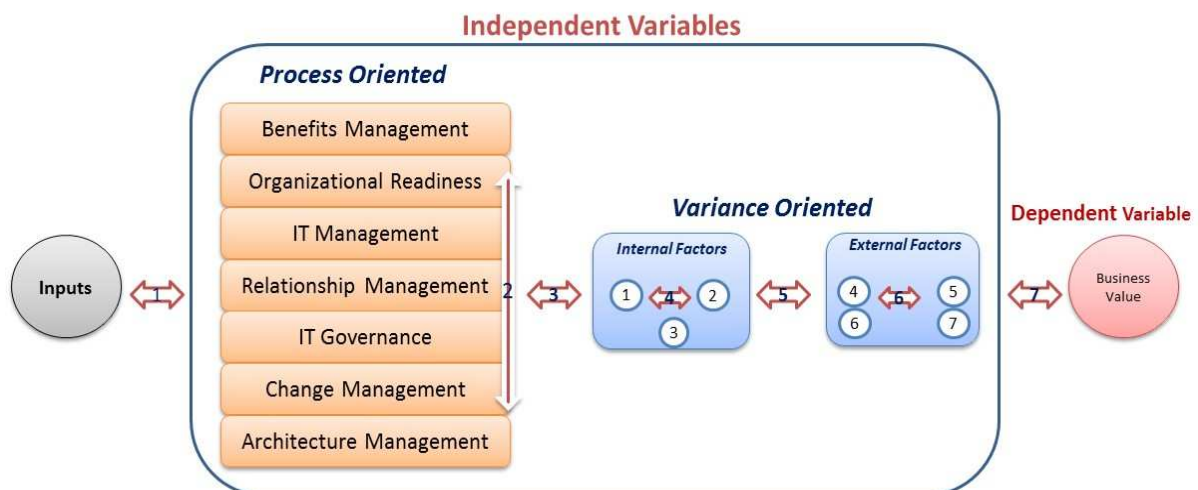
### **5. Conclusions and future steps**

The challenges in deriving business value from IT suggest the necessity to develop certain organizational competencies. While these reflect the Lebanese CIO experience, many of these challenges and related competencies have also been found in the extant literature. As Figure 11 illustrates, some of these

competencies may be classified as process-oriented (“how to derive value from IT”), and others are competencies that require organizations to mind, mitigate, and exploit certain internal and external organizational factors (“when, how, and under what conditions IT value is derived”). Process-oriented competencies are critical; however, they are not enough, and should be complemented by variance-oriented competencies. The need for both types of competencies justifies the use of “Hybrid” models of IT value. The conceptual model that emerges from this study is preliminary and is grounded in the data gathered from key Lebanese CIOs. Future studies should engage with other CIOs, in and out of Lebanon, and with all the other stakeholders involved in the IT value proposition, be it Management, users, vendors, and other key stakeholders, to refine and adjust the model.

The arrows in Figure 11 refer to the various strands of future research that should be conducted. Arrow 1 suggests identifying the inputs driving the entire value proposition, and investigating the relationships between such inputs and the rest of the model. Arrow 2 calls for investigating three aspects of the process part of the model: identifying the sequence (if any) of activities; identifying additional possible missing activities; and investigating the relationships between these activities. Arrow 3 suggests investigating the relationships between the process and variance components of the model. Arrow 4 calls for investigating the relationships between the various internal factors, and also the need to identify additional such factors that impact the value proposition. Arrow 5 calls for investigating the relationships between the various external factors, and also the need to identify additional such factors that impact the value proposition. Finally Arrow 7 suggests investigating the relationships between the independent variables (process and various components) and the dependent variable, “IT Value”. While there is an abundance of literature about the dependent variable itself, additional valuable insights may be gained by continuing the benefits management research agenda developed by Peppard and Ward (2007), and Wards and Daniel (2006, 2012). Finally, future research should also compare and contrast the emerging IT value model with the extant IT value models.

## Conceptual “Hybrid” IT Value Model



**Figure 11:** A Hybrid IT Value Model

## References

- Argyris, C. (2004). ‘Reasons and Rationalisations. The Limits to Organizational Knowledge’. *Oxford University Press*.
- Armstrong, C. P. and V. Sambamurthy (1999). ‘Information technology assimilation in firms: The influence of senior leadership and IT infrastructures’, *Information systems research*, 10(4), 304-327.
- Ashurst, C., Doherty, N. F., and Peppard, J. (2008). ‘Improving the impact of IT development projects: the benefits realization capability model’, *European Journal of Information Systems*, 17(4), 352-370.
- Avison, D. E., Dwivedi, Y. K., Fitzgerald, G., and Powell, P. (2008). ‘The beginnings of a new era: time to reflect on 17 years of the ISJ’, *Information Systems Journal*, 18(1), 5-21.
- Burton-Jones, A., McLean, E.R., Monod, E. (2011) ‘On approaches to building theories: Process, variance and systems’, Working paper, *Sauder School of Business*, UBC.

- Chun, M. and J. Mooney (2009.) 'CIO roles and responsibilities: Twenty-five years of evolution and change', *Information and Management*, 46(6), 323-334.
- CSC (1997). Critical Issues of Information Systems Management - 10th Annual Survey, *Computer Sciences Corporation*, USA: El Segundo, California.
- Cohen, W. M., and Levinthal, D. A. (1990). 'Absorptive capacity: a new perspective on learning and innovation', *Administrative Science Quarterly*, 38, 128-152.
- DeLone, W. H. and. McLean, E. R. (1992). 'Information systems success: The quest for the dependent variable', *Information Systems Research*, 3(1), 60-95.
- Delone, W. H. and McLean, E. R. (2003). 'The DeLone and McLean model of information systems success: A ten-year update', *Journal of management information systems*, 19(4), 9-30.
- Devaraj, S. and Kohli, R. (2003). *The IT payoff: measuring the business value of information technology investments*, FT Press.
- Feeny, D. F. and L. P. Willcocks (1998). 'Core IS capabilities for exploiting information technology', *Sloan Management Review*, 39(3), 9-21.
- Gottschalk, P. (2000). 'Information systems executives: the changing role of new IS/IT leaders', *Informing Science*, 3(2), 31-40.
- Govekar, M. and Adams, P. (2010). 'Hype Cycle for IT operations management 2010', *Gartner Research*, Stamford. 1-62.
- Hitt, L. M. and E. Brynjolfsson (1996). 'Productivity, business profitability, and consumer surplus: three different measures of information technology value', *MIS quarterly*, 20(2), 121-142
- Keen, P. G. (1980). MIS research: reference disciplines and a cumulative tradition: *Center for Information Systems Research*, Sloan School of Management.
- Kohli, R. and Grover, V., (2008). 'Business Value of IT: an essay on expanding research directions to keep up with the times', *Journal of the Association of Information Systems*, 9(1), 23-39.
- Kompass (2009). "Database of Medium-to-Large Organizations in Lebanon". <http://lb.kompass.com/>
- Lane, M. S. and A. Koronios (2007). 'Critical competencies required for the role of the modern CIO', *ACIS 2007 Proceedings*, 90.
- Lucas, H.C. (1993). The business value of IT: An historical perspective and thoughts for future research. In Banker and Kaufman (Eds.), *Strategic IT Management*. Harrisburg: Idea Group.
- Marshall, P., McKay, J., Prananto, A. et al. (2007). 'Business value creation from IT investments: Towards a process theory of IT governance', *Australasian Journal of Information Systems*, 12(2), 192-206.
- Marchand, D.A., Kettinger, W.J., and Rollins J.D. (2000). 'Information Orientation: People, Technology and the Bottom Line', *Sloan Management Review*. July 15, 2000
- Melville, N., Kraemer, K., and Gurbaxani, V. (2004). 'Review: Information technology and organizational performance: An integrative model of IT business value', *MIS quarterly*, 28(2), 283-322.
- Momoh, A., Roy, R. and Shehab, E. (2010). 'Challenges in enterprise resource planning implementation: state-of-the-art', *Business Process Management Journal*, 16(4), 537-565.
- Nissen, H-E. (2002). 'Challenging Traditions of Inquiry in Software Practice,' in Y. Dittrich, C. Floyd and R. Klischewski (editors), *Social Thinking – Software Practice*. Cambridge Mass: MIT Press, 69-90.
- Oracle (2011). 'Corporate CIOs in emerging markets an evolving role', Economist Intelligence Unit. *The Economist*. Accessed 31 May 2015 at <http://www.economistinsights.com/>
- Peppard, J., Ward, J., and Daniel, E. (2007). 'Managing the realization of business benefits from IT investments', *MIS Quarterly Executive*, 6(1), 1-11.
- Peppard, J. (2007). 'The conundrum of IT management', *European Journal of Information Systems*, 16(4), 336-345.
- Peppard, J. and J. Ward (2004). 'Beyond Strategic information systems: towards an IS capability', *The Journal of Strategic Information Systems*, 13(2), 167-194..
- Periasamy, K. P. and A. Seow (1998). 'CIO: Business Executive or Technical Expert', *Institute of Systems Science, National University of Singapore*, 1998 22.
- Peterson, R. (2004). 'Crafting IT Governance', *Information Systems Management*, 21(4), 7-22.
- Polansky, M., T. Inuganti (2004). 'The 21st century CIO', *Business Strategy Review*, 15, 29-33.
- Remenyi, D., Grant, K.A., and Pather, S. (2005). 'The chameleon: a metaphor for the Chief Information Officer', *Journal of General Management*, 30(1), 1-11.
- Sabherwal, R., Jeyaraj, J. and Chowa, C. (2006). Information System Success: Individual and Organizational Determinants, *Management Science*, 52(12), 1849-1864.
- Salvage, I. and Dhand, I.S. (2007). 'IBM White Paper on IT Service Management', <http://whitepapers.theregister.co.uk/search/?q=IBM> viewed 11 Nov 2007.
- Sambamurthy, V. and Zmud, R.W. (1999). 'Arrangements for IT governance: a theory of multiple contingencies', *MIS Quarterly*, 23(2), 261-290.
- Sharma, R. and P. Yetton (2003). 'The contingent effects of management support and task interdependence on successful information systems implementation', *MIS Quarterly*, 27(4), 533-556.
- Schryen G (2013). 'Revisiting IS business value research: what we already know, what we still need to know, and how we can get there', *European Journal of Information Systems*, 22(2), 139-169.
- Ward, J. and Peppard, J. (2002). *Strategic Planning for Information Systems*, 3rd edition. Wiley.



- Ward, J., Daniel, E., and Peppard, J. (2008). 'Building better business cases for IT investments', *MIS Quarterly Executive*, 7(1), 1-15.
- Vreuls, E. and Joai, L. (2011). 'An Exploratory Model for the Relevant Factors Related to the Professional Performance of the Brazilian CIO', *Electronic Journal of Information Systems in Developing Countries*, 47(5), 1-20.
- Weill, P. and Ross, J.W. (2004). 'IT Governance: How top performing firms govern IT', *MIS Quarterly Executive*, 3(1), 1-17.
- Williams, P. (2007). 'Make sure you get a positive return', *Computer Weekly*, 13 Nov 2007.
- Zuo, M. and J. Y. Mao (2005) 'A Survey of the State and Impact of CIOs in China', *proceedings of PACIS 2005*, Bangkok, Thailand. Paper 39.



# Bridging Operational, Strategic and Project Management Information Systems for Tactical Management Information Provision

Renata Petrevska Nechkoska<sup>1,2</sup>, Geert Poels<sup>1</sup> and Gjorgji Manceski<sup>2</sup>

<sup>1</sup>Faculty of Economics and Business Administration, Ghent University, Ghent, Belgium

<sup>2</sup>Faculty of Economics – Prilep, University St. Clement Ohridski, Bitola, Macedonia

[renata.petrevskanechkoska@ugent.be](mailto:renata.petrevskanechkoska@ugent.be)

[geert.poels@ugent.be](mailto:geert.poels@ugent.be)

[gmanceski@t-home.mk](mailto:gstanceski@t-home.mk)

**Abstract:** Tactical Management is a distinctive managerial function that needs to be delineated both in the managerial and information systems sense. This research of literature investigates current types of managerial information systems in order to evaluate the various manners tactical management is addressed. Ongoing research supports us to pursue a goal of properly defining Tactical Management, its characteristics and distinctiveness from the Operational, Strategic and Project Management; but also its connection points and overlapping collaboration areas with these managerial functions. This ought to provide proper basis for recognizing the information system requirements for tactical management and shed light on what should and can be done differently, in order to align the tactical management business profile and needs with the information provisioned by managerial information systems. Given that Tactical Management needs adaptability to changing context (organizational and environmental); is facing the complexity of issues of different nature to be dealt with; communicates with widest scope of stakeholders, entities, processes and developments to be informed about; faces a variable set of diverse incoming and outgoing information flows whose mismatch needs to be addressed; and last but not least, should be able to perform system design, prior process design and management. This research reaches several important findings in the direction of under-addressing of tactical information needs by current types of managerial information systems; ingestion or assimilation of the tactical managerial level of decision-making by operational or strategic management; attempts to automatize the handling of mismatch of incoming and outgoing information; strive for real-time information environments; divided tendencies towards providing adaptability or predictability to the management; diverse ideas for context capturing and treatments of tactical management as process or system. The implicit purpose of the research is to attract attention to tactical management, its importance that can bring substantial competitive advantage to the businesses, and the incremental potential tactical management will realize when being accordingly supported by the information systems of tomorrow.

**Keywords:** tactical management, sense-and-respond framework, adaptability, information systems, requirements engineering

## 1. Introduction

“Tactics play a crucial role in determining how much value is created and captured by firms” (Casadesus-Masanel et al. 2009). It is important to define and explore it in details, in order to be able to point out its managerial distinctiveness as well as similarity with the operational, strategic and project management; and the mutual connecting points and dependencies. There is hard time behind doing the tactical management job, trying to coordinate, translate and/or align operations/strategy, details/summaries, management/employees, clients/company, manual/automatized information systems, human, technical, business, ... aspects of work. The translation and alignment of the mismatch of all these signals, especially observed from the point of view of the person, is highly complex, diverse and changeable, and should be addressed properly. In the continuing challenges for sustainable information systems, Loucopoulos et al. (Loucopoulos et al., 2006) observe the aspects of ecological complexity – perceiving the double sided nature of the companies and the information systems as complex socio-technical systems; product complexity; project management – for getting the wrong requirements and not focusing on the outcome of and information system engineering and implementation; and education. The successful performance of the tactical management function differentiates the success of the company throughout the time, and it is person- and company- specific. Defining and embedding processes and structures in the organization that enable both business and IT people to execute their responsibilities in creating value from IT-enabled business investments (De Haes and Van Grembergen, 2015) is a current tendency on the side of the researchers and practitioners, also supported by standardization (such as ISO 38500 – the International Standard for Corporate Governance

of IT, ISO 31000 – for Risk Management (ISO, 2015)). This motivation is fueling numerous theoretical contributions and business solutions – however the connection points are sporadic, especially when the entire organization or the widest stakeholder structure is observed (Van Grembergen et al., 2015).

This research of literature aims to point out current Information Systems contributions in terms of concepts, approaches, artifacts and implementations with regards to Operational, Tactical, Strategic and Project Management, through the lens of Tactical Management distinctive needs – with the aim to reveal the tactical management specific information system needs and to make visible the junctures where tactical management bridges with operational, strategic and project management. Our standpoint is that tactical management is distinctive from other managerial functions with the:

- High need for adaptability to changing context (organizational and environmental)
- Complexity of issues of different nature to be dealt with
- Widest scope of stakeholders, entities, processes, developments to be informed about
- System design approach, prior Process flow
- Variable set of diverse incoming and outgoing information flows that can't always be predefined, and whose mismatch needs to be addressed

Hence, the tactical management need for information systems is very specific, and can't be satisfied only with cascading goals, reports and automatized processing logic. It needs theoretical specification, relevance confirmation by real-business research, and special provision by the information systems. The direction is towards individualized extraction and combination of inputs, dynamic processing logic, immediate environmental and organizational context capture and customizable outputs in terms of information. It also needs continuous revising of the context to be able to sustain towards an outcome in changing context – in order to capture earlier the relevant impulses and have a mechanism for proper response (Welsh et al., 2011). We are in favor of “heterogeneous requirements engineering” (Lyytinen et al., 2006) in order to avoid social or technological reductionism in sustainable addressing the tactical management function with information. In terms of business pursuit for an “end” (strategic guidelines, KPIs, targets, goals), it is generally a ‘given’ variable. In terms of operations, the prescription of business processes, the pursuit for efficiency and optimization, gives throughout the time (year(s)) certain rigidity and repetitiveness in their existence. However, in terms of tactical management, there are numerous and various in nature specific aspects to be taken care of, while pursuing a goal, with somewhat fixed operational inputs, in terms of alternative paths and adaptations to a very dynamic and generally uncertain (Schwabe, 2014) and/or unpredictable environment. In the highly dynamic business world, one should ‘know earlier’ the most quiet peripheral signals that may shape the future of the work – but that is possible only if one points a radar towards them. From this narrative, we would like to point out the tactical manager's duty - to continuously properly position the sensing of information (Sense), and align the mismatch of information received (Interpret) processes and actions (Decide), with some reasoning and maneuvers to translate them in order to provide and control the right path to fulfillment (Act) – SIDA loop (in the Sense-and-Response Framework, (Haeckel, 2004)). This SIDA loop is perceived as the perpetual engine to adaptability, if continuously run to revise the context (both organizational and environmental). Such capturing of context is of utmost importance for the lens of this research – with the aim not to suffer from the discrepancy between design-time and run-time (Zdravkovic, 2013) states of the socio-technical system being managed. The SIDA loop is also enabling more precise mapping of the Information System needs for tactical management, that differ in manner of obtaining, frequency, content, and many other aspects.

We see the tactical management as a very important and flexible crossroad that should be able to trace a number of alternative paths for the existence of any business. This specific nature of tactical management does need specific addressing with Information Systems and with Managerial Concepts. The organization of the paper is as follows: firstly, we are delineating tactical management from the other managerial functions; after which, brief definition of the concepts used as baseline, the research strategy and criteria according which the subject papers have been filtered, are explained. The analysis performed upon the research categories and interpretation of results and conclusions are given in the last section.

## 2. Tactical Management Definition and Characteristics

We are introducing the managerial background of the Tactical Management in order to point out how the business foundation of tactics is paving the way for proper Information System requirements and appropriate provisions.

One definition of tactics, even though modestly present in literature, stated by Merriam-Webster dictionary, is as follows: (a) the science and art of disposing and maneuvering forces in combat; (b) the art or skill of **employing available means to accomplish an end**; (c) **a system** or mode of procedure"; deriving from Latin 'tactica', from Greek 'taktika' meaning 'fit for **arranging**, to arrange, place in battle formation' (Merriam-Webster). When removing the military context, the important words in this definition are – disposing – positioning, influencing, persuading, ruling ; maneuvering; skill – managerial; employing available means – using and capturing the current context; to accomplish an end – to reach a goal; a system; mode – approach; arranging and re-arranging.

In our working definition we perceive tactical management as the managerial function on **How** to achieve what is **expected** by **utilizing** what is **given** and following certain **governing principles** in the **current context** of the **organization and environment**.

The elements of the definition can be rearranged with reference to the other managerial functions:

- **How** to achieve (tactics)
- what is **expected** (strategy)
- by **utilizing** what is **given** (operations)
- and following certain **governing principles** (strategic guidelines)
- in the **current context** of the **organization and environment** (tactics)

As it is visible from the definition, the tactical management is expected to maneuver with numerous 'givens' – that may change and are changing. The context is also dynamic and to some extent unpredictable, be it the immediate environment, or the organizational context – the purpose, priorities, governing principles, expectations. The socio-technical system being managed is dynamic and unpredictable. We are recognizing that the department, the team, the organization it is a Complex Adaptive System (CAS) (Holland, 1996) that a manager needs to guide towards a goal, which is specific and unpredictable (Janssen, 2015), to begin with. These requirements imply that Tactical Management should have the adaptability as integrated characteristic in the behavior of the manager and in the information system design, in order to perform successfully, throughout time.

The current managerial literature for **strategic management** is diverse and abundant. The main concepts integrated in the literature are effectiveness, organizational alignment, governance, competitive advantage. Strategic managers are assisted with conceptual frameworks and contributions such as the the Balanced Scorecard (Kaplan et al., 2007), Triple Bottom Line (Elkington, 1997), the Performance Prism (Neely et al., 2002), Skandia's Navigator (Edvinsson, 1997), Intangible Assets Monitor (Sveiby, 1997), The Tableau de Bord (Epstein et al., 1997) (Bourguignon et al., 2004) (Pezet, 2009), The Performance Measurement Matrix (Keegan et al., 1989), the Strategic Measurement and Reporting Technique Pyramid (Lynch et al., 1991), The Results and Determinants Framework (Fitzgerald et al., 1991), The Input-Process-Output-Outcome Framework (Brown, 1996), Objectives and Key Results, the Performance Wheel (McNair et al., 2009) and numerous others. These theoretical approaches offer strategic mapping, balanced measurement systems, financial and non-financial dimensions of organizational performance, qualitative and quantitative information, and appropriate scorecards and even dashboards that enable key indicator monitoring and decision making.

The **operational management** is also receiving valuable attention with managerial as well as Information System contributions. In the managerial literature, the key elements are efficiency and business processes. The non-exhaustive list incorporates managerial methods and techniques such as Six Sigma, Total Quality Management, Lean Six Sigma (Tennant G., 2001), Statistical Process Analysis, Statistical Process Control, Agile (Meyer, 2014), and others.

The **tactical management** dilemmas for key concepts in managerial literature are effectiveness vs. efficiency, outcomes vs. outputs, system design vs. process design. There is scarcity of managerial methods and techniques related to tactics – and, this investigation aims to prove that the same situation reflects in the support for tactical management in terms of information systems, too. On the side of the tools and techniques, actively used are Network Planning, Realistic Scheduling, Accurate Estimating, Work Breakdown Structure, Product and Project Lifecycle. Tactical Management is mostly supported in Project Management literature – with the well-established concepts of PMBOK (Project Management Institute, 2004), Scrum, Prince 2, Agile Project Management, Management of Value and others. However, the tactical management as continuous function has distinctive characteristics from the project management function, so to some extent the project management literature is addressing but not completely covering the tactical management needs.

The intersections of the Tactical Management function with the operational, strategic and project management functions (discussed in our definition), stress the junctions where tactical management connects these functions in the socio-technical system of an organization. The distinctiveness of the Tactical Management function from the operational, strategic and project management functions (discussed in the Introduction), points out how it needs to be addressed with Information System provisions.

### **3. Research design**

#### **3.1 Concepts in the research**

With the abovementioned Tactical Management definition and characteristics in mind, we have performed a theoretical research in order to get deeper insight in the support that the tactical management is having at this point in time, with broad information systems artifacts, frameworks, methods and tools. To be more specific, the literature research was guided by the following questions: (1) understanding of the essence of the paper, the proposed contribution and its integration in management per level (Operational, Tactical, Strategic, Project) and the proposed combinations; (2) analyzing the specific information and processing input for Tactical Management, depending on the used Tools, Methods, Approaches, Artifacts; (3) detection of how the proposed artifact takes in consideration (used the term “closing” with) an End – may it be performance measurement framework, such as Balanced Scorecard, Triple Bottom Line, ... or Business Plan, KPIs, Goals, Targets, Reason for Being, Purpose, Accountability; (4) how the work handles the mismatch of the information for tactical management; (5) the prescription of Real-time or tactical management specific Right-time information need; (6) The presence or absence of Sense-and-Respond Framework and the adaptability loop (such as Sense-Interpret-Decide-Act (SIDA) Loop); (7) the support for Adaptability (8) the perception of Predictability in the specific approach (9) the Context capture approach and (10) the artifact’s underlying focus on System Design, Process Design or both.

#### **3.2 Research strategy**

The background idea that is guiding this research is to detect the provisions of adaptability i.e. and Information System requirements for tactical management.

The initial stage of the research was performed on 350 theoretical contributions obtained from EBSCO database; Web Of Science Listing of high ranking Information Systems journals, Google Scholar engine; Research Gate Portal; searched with the keywords: information systems, management information systems, tactical management information system, operational management information system, strategic management information system, project management information system, business and IT alignment; decision support systems; enterprise architecture, enterprise ontology, business process modeling, business modeling. Also, snowballing technique was used, cross-checking and expanding the search with referenced publications in the initially selected works. This literature review investigates in-depth 25 theoretical contributions published in the time frame of 2004-2015 that are offering information systems artifacts, implementations and knowledge to the operational, tactical, strategic and project management, using various foundations technologies and combinations, and from different viewpoints. The selection of 25 papers out of 350 was performed according specified inclusion and exclusion criteria. As initial step, we recognized the widest foundations for positioning the information systems foundations in the categories Enterprise Architecture, Enterprise Ontologies, Business Modeling and Business Process Modeling. With the intention to provide overarching representation of contributions, we have conducted selection of 25 papers to represent extensions in use of these categories. The inclusion criteria was regarding the content of the works –

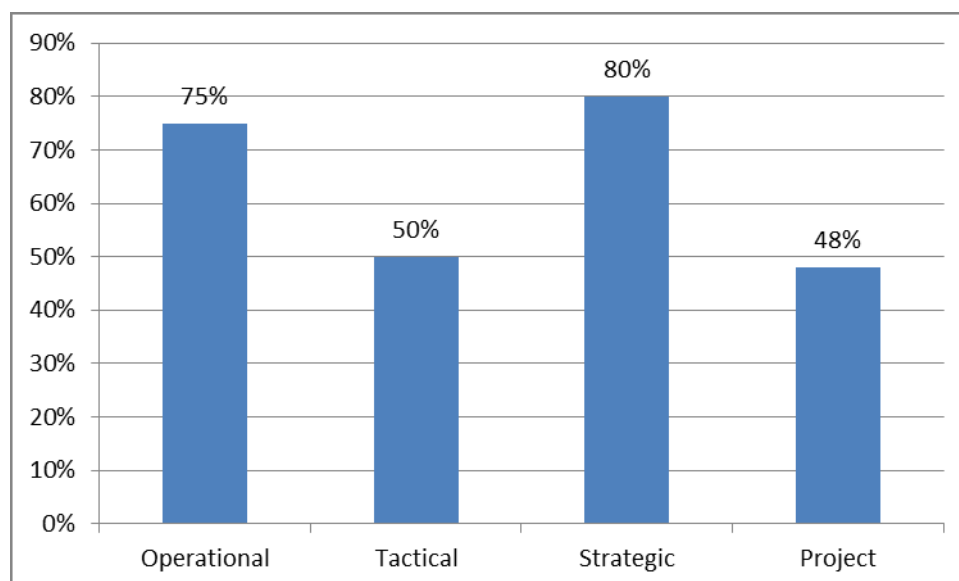
addressing information systems for operational, tactical, strategic, project management in at least two managerial functions (operational and tactical; tactical and strategic; ...); containing information for tactical management information input, output, handling of mismatch; treatment of real-time or right-time information; inclusion of adaptability or predictability feature; addressing context capture and system or process design in the information system design. The works that had input for the before-mentioned criteria have been shortlisted and selected according belonging to the use of the four categories, described as initial foundation. Contributions that have been domain specific or business line specific have not been taken in consideration. Another, exclusion criteria was commercialized tools and solutions – the analysis is performed on theoretical artifacts only. Third exclusion criteria was for contributions that are addressing only one of the operational or strategic management, and every artifact in the shortlist addresses at least two of the managerial functions – inevitably including, or overseeing tactical management, which has been very useful to observe.

#### 4. Analysis

The analysis of the selected literature according the questions stated in section 3.1 follows:

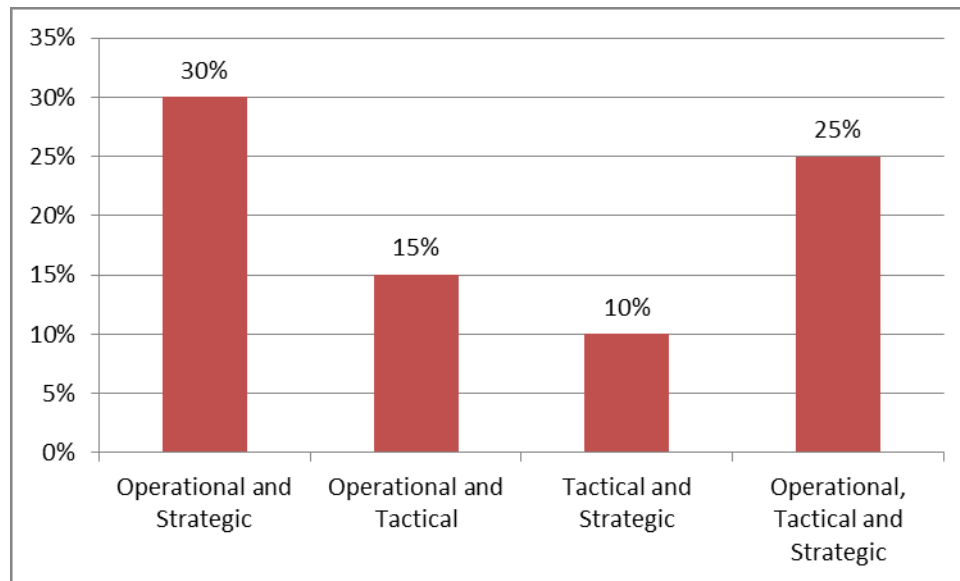
##### 4.1 Primary orientation in terms of operational, tactical, strategic, project management and combinations of the contributions

The Information system support for tactical management, we argue, should be approaching the target audience according its characteristics - not generalization as any other type of management. As discussed in the introduction, the tactical management is facing high complexity and unpredictability. Since it is being the way to achieve the expectations of the company's existence, and since it is so much diverse and person- and company-dependent, it is addressed with the general principles of a certain level of management. From this standpoint, it was an interesting quest to see in what way which artifacts are assisting tactical management. Hence, the initial categorization is to be made by which level of management the analyzed papers are focusing on.



**Figure 1:** Coverage of the managerial functions (Operational, Tactical, Strategic, Project management) by the investigated works

Of course, one can argue that this is not complete and thorough literature review but more an “emerging issue that would benefit from exposure to potential theoretical foundations” (Webster and Watson 2002) and as such, conclusions about absence of focus to the characteristics of the tactical management and appropriate information systems can't be made. However, this investigation shows that there is significantly less coverage in some form addressing tactical management in general, present in only 50% of the papers, while Operational is in a hive of solutions with 75% preceeded by Strategic with 80%. Project management has been addressed in 48% of the works (Figure 1).



**Figure 2:** Combinations of focus of the information system solutions of the analyzed works in terms of operational, tactical, strategic and project management

Figure 2 shows the combinations that exist in the reviewed artifacts and approaches: interestingly, 30% of the investigated works tend to overarch Operations to Strategy (Iafrate 2013), (Buckley et al. 2005), (Werner 2013), (Kapoor et al. 2005), (Hoogervorst 2009), (Ba et al. 2008)(Berzisa et al., 2015); the one end of Operational and Tactical issues is being tackled by 15% of the works (IBM 2008), (Hoontae et al. 2007), (Hill 2009); and the other end of Tactical and Strategic by 10% of the works (Maes 2007), (Cherbakov et al. 2005)(Francesconi et al., 2013) (Frank, 2014) and complete solutions for Operations, Tactics and Strategy are being given in 25% of the investigated works (Barone et al. 2010), (Gill 2013), (Berkem 2008), (Forno 2012), (Haeckel 2004) (Poels et al., 2013),(ISACA, 2012).

#### 4.2 Information and processing input for tactical management, depending on the used tools, methods, approaches, artifacts

This aspect is browsed through the literature in order to perceive the provision of tactical management with information from the operations and/or wider entities and processes that are happening in the everyday work. This is one aspect that supports our idea that the tactical management is facing mismatch of incoming information vs outgoing information flows and outcome expectations. The idea behind is that tactical management proper information is much more than standard reports or automated dashboards because there are many operations, modifications and maneuvers that need to be done to any incoming data prior the tactical management information is appropriate for use. The solutions in literature are diverse. Starting from wide range of event driven and on-demand data with near-zero-latency Business Intelligence, predictive modeling, incorporating best practices and exceptions management (Iafrate 2013) Big analytics, massive data capture and business intelligence, “what-if” analysis, forecasts and trends (Buckley et al. 2005), support with processed data and integrated business intelligence (Werner 2013), as well as use of Business Event Processing, heterogeneous event types, internal and external multiple sources, event processing logic maintained by user – dashboards (IBM 2008) and personalized monitoring dashboards (Hoontae et al. 2007) that incorporate event-driven and on-demand information to be given at hand (Kapoor et al. 2005). Number of contributions are noted using enterprise architecture to facilitate context analysis (Hoogervorst 2009) (Gill 2013), ‘Business Execution layer’ feeding information (Simon et al. 2013). Enterprise modeling is being used in providing design of the sensing mechanism based on the Business Intelligence Model (BIM) and i\* (Nalchigar 2013), in order to monitor the achievement of strategic goals, develop alternative responses, select the most suitable alternatives, implement and monitor the response (Barone et al. 2010). Frequent is the observation that the tactical choices that are available depend on the business model chosen by the firm in the first stage that depends on the strategy (Casadesus-Masanell 2009), while Ba et al. develop method aimed at effectively organizing, integrating, reusing knowledge and model components in direction of providing information and knowledge input for the alternatives, scenario models and model solutions of the decision maker (Ba et al. 2008). With Component Business Model (CBM) (Cherbakov et al. 2005) have seen information support through



the componentization and the dynamic processes, while the Business Motivation Model (BMM) and Service Oriented Architecture (SOA) are the basis for designing 'The Why (Business motivation), the What (Services) and the How (Service Description and Realization)' (Berkem 2008) to provide organized information supply. Business Process Execution Measurement Model (BPEMM), Business Activity Monitoring (BAM) and Process Mining (PM) are the basis for Overall Business Process execution measurement and Improvement approach that serves the levels of management with relevant BP information (Delgado et al. 2014). Modeling selected Business Processes, Describing functions, Roles, Alternatives, Actions is the approach used by (Frank, 2014) Noteworthy designs for information provision and automated decision-making are seen in the SIFT framework an abstract artifact (a framework comprising of models, measures and a method) for Information Quality improvement (Hill 2009), Integrative framework for Information Management (Maes 2007) where Strategy, Structure and Operations are differentiated and in the Adaptive Enterprise Service System Model (Gill 2013). Goals cascade and the Process-Practice-Activity concepts, especially the inputs and outputs of the Practices being useful for Tactical Management in the COBIT 5 framework (ISACA, 2013). Tactical view (for internal aspects of tactic) and Partnership view (for the partnerships among enterprises) are the way of addressing tactic in the TBIM (Francesconi et al., 2013). Core concepts, Ecology concepts, Execution concepts, Evaluation concepts are the main elements which intertwine in the work of (Poels et al., 2013) To end with the other side of this spectrum, with the approaches of Forno and Haeckel, where proper positioning of information sensors with regard to the current accountability is recommended. (Haeckel 2004) (Forno 2012)

### **4.3 Output expected of tactical management ('ends')**

With regard to the expected outputs or outcomes from the tactical management function, the literature analysis has resulted with the notion that most of the contributions expect the 'endings' to be Key Performance Indicators (KPIs), some of which using the Balanced Scorecard (BSC) as strategic framework, with the following modalities: KPIs (Ba et al. 2008) (IBM 2008) (Delgado 2014); Indicators and KPIs (Hoontae et al. 2007) (Berzisa et al., 2015); KPIs that align with strategic goals (Iafrate 2013); KPIs, Goals and Objectives (Buckley et al. 2005); KPIs and projections (Maes 2007); two loops for monitoring KPIs and ex-post periodic analysis (Werner 2013); KPIs through BSC perspectives (Kapoor et al. 2005) (Nalchigar et al. 2013) (Barone et al. 2010). 'Endings' in broader sense are defined and used as Mission, Goals (Hoogervorst 2009); Goals and Priorities (Gill 2013); Targets, Goals (Cherbakov et al. 2005); Strategic guidelines reflected in the selected business model (Casadesus-Masanell et al. 2009); Business motivation, Business Model (Simon et al. 2013); and Metrics (Hill 2009). Business goals as part of the ends drive courses of actions (strategy and tactic), directives (rules and policies) till business processes in the (Berkem 2008) paper. Strategic goals are used in the work of (Francesconi et al., 2013) (Frank, 2014) The RACI charts roles that address tactical manager's role expectations as well as the integrated goal cascades are used in COBIT 5 (ISACA, 2013). Evaluation concepts (quality, productivity, legal compliance, sustainable innovation) serve as KPIs in the work of (Poels et al., 2013). To complete the horizon with the Reason for being (Purpose) and the Outcomes accountable for, that are used as 'endings' defined and used by (Forno 2012) and (Haeckel 2004) while achieving whatever indicators a company needs.

### **4.4 Handling mismatch of information**

According the previous two concepts, our standpoint that the tactical management position in the middle of Strategy and Operations, Clients and Company and Management and Employees faces mismatch of incoming and outgoing information that needs to be handled in some way. Usually, the additional operations of data exported from the existing systems are performed by the manager him/herself (research in progress); but there is significant variance in time, quality, personal approach and effects when that operation is performed individually. The theoretical approaches offer different solutions for this problem: starting from Automatized conversions and reasoning of data (Iafrate 2013) and automated decision making (Hill 2009); Sense and Respond Business Performance Management that orchestrates dynamic, structured and unstructured information within a continuous, adaptive event-based planning process, also determines business rules and policies and orchestrates among the value partners to achieve better overall performance (Buckley et al. 2005) through management by exception, most of the data is automatically converted with some prescribed reasoning and processing logic (IBM 2008). Business Process design and KPI definition (Werner 2013) and essential alignment of measures that are related to business strategy and goals for the entire organization with the ones that are specific for each business process (Delgado et al. 2014) are another type of approaches trying to address the mismatch of information on tactical level. Modeled conversions and reasoning of data are visible in the papers of (Kapoor et al. 2005), (Nalchigar et al. 2013), (Ba et al. 2008), (Hoontae et al. 2007),



all the way to more specific, short-term, semi-structured modeling possible for Mid-level management control (Barone et al. 2010). "Means (Strategy, Tactics) and Ends (Vision, Goal, Objective) to cover the "total disconnection" of the business processes with the business goals and rules" (Berkem 2008). Comparison of the model (requires vs. produces) is intended to handle the in-out mismatch of information (Frank, 2014). Noteworthy for our suggestion for tactics is the design of "establishing capability delivery patterns and context indicators that monitor whether the design for capability delivery is still valid for the current context situation" (Berzisa et al., 2015) Heads Up displays for every role (Haeckel 2004) and no ambiguity in the defined Purpose and Governing principles together with proper communication and sensors while negotiating towards the outcome (Forno 2012) are the approach that can be adapted to any level of management, including tactical.

#### **4.5 Right-time information or real-time information**

Our idea for tactical management underlines the necessity of right-time information, which has some low latency in terms of time and frequency and almost no latency in terms of structure and scope. However, theoretical contributions discuss and strive for real-time information (Iafrate 2013), (Buckley et al. 2005), (Werner 2013), (Kapoor et al. 2005), (Ba et al. 2008), (IBM 2008), (Hoontae et al. 2007), (Cherbakov et al. 2005), (Delgado et al. 2014), (Barone et al. 2010); or in terms of shortening the latencies (Nalchigar et al. 2013), (Forno 2012), (Haeckel 2004). Some of the papers are not addressing this issue at all, not being focus of their approach.

#### **4.6 Sense-and-respond framework and adaptability loop**

We perceive the Sense-and-Respond managerial concept as introduced by Haeckel in 1999 as good starting point for attempting to solve the adaptability, ambiguity, uncertainty and complexity the tactical management is facing with (Petrevska Nechkoska et al., 2014). Its component, the SIDA Loop is the revising mechanism that provides the adaptability to changing environment, circumstances, stakeholder needs and accountabilities. From this standpoint, we submit the reviewed contributions also to these concepts to perceive whether they have been used or not, and with which understanding and implementation. No explicit use of these concepts has been noted in the papers of (Hoogervorst 2009), (Ba et al. 2008), (Hoontae et al. 2007), (Hill 2009), (Berkem 2008), (Maes 2007), (Simon et al. 2013), (Delgado et al. 2014), (Casadesus-Masanel et al. 2009). However, according our perception, the SIDA loop has been implicitly integrated in the BPCIP (Delgado et al. 2014); in the Plan-Do-See-Act design (Hoontae et al. 2007); and addressed through the Input of the Knowledge Provider, the Processing of the Knowledge Broker and the Output of the Decision Makers (Ba et al. 2008) and Scan&Sense, Interpret&Analyze, Decide&Respond (Gill, 2013). In own interpretation, both terms have been used by (Barone et al. 2010) and separately with BIM to sense and interpret and with their artifact to decide and act (Nalchigar et al. 2013). The TBIM (Francesconi et al., 2013) uses the automated reasoning techniques, including 'what if' and 'is it possible'; SWOT analysis - all included in the BIM as baseline framework. In the work of (Frank, 2014) the MEMO steps (Multiperspective Enterprise Modeling) are prescribed to provide adaptability of the system and processes. IBM's definition and approach to these concepts is visible in the work of (IBM 2008), (Cherbakov et al. 2005), (Buckley et al. 2005), (Werner 2013) and in a way that the S&R system uses available data, such as forecasts, customer orders, and supply commitments, and aims to provide an early warning system for conditioning with an important innovation - a new algorithm that identifies potential problems by using historical information and future indicators to forecast trends for customer orders and to compare trends and forecast as lead indicators of future occurrences (Kapoor et al. 2005). The core definition, Knowing earlier, Managing by wire, Dispatching capabilities from the event back, Designing a business as a system (Haeckel 2004) as Sense-and-Respond basics are explicitly used by (Forno 2012).

#### **4.7 Adaptability**

The concept of Adaptability is analyzed in conjunction with modularity, and the deduction is as follows: when the discussion of the authors is in terms of business processes, the adaptability is perceived in their adjustment (Iafrate 2013), predefinition (Werner 2013), corporate agility (IBM 2008), Monitoring Modeling, Event Modeling, Indicator Modeling, Alert and Response Modeling (Hoontae et al. 2007), Business Processes and stable and loosely coupled services (Berkem 2008) all the way to setting up continuous improvement cycle for business processes implemented by services in organizations based on BP execution measurements (Delgado et al. 2014). Enterprise design and architecture create the ability to adapt and change for the future and systems thinking is significantly present in the adaptability aspect of the work of (Hoogervorst 2009). Enterprise-wide business processes and setting the context, designing for change, executing the SIDA loop -

process for re-engineering the enterprise are significant for Kapoor et al. 2005, while composite services and dynamic processes based on componentization, partner networks; value nets, service oriented enterprise are discussed by (Cherbakov et al. 2005). (Maes 2007) sees the modularity and the adaptability prescribed in the structure of the company, while their determination by the selected business model is present in the work of (Casadesus-Masanel 2009), (Barone et al. 2010) (Simon et al. 2013), (Ba et al. 2008), culminating with continued focus on responsiveness and adaptability provided by a a model-driven capability design and an architectural framework of loosely coupled components for adaptive business management (Buckley et al. 2005). Adaptive Enterprise Service System Model and underlying adaptive enterprise architecture into adaptive enterprise architecture capability for handling complex enterprise transformations based on the view of the enterprise as a system with subsystems are largely discussed by (Gill 2013). Adaptability is not explicitly set up but is recommended in the accountabilities in COBIT 5 (ISACA, 2013). Alternative plans are the prescribed way of addressing adaptability in the work of (Francesconi et al., 2013) and (Frank, 2014). The SIDA loop as generator of adaptability, the constant negotiations and the system design of the enterprise existence with flexible role occurrences are used in their generic sense by (Haeckel 2004) and (Forno 2012).

#### **4.8 Predictability**

For indirect support of our choice of the Sense-and-Respond concept is the investigation how do all these different authors perceive predictability or unpredictability of the environment into account for their contributions, we performed the scan of the approaches through the lens of this concept. If we set aside the works where this issue hasn't been addressed or not being focused on, there are two general standpoints: attempts to provide forecasting, what-if alternative analysis, extrapolation, optimization and predicting ability to the management, by different tools, algorithms and business intelligence activities (IBM 2008), (Hoontae et al. 2007), (Hill 2009), (Delgado et al. 2014), (Barone et al. 2010) (ISACA, 2013), through the variation of identifying runtime variations (Werner 2013) and maintaining lowest latencies possible (Nalchigar et al. 2013) all the way to assuming unpredictability and uncertainty (Hoogervorst 2009), (Gill 2013), (Forno 2012), (Haeckel 2004), (Cherbakov et al. 2005). Patterns that reflect best practices and their run-time or execution-time adaptation are the specific instrument used in the work of (Berzisa et al., 2015)

#### **4.9 Context capture**

Capturing the context is of primary importance for any managerial function. It becomes strikingly observable for tactical management – both in terms of organizational context (changes in purpose, goals, governance, priorities, structure, resources ...) and in terms of the environment (immediate events that influence the work, early signals from important entities or events, ...) "The temporal dimension has been found to play a central role in the understanding of the explanatory factors of IS success and failure in an organizational context (Alter 2013; Pettigrew et al. 2001)" (Dwivedi et al., 2015). The authors Berzisa et al. (2015) and Zdravkovic (2013) define in a plastic way as 'design-time' ("by eliciting business goals, Key Performance Indicators (KPI), designing generic business processes and resources, as well as by specifying capabilities, relevant context sets and patterns") and 'run-time' (when the IS ability "to handle changes in different context is put to test"). This concept has been addressed in abundant diversity. We have grouped the findings in regards to contextual scanning in three main directions, and we will present the different original approaches within, by the various contributions:

- Approach 1: Real-time context scanning
  - Real-time monitoring (Buckley et al., 2005) (Cherbakov et al., 2005) (Maes, 2007)
  - Business Activity Monitoring (IBM, 2008)
  - Dashboard with user-defined rules for alerts; Management by Exception (Hoontae et al., 2007)
  - Context-Mechanism-Outcome Configuration (Hill, 2009)
  - Zero-latency contextual scanning (Iafrate, 2013)
  - Set the context, Design for change, Execute the SIDA loop - process for re-engineering the enterprise (Kapoor et al., 2005)
  - Continuous Business Process Improvement; real-time monitoring on business process execution and BP improvement (Delgado et al., 2014)
- Approach 2: Contextual scanning and reaction according needs – potential for 'right-time' information

- Sense-and-Respond and/or SIDA loop use for context capture (Buckley et al., 2005) (Kapoor et al., 2005) (Nalchigar et al., 2013) (Forno, 2013) (Haeckel, 2004)
- Scan&Sense, Interpret&Analyze, Decide&Respond (Gill, 2013)
- Feedback and the Monitoring process (ISACA, 2013)
- Context indicators monitor whether the design for capability delivery is still valid for the current context situation (Berzisa et al., 2015)
- Ecology concepts aggregates the service system entities that are involved in the service system and Evaluation concepts(quality, productivity, legal compliance, sustainable innovation) that serve as KPIs that are monitored for realization (Poels et al., 2013)
- Approach 3: Ex-post periodic analysis and comparisons
  - Two loops, monitoring KPIs, ex-post periodic analysis (Rausch et al., 2013)
  - Discrete, What-if and SWOT analysis (Barone et al., 2010) (Berkem, 2008) (Francesconi et al., 2013)
  - Enterprise Architecture facilitating context analysis, Learning rather than planning (Hoogervorst, 2009)
  - Comparison of the model (requires vs. produces) (Frank, 2014)

Our interest in tactical management defines our standpoint that when performing this function, the manager should continuously scan the context both for changes organization-wise (in the goals, governing principles, priorities, ...) that happen occasionally, but also for daily organizational changes (staff, resources, incidents, cascading changes in plans, ...) and environmental changes (competitors, other stakeholders, clients, other departments, ...) Adaptation of the work to all these changes, while still pursuing the given goal, is necessary, especially for the tactical management. From the three approaches observed in literature, we would be in favor of right-time contextual scanning – in order to relief the burden of unnecessary real-time information enterprise systems investments and still provide proper alert for the manager.

#### 4.10 System design, Process design focus or combination of approaches

From a managerial point of view, the need for system view, if not even system design, is highest for strategic management and tactical management (including project management), and the accent on process design is needed for operational management. Of course, strategic management pays attention to efficiency and processes, at the same time; while, in our perception, the tactical management puts effectiveness before efficiency – and system design prior process design. There are contributions that address Operational and Tactical Management but persist in the process design usage - 12%, Operational and Strategic Management and still retain the process design – 16% and 4% of approaches that treat Tactical and Strategic Management with Process Design only (Table 1). The rest of the contributions, use either system design or both system and process design because they are addressing the whole company or Tactical and Strategic Management.

**Table 1:** Overview of Process, System or combined approach usage in the investigated works

	Operational, Tactical	Operational, Strategic	Tactical, Strategic	Operational, Tactical, Strategic
Process design	12%	16%	4%	
System design			12%	8%
System and Process design		20%	12%	16%

### 5. Interpretation of the results and conclusions

The tactical management specificity should be stressed to a great extent when designing information systems for the companies. This research reaches several important findings in the direction of under-addressing with specific approach by the Information System contributions; ingestion or assimilation of the tactical by the operational or strategic management; attempts to automatize the handling of mismatch of incoming and outgoing information; to some extent unnecessary strive for real-time information environments; divided tendencies towards providing adaptability or predictability to the management; diverse ideas for context capturing and treatments of tactical management as process or system.

The feeding with information to the tactical management is done mostly on a technical level of implementation, and usually with structured, automatized data and automatic connections and dashboards. The present tendency of closing with endings by shooting real-time operational data towards strategic dashboards that are performing some sort of KPI monitoring on different levels of management is visible in 30% of the papers (Figure 2), which, according to our standpoint, is too big of a distance, and too present of mismatch for feasible implementation in the real business world. Hence, the current support for handling the mismatch of information in the middle is done with automatized logic, that can't always be prescribed, with modeling and incorporation in business processes, but maybe with not exploited enough governing principles and purpose that individualize the conversion logic and bring it down to context and structure.

The top-down approaches starting from strategic level, cascading outcomes, quantitative but also qualitative expectations, are somewhat assimilating tactical management specifics. There is significant 'ingestion' of the tactics by operations or strategy, in the last period of time.

In terms of adaptability, still, the solutions base on the somewhat rigidity of business processes, or their continuous improvement, while tactical management needs flexible support in flexible/unstructured/dynamic processes. Unpredictability is still little concern to the contemporary solutions, which for the whole companies and especially for tactical management should not be assumed. The context capture is of interest in all the contributions, noting diverse ideas and approaches on how to address it. With regards to tactical management the context capture is an ongoing process of revising the current setup – sensing, interpreting what it means to the functionality of the socio-technical system and its outcomes, deciding what should be changed, which is the trigger to being informed and mapping the information system needs for this function, and acting. Last, but not least, we would like to contribute with the finding that the tactical manager needs system thinking and system design in order to facilitate the socio-technical system towards an outcome and effect, while the efficiency should be a second criterion when reasoning and acting.

Hopefully, this research will turn the lights towards tactical management, as present and making a difference in every pore of life, especially in business, with its specifics and elasticity, rather than general managerial treatment; which should be addressed with appropriate identification of characteristics and followed up by innovative information systems concepts and solutions.

## References

- Ba S., Lang K. R., Whinston A. B., (2008) "Compositional Enterprise Modeling and Decision Support", *Handbook on Decision Support Systems 2*, Springer Berlin Heidelberg
- Barone D., Mylopoulos J., Jiang L., Amyot D., (2010) *The Business Intelligence Model: Strategic Modelling*, University of Toronto, Canada
- Berkem B., (2008) "From The Business Motivation Model (BMM) To Service Oriented Architecture (SOA)", *Journal of Object Technology Vol. 7 No. 8*, ETH Zurich
- Berzisa S., Bravos G., Gonzales T. C., Czubayko U., Espana S., Grabis J., Henkel M., Jokste L., Kampars J., Koc H., Kuhr J.-C., Llorca C., Loucopoulos P., Pascual R. J., Pastor O., Sandkuhl O., Sandkuhl K., Simic H., Valverde F. G., Zdravkovic J. (2015) "Capability Driven Development: An Approach to Designing Digital Enterprises", Springer Fachmedien Wiesbaden
- Buchanan R. D., Soley R. M., (2002), *Aligning Enterprise Architecture and IT Investments with Corporate Goals Whitepaper*, Object Management Group
- Casadesus-Masanell R., Ricart J. E., (2009) *From Strategy to Business Models and to Tactics*, IESE Business School – University of Navarra
- Cherbakov L., Galambos G., Harishankar R., Kalayana S., Rackham G., (2005) Impact of the service orientation at the business level, *IBM Systems Journal* Vol. 44, No. 4
- Delgado A., Weber B., Ruiz F., Guzman I. G.-R., Piattini M., (2014) "An integrated approach based on execution measures for the continuous improvement of business processes realized by services", *Information and Software Technology*, Elsevier B. V.
- Dwivedi Y. K., Wastell D., Laumer S., Henriksen H. Z., Myers M. D., Bunker D., Elbanna A., Ravishankar M. N., Srivastava S. C. (2015) "Research on Information Systems Failures and Successes: Status update and future directions", *Information Systems Frontiers*, vol. 17, Springer, p: 143-157
- Edvinsson, L., Malone, M. S. (1997) "Intellectual Capital: The Proven Way to Establish Your Company's Real Value By Measuring Its Hidden Values", Piatkus. London.
- Elkington, J. (1997) "Cannibals with Forks: the Triple Bottom Line of 21st Century Business", Capstone Publishing Ltd. Oxford.

- Forno D. J., (2012) *Applying Sense&Respond to Create Adaptive Organizations*, Available: <http://www.senseandrespond.com/downloads/AdaptiveEnterpriseExperience--Forno.pdf>. Last accessed on 1 April 2014
- Francesconi F., Dalpiaz F., Mylopoulos J. (2013), "TBIM: A language for Modeling and Reasoning about Business Plans" Technical Report #DISI-13-020, Department for Information Engineering and Computer Science, University of Trento, Italy,
- Frank U. (2012) "Multi-perspective enterprise modeling: foundational concepts, prospects and future research challenges", *Software Systems Models*, Springer-Verlag
- Gill A. Q., (2013) "Towards the Development of an Adaptive Enterprise Service System Model", *Adaptive Enterprise Architecture Toolkit*, Proceedings of the Nineteenth Americas Conference on Information Systems, Chicago, Illinois
- Haeckel S. H., (2004) "Peripheral Vision: Sensing and Acting on Weak Signals Making Meaning out of Apparent Noise: The Need for a New Managerial Framework", *Long Range Planning*, Elsevier
- Haeckel S. H., (1999) *Adaptive Enterprise: Creating and Leading Sense-And-Respond Organizations*, Harvard Business School Press Boston
- Hill G., (2009) *A Framework for valuing the quality of Customer Information*, PhD Thesis, The University of Melbourne
- Hiekkanen K., Helenius M., Korhonen J. J., Patricio E., (2013) "Aligning Alignment with Strategic Context: A Literature Review", *Digital Enterprise Design and Management*, Springer-Verlag Berlin Heidelberg
- Holland, J. H. (1996). Hidden order. How adaptation creates complexity. Reading, MA: Addison Wesley, p: 10.
- Hoogervorst J., (2009) *Enterprise Governance and Enterprise Engineering*, Springer London
- Hoontae K., Yong-Han L., Hongsoon Y., Nam Wook C., (2007) "Design and Implementation of a Personalized Business Activity Monitoring System", *Human-Computer Interaction*; Springer-Verlag Berlin Heidelberg
- Iafrate F., (2013) "Use Case: Business Intelligence "New Generation" for a "Zero Latency" Organization (When Decisional and Operational BI are Fully Embedded)", *Digital Enterprise Design and Management*, Springer Berlin Heidelberg
- IBM, (2008) "Empowering the business to sense and respond: Delivering Business Event Processing with IBM WebSphere Business Events, Business Event Processing", *WebSphere software White Paper*, IBM New York
- International Organization for Standardization 2015. <http://www.iso.com> (5 May 2015).
- ISACA (2012) "Cobit 5 – A business framework for the governance and management of enterprise IT",
- Janssen M., van der Voort H., van Veenstra A. F., (2015) "Failure of large transformational projects from the viewpoint of complex adaptive systems: Management principles for dealing with project dynamics", Springer Science+Business Media New York
- Kaplan, R. S., Norton D. P., 2007. Using the Balanced Scorecard as a Strategic Management System, Harvard Business Review.
- Kapoor S., Bhattacharya K., Buckley S., Chowdhary P., Ettl M., Katircioglu K., Mauch E., Phillips L., (2005) "A technical framework for sense-and-respond business management", *IBM Systems Journal*, Vol 44, No 1
- Loucopoulos P., Lyytinen K., Liu K., Gilb T., Maciaszek L.A.: (2006) "Project Failures: Continuing Challenges for Sustainable Information Systems", *Enterprise Information Systems VI*, Seruca I., Cordeiro J., Hammoudi S., Filipe J. (Ed.), Springer (p: 1-8)
- Lyytinen K., Bergman M., King J. L.: (2006) "Large Scale Requirements Analysis as Heterogeneous Engineering", *Enterprise Information Systems VI*, Seruca I., Cordeiro J., Hammoudi S., Filipe J. (Ed.), Springer (p: 9-22)
- Maes R., (2007) "An Integrative Perspective on Information Management", *PrimaVera Working Paper Series*, University of Amsterdam
- McNair, C.J., Watts, T. (2009) "The integration of balanced scorecard models", *Cost Management*
- Meyer B., (2014) "Agile! The Good, the Hype and the Ugly", Springer International Publishing Switzerland
- Nalchigar S., Yu E., (2013) "From Business Intelligence Insights to Actions: A Methodology for Closing the Sense-and-Respond Loop in the Adaptive Enterprise", *The Practice of Enterprise Modeling*, Springer Berlin Heidelberg
- Neely A. D., Adams C., Kennerley M. (2002) "The Performance Prism: The Scorecard for Measuring and Managing Business Success", Financial Times Prentice Hall. London.
- Petrevska Nechkoska, R., Manceski, G., Poels, G., (2014): "Meeting Point of Strategy and Operations: Tactical Management Sense-and-Respond Framework Enhancement," Proceedings of the 8th ECIME 2014, AC&PI Ltd., UK.
- Poels G., Van Der Vurst G., Lemey E. (2013) "Towards an Ontology and Modeling Approach for Service Science" in IESS 2013, LNBIP 143, e Cuhna J.F., Snene M., Novoa H. (Eds), Springer-Verlag Berlin-Heidelberg, pp. 285-291
- Rausch P., Sheta A. F., Ayesh A., (2013) "Business Activity Monitoring", *Business Intelligence and Performance Management, Theory, Systems and Industrial Applications*, Springer-Verlag London
- Schwalbe K. (2014) "Information Technology Project Management", Course Technology, Boston, USA, pp. 7
- Simon D., Fischenbach K., Schoder D., (2013) "Enterprise architecture management and its role in corporate strategic management", *Information Systems E-Business Management*, Springer-Verlag Berlin Heidelberg
- Sveiby K. (1997) "The Intangible Assets Monitor", *Journal of Human Resource Costing and Accounting*, Emerald Insight
- "tactics." Merriam-Webster.com. 2014. <http://www.merriam-webster.com> (2 January 2014).
- Tennant G., (2001) "Six Sigma: SPC and TQM in manufacturing", Gower Publishing Limited England
- Van Grembergen W., Saull R., De Haes S. (2015) "Linking the IT Balanced Scorecard to the Business Objectives at a Major Canadian Financial Group", University of Antwerpen Management School, ITAG Research Institute, <http://www.antwerpmanagementschool.be/media/287506/linking%20it%20scorecard%20to%20bus%20objectives%20can.pdf> (accessed on 5 May 2015)

- Webster J. and Watson R. T., (2002) *"Analyzing the Past to Prepare for the Future: Writing a Literature Review"*, MIS Quarterly, Vol. 26, No. 2
- Werner S., (2005) *"Sense and Respond Business Performance Management"*, *Supply Chain Management on Demand: Strategies, Technologies, Applications*, Springer Berlin Heidelberg
- Welsh K., Sawyer P., Bencomo N. (2011) *"Towards Requirements aware Systems: Run-time Resolution of Design-time Assumptions"*, IEEE Explore, USA
- Zdravkovic, J., Stirna, J., Henkel, M., Grabis, J. (2013) *"Modeling Business Capabilities and Context Dependent Delivery by Cloud Services"*, CAISE 2013, LNCS 7908, Springer-Verlag Berlin Heidelberg



# Intelligent Models and Systems in Spatial Marketing Research

Elena Serova<sup>1</sup> and Mikhail Krichevsky<sup>2</sup>

<sup>1</sup>St. Petersburg State University of Economics, St. Petersburg, Russia

<sup>2</sup>St. Petersburg State University of Aerospace Instrumentation, St. Petersburg, Russia

[serovah@gmail.com](mailto:serovah@gmail.com)

[mkrichovsky@mail.ru](mailto:mkrichovsky@mail.ru)

**Abstract:** This paper deals with the issues of Russian and international researches in the field of design of sustainable information architecture of management systems in the context of spatial economics. It is theoretical and empirical research in equal measure. Research methodology is methods and procedures of modeling. The main purpose of this paper is consideration the features of application of contemporary intelligent information technologies and systems for spatiotemporal analysis. The paper is devoted to the study of issues of stability of architecture of spatial information system. Now modern intelligent methods and technologies are essential components for developing management decision process that will enable companies to succeed in a rapidly changing environment. The latest achievements in the field of intelligent technologies in economy and management, including the methods and tools of agent-based modeling and soft computing are the key factors in improving organizational performance and increasing its competitiveness. Fuzzy technologies as technologies of artificial intelligence are having a significant influence on information systems (IS) design and analysis. At the same time IS sustainability is now one of the key drivers of business success. Original contribution of the work is based on the applying of intelligent information technologies and modern modeling methods for creating scoring model of IS sustainability. The paper also contains theoretical foundations of information systems architecture and the brief overview of spatial sciences development in Russia.

**Keywords:** spatial economics, sustainability of information systems, soft computing, Fuzzy logic methods, hybrid model, scoring model

---

## 1. Introduction

In Russia today the use of advanced information technologies in economy and management is a key factor in improving organizational performance and increasing competitiveness. Distinctive features of the successful companies are sustainable business model, innovation, adaptability, and a deep understanding of consumer preferences. 80% of Russian executives believe that information communication technologies are playing a dominant role in the use of innovative business models and strategic goals realization. Information communication technologies (ICT) can reduce operating costs and increase profitability. Influenced by information technologies the activities of the company's basic departments (marketing, sales, and finance) are changing. This is due to the more efficient accumulation and analysis information. ICT can govern the ability of companies to generate the sustainable business models (Chesbroug, 2003, 2006; Osterwalder and Pigneur, 2010; Serova, 2013a). In industrial countries the questions of selection and application of modern information systems and technologies for strategic business objectives and market needs are in the spotlight.

Information technologies are dramatically changing people's lives. Industrial processes are becoming more and more intellectual, with their growing efficiency. ICT's constant development and appearance of new functions are driving large-scale economic changes. Under the influence of ICT, relations between government, companies, and people are significantly transforming. However, practice shows that ICT, having essential potential for economic growth and sustainable development, appear to have certain drawbacks. It is extremely important to note that their positive and negative characteristics are not only economic, but social and ecological. To maximize positive effects and neutralize drawbacks, ICT should be managed by government, businesses and societies together.

Owing to implementation contemporary information technologies, management processes are changing tremendously. Society is also changing. Interests and values of different social groups are evolving and modifying. Some of the reasons are that ICT are quickly spreading into the social network of society, they are extremely wide-reaching and wide-accessible. We have now progressed from the knowledge-based economy to the knowledge-driven economy, emphasizing the fact that the current contribution of knowledge is very significant. Knowledge is considered as an economic driver in today's economy, it has become a commodity that can be packed, bought and sold. This evolution has been enhanced by the development of information and communication technologies that have reduced the cost of gathering and disseminating knowledge. The



knowledge-driven economy brings new challenges for business. Markets are becoming more global with new competitors, product life cycles are shortening, customers are more demanding and the complexity of technology is increasing. So while the knowledge economy represents new opportunities, ICT innovation is needed to support and take advantage of them.

At the same time spatial science, as an area of interdisciplinary scientific research, has become especially popular in the last decades. Attention of many scientists, including researchers in the field of spatial sciences, in particular, spatial economics, more and more focuses on the study of such important elements in formation of spatial relationships, as information infrastructure and architecture of spatial information systems.

At present intelligent information systems and technologies are evolving actively. These technologies and systems are based largely not on tangible, but on information and communication resources that belong to the class of synergistic resources. The class of intelligent information technologies (IIT) and systems, including multi-agent systems (MAS), neural network (NN), and fuzzy logic (FL) continues to improve (Serova, 2013c). IIT are developed rapidly over the past ten years and they allow creating models of interaction between different kinds of spaces. Simultaneously IS sustainability is now one of the key drivers of business success. Paper contains the brief review and comparison of soft computing methods and techniques, and it focuses on the various intelligent modeling methods that are employed in evaluation of sustainability of information systems architecture in management and economy. The paper describes the main features of soft computing, discusses its implementation for design of sustainable information systems, and considers the role of fuzzy logic method and using scoring model of IS sustainability. It does so from research base that draws from theoretical underpinnings as well as international and domestic industry practices.

## **2. Theoretical background**

### **2.1 Information system architecture**

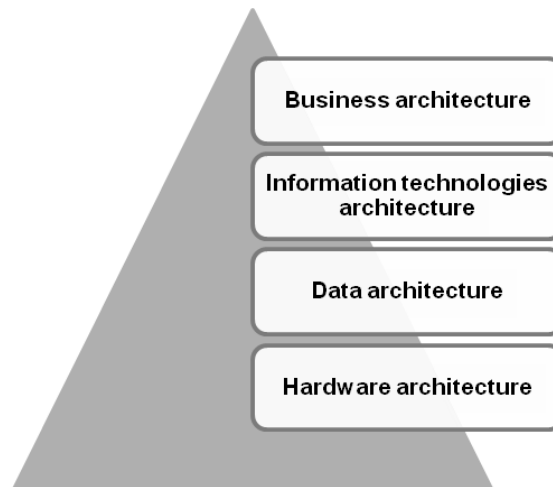
Variety of information systems applications for solving problems in management and economics has led to the requirement of using of information processes and technologies together with systems approach based on information systems architecture. When it comes to what actually is meant by the term "information system architecture", there is not usually lack of definitions. For example, there are a few tens of system architecture definitions on the site of Software Engineering Institute (SEI, 2014). Here are some of them:

- The architecture of a system is an abstraction of the system giving the semantics and specification for the patterns of information content and context.
- System architecture defines the physical, logical and information elements of the system which come together to realise a required set of functionality
- Architecture is the identification of different building blocks of the system according to their responsibilities, external properties of these blocks and their interrelationships.
- Architecture - the organizational structure of a system
- Architecture defines the data, processes, and components that make up the overall information system, and provides a plan from which products can be procured—and systems developed—that will work together to implement business solutions. Simply put, architecture provides the direction to make technology work for the business.
- Architecture is defined by the recommended practice as the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution.

Architecture of management information system can be considered as a concept, which determines the model, the structure, functions and components' relationship. The term "Enterprise architecture" is usually used concerning organizations and as shown in Figure 1, the next main types of architectures are assigned (Sovetov et al, 2012):

- Business architecture,
- Information technologies architecture,
- Data architecture,

- Application architecture or Software architecture, and
- Hardware architecture.



**Figure 1:** Information system architecture

Typically, information systems are focused on the use and satisfaction of customers' needs within a specific subject area. As examples of information systems application for solving problems in economics and management can be specified the following:

- Enterprise management information systems,
- Trading information systems,
- Marketing information systems,
- Geographic information systems,
- Health care information systems, etc.

Sustainability of architecture of information system is determined by the stability of its structure, state parameters, and the most important is the stability of the current processes of its functioning and development. Adaptability of information system first of all means its flexibility and property of adjusting itself under varying changes. Adaptive architecture of information system is a methodology to create a more flexible and rational, customizable architecture that allows organizations of any size to react promptly to market and information flow changes. Design of sustainable and adaptive information architecture of information systems is possible based on the applying of such intelligence information technologies as neural networks and fuzzy logic.

The group of modern enterprise management systems, in the first place, includes Enterprise Information Systems (EIS) - systems using various information technologies. EISs serve for data processing of different information flows on the different management levels.

It should be noted that there is no generally accepted classification, but as a rule, the strategic level systems include analytical retrieval systems technology-based Data Mining, expert information systems (EIS), Executive Support Systems (ESS), and Decision Support Systems (DSS). IS of the middle management level include Knowledge Management Systems (KMS) and Management Information Systems (MIS). Transaction Processing Systems and Office Automation Systems are used on the operation level of management (Pearlson et al, 2006; Rainer et al, 2006; Kazantsev et al, 2007; Turban et al, 2008; Serova, 2012b). Today in the publications on the topic of business efficiency and competitiveness of enterprises, many names and acronyms are mentioned, such as Product Lifecycle Management (PLM), Supplier Relation Management (SCM), Customer Relation Management (CRM) (Payne, 2006), and ERP. These names come after the concepts and management techniques used by successful companies. Interest in them is growing in Russia. Leaders of Russian companies are increasingly turning to the experience of the use of solutions that help integrate the people, information and business processes to effectively manage all areas of business. The term ERP — Enterprise Resource Planning, is one of the key issues in this series of current concepts. According to Serova (2012b), the recent

trends in the development of enterprise information systems are associated with the intention to use information generated within the company, in the external environment to ensure cooperation with other enterprises, customers and partners. Today we should take into account the new concept of Enterprise Information System: the emphasis is placed on the EIS which is opened for the all partners operating in common business interests instead of on traditional internal business process management optimization. This concept includes five new tendencies (Serova, 2012b):

- Change the role of ERP system. Automation the internal business processes as well as external, counteragent relationships: customers, suppliers, banks, tax authorities;
- The system technologies move towards an openness and transparency. Internal processes are becoming more open. Information and data about activity of an enterprise can be available for business society member. Use of Web-technologies.
- Structural changes of system architecture. Instead of closed monolithic platform – open multilevel applications built on concepts of service-oriented architecture (SOA). Use E-SOA;
- Expansion of system implementation. Adaptation for enterprises of different kinds and sizes;
- Deepen the system functionality. All enterprise business processes should be automated;

## **2.2 Brief history and theory of the “economic space”**

The definition and conceptual framework of the Spatial Sciences are still in the stage of discussion and debate. Several scientific schools of spatial economics were founded in Russia: in St. Petersburg and Moscow, Far Eastern school, Siberian school, and the Ural school. The Economic Research Institute of the Russian Academy of Sciences (RAS), with the support of the Scientific Council for Regional Development at the RAS Presidium, has been publishing the academic journal “Spatial Economics” since 2005. RAS’s research program “Fundamental Problems of Spatial Development of the Russian Federation: an Interdisciplinary Synthesis” was started in 2009.

In accordance with the basic hypothesis of the program, spatial science is defined as an interdisciplinary scientific direction, and objects of research are forms and processes of a modern society, which are space-dependent (Granberg, 2009). Three statements are offered as a conceptual basis. They related to the spatial, regional and international aspects.

In the other countries the attention of the public to scientific research in the area of spatial sciences and spatial development is also growing. “Journal of Spatial Science” has being published in Australia (information available from the website: MSIA mapping science institute, 2012).

Famous international publisher Springer has produced more than 40 volumes of the series “Advances in Spatial Science” (information available from the website: Springer, 2013). U.S. National Science Foundation (NSF) has approved a strategic plan for research in 2008-2012 entitled “Geography Spatial Sciences” (information available from the website NSF National Science Foundation, 2013).

Great importance, both in Russia and in the other countries, is given to the development of global, regional and national spatial data infrastructure. The most important initiatives in this direction are the existing international programs: Infrastructure for Spatial Information in Europe, National Spatial Data Infrastructure, Global Spatial Data Infrastructure, and Global Monitoring for Environment and Security. What is important concerning Russia is, that the general architecture has created and the main components of the Russian segment of the information infrastructure and its integration into the world system have defined (Krasnopol’skii, 2010).

## **2.3 Spatial marketing researches**

The concept and theory of the “economic space” was formed in compliance with geographic, geopolitical, and regional concepts. And now an economic space is considered in the framework of concepts of globalization, industrial spatial clusters, “cumulative causation”, high information technologies and network. Analysis of points of view on the economic space can be divided into four approaches to the study of this category: territorial, resources, information and process (Bagiev et al, 2012).

The territorial approach has long dominated over the other approaches. The essence of this approach is based on economic space as a saturated territory having a plurality objects and the relationships between them. Resource-based approach determines the economic space as an environment for decision making about use of resources. The essence of the information approach is that economic space is considered as the information component of the economic process. Information approach adequately reflects the role and importance of information exchange between business entities. Process-based approach gives reason to determine the economic space as a relationship between economic processes of business entities and aggregate economic process with the purpose of formation of the possible outcomes of economic activity. Adding the marketing function to the structure of the functions of economic space is dictated by the need to replicate the economic space in time under the influence of scientific and technological progress, innovation, transformations in the environment due to the constant changes in requirements and fluctuations of supply and demand (Bagiev et al, 2012).

The major advantage of the spatial approach is the ability of multidimensional representation of spatially localized complex systems, in which the economic, ecological, social, geographical, political, and technological components interact. These components determine the functioning equilibrium and development of the region, as well as creating conditions to maximize region's contribution to the spatial systems development of higher level. The basis of the spatiotemporal concept to marketing is the principle of systemic approach and consideration of marketing system as a large complex system consisting of elements of different types and having heterogeneous relationships between them. Spatial system of marketing is treated as a complex system, a set of subsystems and their relations in many dimensions: social, industrial, territorial, etc.

Interdisciplinarity of spatial marketing researches consists not only in expanding the subject of research (joint study of the marketing spaces of different types), but in the synthesis of notions, concepts and methodologies of the social, humanitarian, sociological and engineering sciences, modelling and prediction of interaction and mutual influence of different kinds spaces, a generalization of the theoretical results and creating of the interdisciplinary databases. Definition of qualitative parameters that impact on equilibrium of operation and development of spatial marketing system and formation of conditions for maximizing its effectiveness entails consideration of four main groups of factors: market, macroeconomic, industrial, and social and technological (Table 1). The decision of such multicriterion tasks involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. All of these types of systems are not mutually exclusive. Moreover, there are hybrid systems that contain all three elements - optimization, simulation and fuzzy inference system.

**Table 1:** The main groups of factors and indicators

Factors	Indicators
Market	Market segments
	Needs and demands
	Market issues (forces)
	Switching cost
	Revenue attractiveness
Macroeconomic	Economic infrastructure
	Commodities and other resources
	Capital market
	Global market condition
Industry	Competitors
	New entrants
	Stakeholders
	Suppliers
	Substitute products and services
Society and technologies	Societal and cultural trends
	Socioeconomic trends
	Technology trends
	Regulatory trends

### **3. Intelligence information technologies for architectural design of spatial information systems**

#### **3.1 Agent-based modeling**

The increasing demand for optimization of architecture of spatial information systems has caused leading modelers to consider intellectual information technologies and computer modeling in order to obtain deeper insights into complex and interdependent processes.

Modern modeling tools should facilitate mutual understanding at different organizational levels when making strategic management decisions thus bridging the gaps between a strategic vision and its implementation (Pidd, 2004). One approach involves multi-agent systems (MAS) which, as a class, have developed rapidly over the last decade. The advantage of a multi-agent approach relates to the economic mechanisms of self-organization and evolution that become powerful efficiency drivers and contribute to enterprise's development and prosperity. New intellectual data analysis can be created, through MAS which is open, aimed at flexibly adaptive problems solving, and deeply integrated in decision support systems (Serova, 2012a). Modern business modeling tools use special software, programming languages and systems to develop models of business processes, relations between people and areas for optimization in the organizational structure as a whole. Building a sustainable and adaptive architecture of spatial information systems is possible on based of the applying of modern modeling methods and technologies.

The major approaches (or methods) in simulation for business are: System Dynamics (SD), Discrete Event (DE) and Agent Based (AB). While SD and DE are traditional approaches, AB is relatively new. Compared to SD or DE models, AB models do not allow the definition of global system behaviour (dynamics); instead, the modeler defines behaviour at individual level, and global behaviour emerges as a result of the actions of multiple actors, each following its own behaviour rules, living together in some environment and communicating with each other and with the environment (Borshchev, Filipov, 2004; Serova, 2013c).

Multi-Agent Systems as a system of distributed artificial intelligence, integrated into the information structure of the company, may be considered as an effective tool for spatiotemporal analysis of marketing information resources and creating of architecture of spatial marketing information system. With the using Agent Based Modeling we can obtain and analyse geospatial data, create models, linked to geographic coordinates and to develop of geoinformation architecture of complex marketing systems. Multi-Agent systems and agent-oriented programming represent a step forward from object-oriented programming (OOP) and integrate the latest advances in the areas of artificial intelligence, parallel computing, and telecommunications.

Any MAS consists of the following components:

- A set of organizational units with a subset of agents and objects;
- A set of tasks;
- A business ecosystems - a space where agents and objects exist;
- A set of relations between agents;
- A set of agent actions (operations on objects).

Intellectual agents have the most comprehensive set of qualities; their intellectual capacity allows them to build virtual worlds where they form action plans. Minimum set of basic characteristics for any agent includes qualities such as activity, autonomy, adaptability, and reactivity.

As systems of distributed artificial intelligence, Multi-agent Systems have the following advantages which can be successfully use for marketing spatial research (Serova, 2013):

- They speed up task fulfilment through parallelism and reduce the volume of data transmitted by passing high-level partial solutions to other agents;
- They are flexible since agents of various capacities are used to carry out a task dynamically cooperatively;
- They are reliable given that functions that one agent is unable to carry out will be passed to other agents.

Agent technologies usually involve the use of certain typologies of agents, their models and MAS architectures. These technologies are based on appropriate agent libraries and tools which serve for support development of different types multi-agent systems.

Applying multi-agent systems in order to design information architecture of marketing spatial systems can consist in the following (Serova, 2013c):

- To simulate and forecast clients' behaviour, both adopted and potential ones';
- To coordinate dealers and remote divisions based on multi-agent system;
- To automate and improve the customer support process within the CRM concept;
- To store knowledge and skills of marketing and sales specialists in the relevant agents' databases;
- To develop an integrated multi-agent Internet portal for agents to keep users' personal contents;
- To create a search agents to monitor outside information;
- To organize a distance-learning portal.

### **3.2 Fuzzy logic method for design of sustainable architecture of information systems**

Design of sustainable and adaptive information architecture of spatial information systems is possible based on the applying of such intelligence information technologies as neural networks and fuzzy logic. Neural networks and fuzzy logic - are methods related to Soft Computing (SC). Applying the information and communication technologies, which are used in Soft Computing, allows achieving the quantitative results, which is very important for manager to make a decision. Fuzzy set (FS) was introduced by Lotfi A. Zadeh (Zadeh, 1994) as a means of representing data that was neither precise nor complete. There are two main characteristics of fuzzy systems that give better performance for specific applications: the first is that fuzzy systems are suitable for uncertain or approximate reasoning and the second is that fuzzy logic allows problem solving and decision making on the basis of incomplete or uncertain information. Fuzzy technologies as technologies of artificial intelligence are now having a significant influence on information systems design and analysis (Kecman, 2001; Krichevskii, 2005; McNelis, 2005).

Soft computing techniques are meant to operate in an environment that is subject to uncertainty and imprecision. According to Zadeh (Zadeh, 1994), the guiding principle of soft computing is: exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness, low solution cost and better rapport with reality. Fuzzy technologies as technologies of artificial intelligence are now having a significant influence on information systems design and analysis. At the same time IS sustainability is now one of the key drivers of business success. On the application level fuzzy logic can be considered as efficient tool for embedding structured human knowledge into useful algorithms. Mathematical models simplify and conceptualize events in nature and human activities by employing various types of equations which must be solved. However, the use of mathematical models gives rise to the question how accurate they reflect reality. In complicated cases the creating of such models might be impossible. Fuzzy models will become more and more popular as solution schemes, and it will make fuzzy systems theory a routine as opposed to its previous status as a "new, but curious technology". Fuzzy logic models employ fuzzy sets to handle and describe imprecise and complex phenomena and use logic operations to find a solution. The goal of control process in management is making the decision. It might be also suggestion, instruction, conclusion, evaluation, forecasting. A block diagram of Fuzzy logic model is represented in Figure 2.



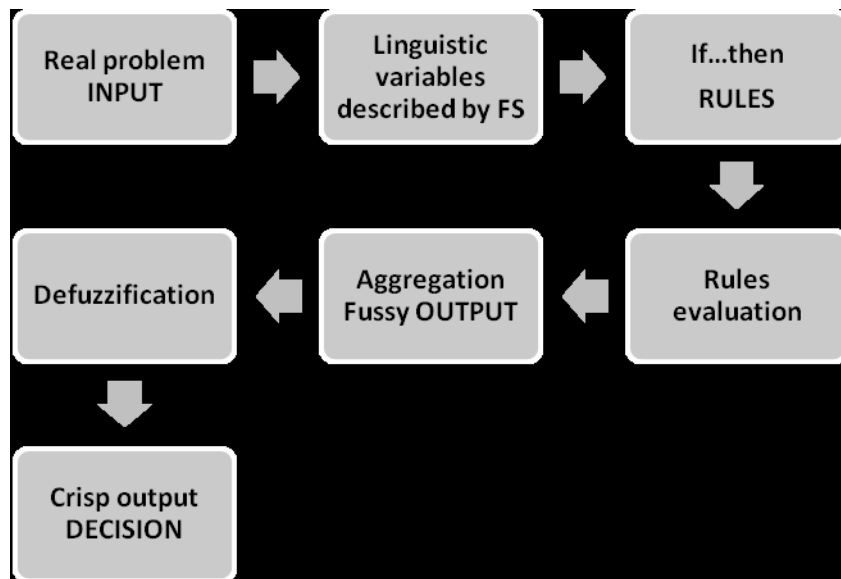


Figure 2: Block diagram of FL model creating

#### 4. Hybrid intelligent models for design of spatial marketing systems architecture

##### 4.1 Scoring model of product diffusion system sustainability

This section of the paper is devoted to the creation of FL model with the purpose of assessment of product diffusion system sustainability. Potential Adopters become Adopters at Adoption Rate that depends on advertising and word of mouth promotion. The figure 3 shows the fuzzy inference system (FIS) for three input variables and one output parameter. This FIS is destined for the assessment of the IS sustainability. The input parameters are advertisement (ad), contact rate (cr), number of potential adopters (npa). Three selected attributes are included as input data to a fuzzy inference system. The output parameter determines the IS sustainability as the adoption fraction (af). The control objective is to find the output value for a particular set of input variables. Each of input parameters is the linguistic variable with three terms: *low*, *middle*, *big*. Membership functions characterize the fuzziness in a fuzzy set in a graphical form for eventual use in the mathematical formalisms of fuzzy set theory. The Figure 4 gives the information about the membership functions for the input and output variables. All calculations were performed in MATLAB v. 7.01.

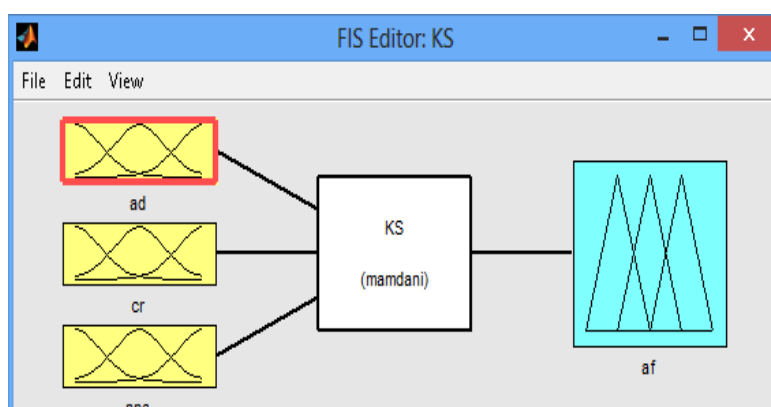
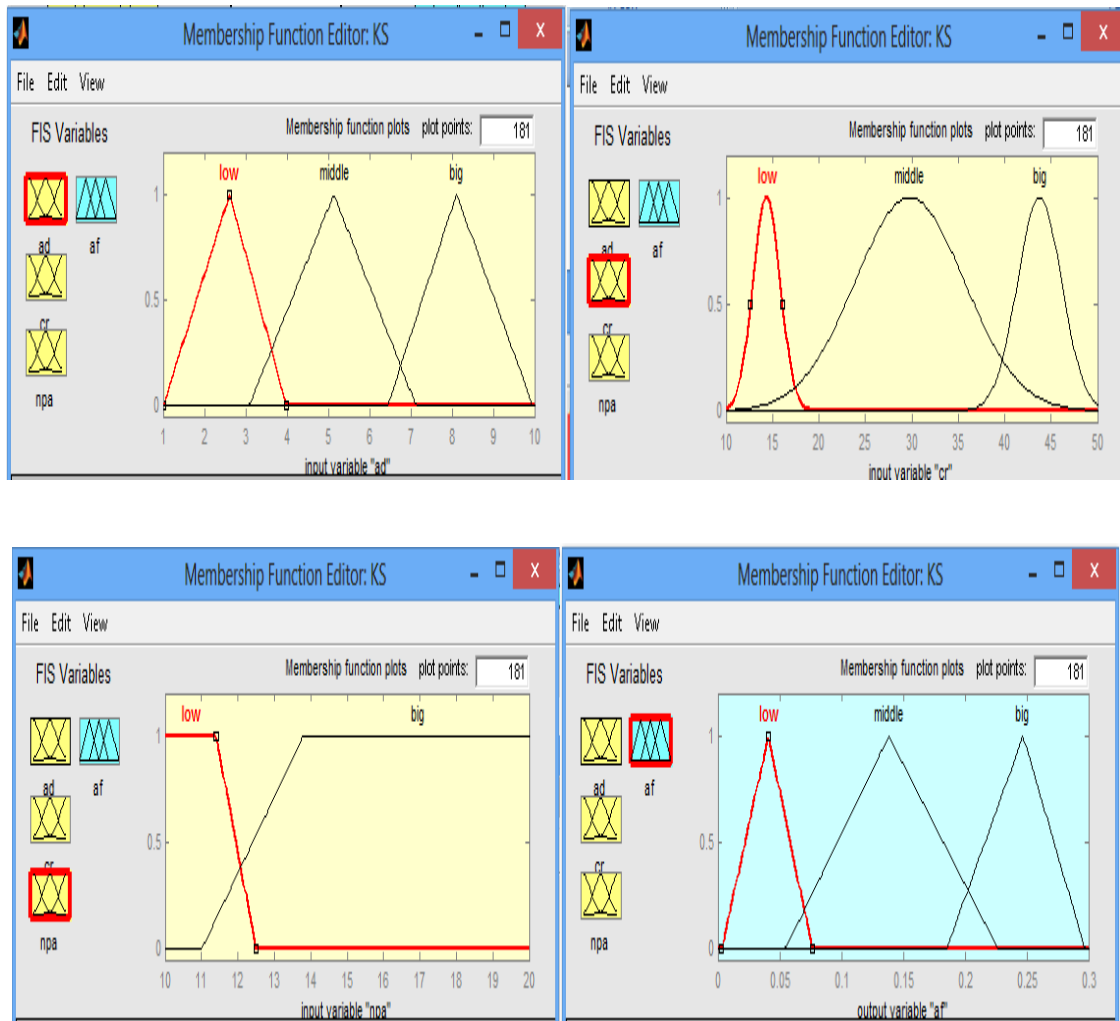


Figure 3: Fuzzy inference system (FIS)

The next step is definition of the FIS rules. The number of the rules is the product of the number of terms in each input variable:  $3 \times 3 \times 2 = 18$ . After forming bases of rules FIS gives the values of IS sustainability as conditional units. We finally get a crisp value of the output which represents the values of IS sustainability. Figure 4 displays the value of sustainability equal 0.12 for given set of input variables:  $ad = 6.8$ ;  $cr = 26.1$ ;  $nap = 11$ . The fuzzy approach for assessment of IS sustainability was supplemented by the regression equation in conclusion. In the first step all input variables were modeled by Monte-Carlo method. In the second step the

modeled inputs were introduced into the FIS and the values of IS sustainability were formed as outputs of the FIS.



**Figure 4:** Membership functions for the input and output variables

Table 1 contains the modeled inputs and the values of IS sustainability calculated by FIS (the fourth column).

**Table1:** The modeled inputs and calculated outputs

1	X1	X2	X3	Y (Fuzzy Logic)	Y(Regression)
2		5,0	34	0,18	0,04
3		3,6	20	0,11	0,092
4		5,9	35	0,14	0,041
5		7,4	36	0,12	0,153
6		7,3	38	0,20	0,149
7		8,1	42	0,15	0,163
8		2,2	22	0,26	0,102
9		5,1	32	0,13	0,04
10		7,1	35	0,08	0,14
11		3,9	29	0,07	0,063

In the third step the regression equation was derived with the use the first four columns of Table 1. The regression equation is of the form

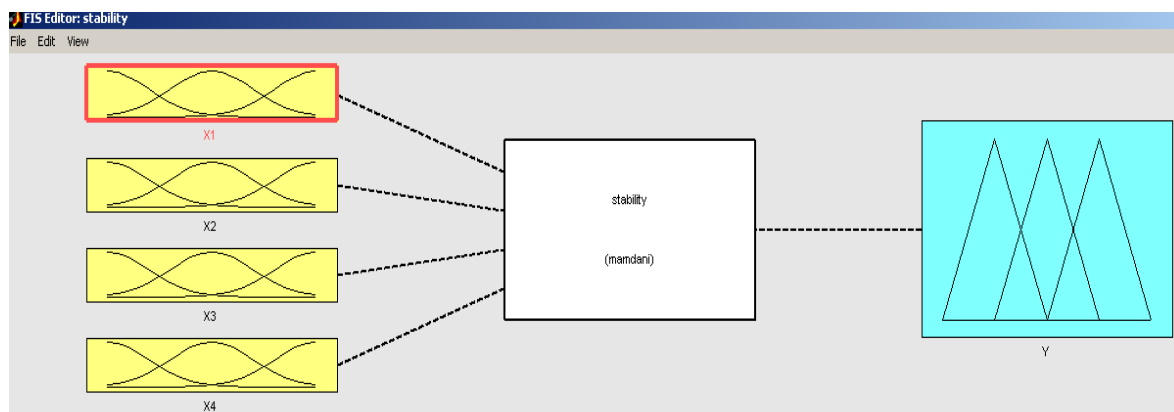
$$Y = 0.085 + 0.046 \cdot X1 - 0.01 \cdot X2 + 0.33 \cdot X3,$$

where  $X_1$ ,  $X_2$ ,  $X_3$  - are advertisement, contact rate, number potential adopter;  $Y$  - numerical value of IS sustainability.

The last column of Table 1 contains the value of IS sustainability which is calculated by the regression equation. The comparison of the values of IS sustainability calculated by FIS (the fourth column of the table 1) and the regression equation (the fifth column) shows their similarities. Thus the derived regression equation can be used to assess the numerical value of IS sustainability.

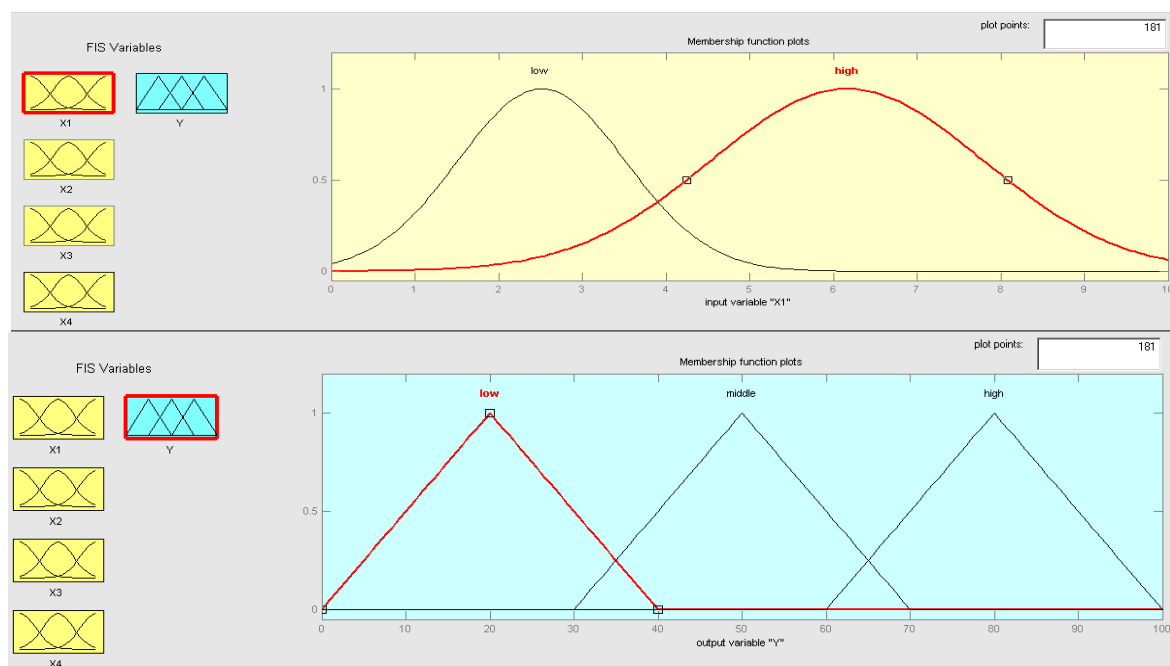
#### 4.2 Fuzzy-logic model for evaluation impact of market factor

Market factor is one of the main forces influencing on equilibrium and sustainability of operation and development of spatial marketing system and formation of conditions for maximizing its effectiveness. The figure 5 shows the fuzzy inference system for four input variables and one output parameter. This FIS is destined for the assessment of the IS sustainability. The input parameters are market segments ( $X_1$ ); market needs ( $X_2$ ), market issues or forces ( $X_3$ ), and revenue attractiveness and switching costs ( $X_4$ ). Four selected attributes are included as input data to FIS. The output parameter determines the IS sustainability ( $Y$ ). The control objective is to find the output value for a particular set of input variables.



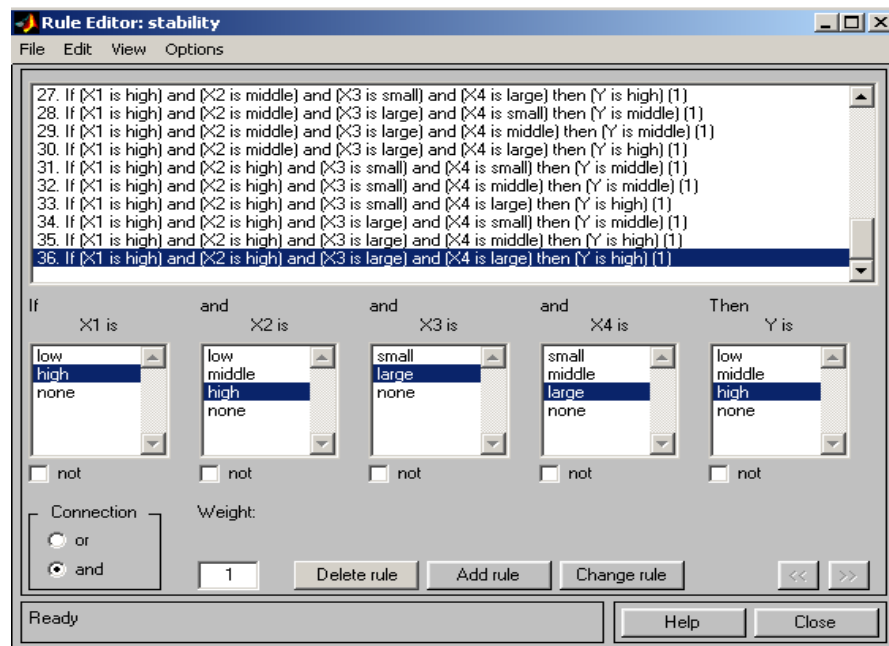
**Figure 5:** Fuzzy Inference System (model for evaluation impact of market factor)

The Figure 6 shows the information about the membership functions for the first input and output variables. All calculations were performed in MATLAB v. 7.01.



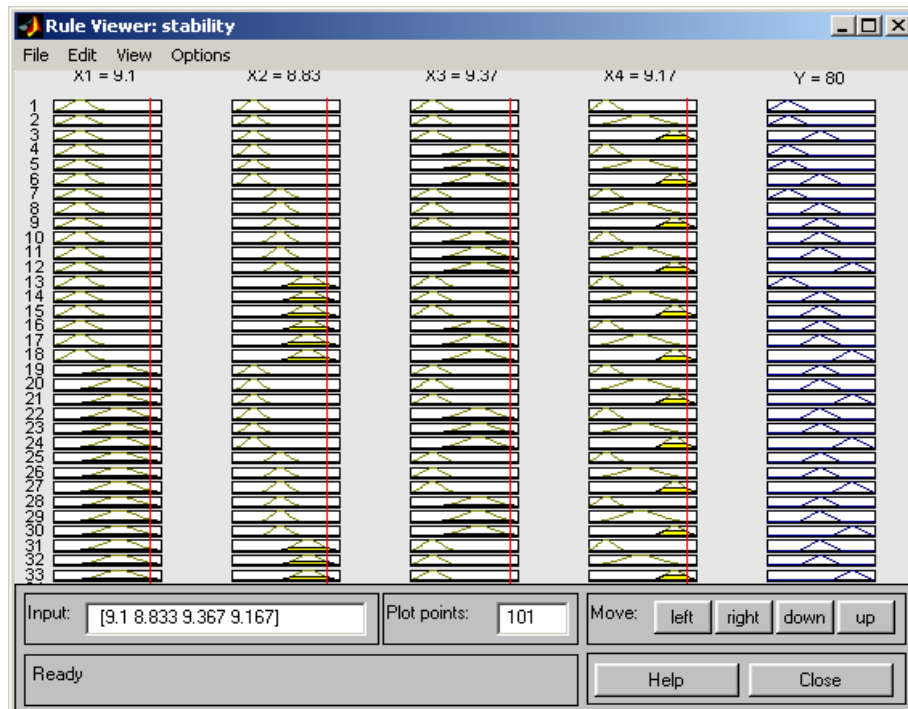
**Figure 6:** Membership functions for the input and output variables (model for evaluation impact of market factor)

The number of the rules is the product of the number of terms in each input linguistic variable:  $2 \cdot 3 \cdot 2 \cdot 3 = 36$ . The Figure 7 displays the forming the base of rules.



**Figure 7:** The process of forming the base of rules

After the forming base of rules the system of FL control gives the value of sustainability as conditional units. Fig.8 displays the value of quality equal 80 points for given set of input variables:  $X1 = 9,1$ ;  $X2 = 8,8$ ;  $X3 = 9,4$ ;  $X4 = 9,2$ .



**Figure 8:** The results of modeling

## 5. Conclusion

At present the use of the latest achievements in the field of Information Communication Technologies (ICT) in economy and management, including the contemporary methods and tools of computer modeling is one of the key factors in improving organizational performance and increasing its competitiveness. Formation of architecture of spatial systems is determined by the problem increased use of spatial information in sustainable development of the territories and is one of the perspective areas of research in the field of spatial information systems. Theoretical and empirical researches prove that spatiotemporal analysis of data can be performed through applying of contemporary intelligent information technologies with using multi-agent systems as systems of distributed artificial intelligence. Architecture of spatial information system can be considered as a concept, which determines the model, the structure, functions and components' relationship. Building a sustainable architecture of management information systems, including marketing information system, is possible with the use of soft computing methods, such as fuzzy logic.

System researches of marketing space, the use of spatial approach and multidimensional representation of spatially localized complex management systems may be based on the analysis of four main groups of factors: market; macroeconomic; industrial; social and technological. The decision of such multicriterion problems involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. Determination of the parameters that impact on the sustained development and operation of the spatial marketing system and creation of conditions for maximizing of its effectiveness is possible by using hybrid intelligent models and systems.

## References

- Albright, S.C., Zappe, C. J, and Winston W. L. (2011) *Data Analysis, Optimization, and Simulation Modeling*, Canada: South-Western, Cengage Learning.
- Bagiev, G.L., Serova, E.G., Pinchuk, A.V., Shul'ga, A.O. (2012) "Marketing of Spatial Interaction Theoretical Principles, Informational Replication, Measuring, Evaluation of Efficiency", *Eurasian International Scientific-Analytical Journal "Problems of Modern Economics"*, Issue 4(44), pp 219-225.
- Bagiev, G.L. and Tarasevich V.M. (2012) *Marketing*. St. Petersburg: Publishing House "Piter".
- Bojadziev V, Bojadziev M. (2007) *Fuzzy logic for business, finance and management*. World Scientific, New Jersey.
- Borshchev, A. and Filipov, A. (2004) "AnyLogic — Multi-Paradigm Simulation for Business, Engineering and Research", Paper read at The 6th IIE Annual Simulation Solutions Conference, Orlando, Florida, USA.
- Chen, D. and Dahlgren, C. (2005) "The Knowledge Economy, the KAM Methodology and World Bank Operations", [online], The World Bank, [http://siteresources.worldbank.org/KFDLP/Resources/KAM\\_Paper\\_WP.pdf](http://siteresources.worldbank.org/KFDLP/Resources/KAM_Paper_WP.pdf).
- Chesbrough, H. (2003) *Open Innovation. The New Imperative for Creating and Profiting from Technology*, Massachusetts: Harvard Business School Press.
- Chesbrough, H. (2006) *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press.
- Forrester, J. (1961) *Industrial Dynamics*. Cambridge, MA: MIT Press.
- Gavrilova, T.A. and Muromtsev, D.I. (2007) *Intellectual technologies in management: tools and systems*, GSOM SPbSU, St. Petersburg.
- Granberg, A.G. (2000) *Foundation of the Regional Economy*, Moscow: SU Higher School of Economics.
- Granberg, A.G. (2009) "About Program Fundamental Researches of Spatial Development of Russia", *Region: Economics and Sociology*, № 2, pp 168-170.
- Karpov, Yu. (2005) *System simulation modeling. Introduction to modeling with AnyLogic*, St. Petersburg: BHV.
- Kazantsev, A., Serova, E., Serova, L., and Rudenko, E. (2007) *Information technology resources of Russia's economy*, St. Petersburg: St. Petersburg University Publishing House.
- Kecman, V. (2001) *Learning and Soft Computing - Support Vector Machines, Neural Networks, and Fuzzy Logic Models*, London: The MIT Press.
- Krasnopol'skii, B. (2010) "Spatial Sciences and Their Role in Studying Spatial Formations Economics", *Spatial Economics*, № 1, pp 147-156.
- Krichevskii, M.L. (2005) *Intelligent Methods for Management*, St. Petersburg: Publishing House "Piter".
- Law, A.M., Kelton, W.D. (2000) *Simulation Modelling and Analysis*, 3rd ed. McGraw-Hill.
- McNelis, P.D. (2005) *Neural Networks in Finance: Gaining Predictive Edge in the Market*, Amsterdam: Elsevier Academic Press.
- Magedanz, T. "OMG AND FIPA standardization for agent technology: competition or convergence?". CORDIS. [online], <http://cordis.europa.eu/infowin/acts/analysys/products/thematic/agents/ch2/ch2.htm>.
- Minakir, P.A. (2006) *Economics of Regions. Far East*, Moscow: Publishing House "Economics".
- NSF Geography and Spatial Science Program Strategic Plan, 2008-2012 (K-1/19/09), [online] [http://www.nsf.gov/sbe/bcs/grs/GSS\\_StrategicPlan\\_2008.pdf](http://www.nsf.gov/sbe/bcs/grs/GSS_StrategicPlan_2008.pdf).

- Osterwalder, A., Pigneur, Y. (2010). *Business Model Generation. A handbook for Visionaries, Game Changers, and Challengers*, WILEY, John Wiley & Sons.
- Payne, Adrian. (2006) *Handbook of CRM: achieving excellence in customer management*, Elsevier, Amsterdam.
- Pearlson, Keri E., Saunders, Carol S. (2006) *Managing and Using Information Systems. A Strategic Approach*. Third Edition, John Wiley & Sons, USA.
- Pidd, M., (2004) *Computer Simulation in Management Science*, 5th Edition, Wiley.
- Rainer, R., Turban, E., Potter, Richard E. (2006) *Introduction to Information Systems: Supporting and Transforming Business*, John Wiley, USA.
- Ross T.J. (2010) *Fuzzy Logic with Engineering Applications*. John Wiley & Sons Ltd, United Kingdom.
- Serova, E. (2012a) "Distributed Artificial Intelligent Systems for Decision Making Support", Paper read at The 26th Annual Conference of the British Academy of Management BAM 2012, Cardiff: Cardiff University, Cardiff Business School, the United Kingdom, September.
- Serova E. (2012b) "Enterprise Information Systems of New Generation". *The Electronic Journal Information Systems Evaluation*, Volume 15 Issue 1: 116-126, available on line <http://www.ejise.com> [accessed 20 June 2013].
- Serova, E. (2013a) "Formation of Sustainable Adaptive Architecture for Marketing Information Systems under Conditions of Spatial Economics". *Scientific Works of the Free Economic Society of Russia*, Volume 179: 646-654, available on line <http://www.iuecon.org/2013/179-veor.pdf> [accessed 20 Feb 2014].
- Serova, E. (2013b) "Information Architecture Design of Spatial Marketing Systems", Paper read at The 8th International Scientific Conference "Information Technologies in Business", St. Petersburg State University of Economics, St. Petersburg, Russia: SPbSUE, pp. 42-45, June.
- Serova, E. (2013c) "The Role of Agent Based Modelling in the Design of Management Decision Processes". *The Electronic Journal Information Systems Evaluation*, Volume 16 Issue 1: 71-80, available on line <http://www.ejise.com> [accessed 20 Feb 2014].
- Software Engineering Institute, *Community Software Architecture definition* [online], <http://www.sei.cmu.edu/architecture/start/glossary/community.cfm> [accessed 20 Feb 2014].
- Sovetov, B., Dubenetskiy, V., Tsehanovskiy, V. (2012) *Architecture of Information Systems*, Moscow: Akademia.
- Turban, E., Leidner, D., McLean, E., Wetherbe, J. (2008) *Information technologies for Management. Transforming Organization in the Digital Economy*, John Wiley, New York.
- White, Terry. (2004) *What business really wants from IT: a collaborative guide for senior business and IT managers*, Elsevier, London.
- Zadeh Lotfi. (1994) "Neural Network, and Soft Computing", *Fuzzy Logic, Communication of the ACM*, Vol. 37. № 3, pp. 77-84.



# Antecedents of Green IT Adoption in South African Higher Education Institutions

Shaun Thomson<sup>1</sup> and Jean-Paul van Belle<sup>2</sup>

<sup>1</sup>Forestry Tasmania, Tasmania, Australia

<sup>2</sup>University of Cape Town, Cape Town, South Africa

[thomsonza@gmail.com](mailto:thomsonza@gmail.com)

[jean-paul.vanbelle@uct.ac.za](mailto:jean-paul.vanbelle@uct.ac.za)

**Abstract:** Organizations are now increasingly expected to address the sustainability of their information technology (IT) and communication infrastructure. This research investigates the antecedents for the adoption of Green IT in South African higher education institutions (HEI), namely which drivers and readiness factors influence Green IT adoption. Green IT comprises of server virtualization, storage virtualization, storage consolidation, environment-friendly IT procurement, electronic waste management policies and measuring the environmental impact of IT. For the purpose of this research, Green IT drivers were classified into economic, ethical, response and regulatory drivers as per Molla's (2008) Green IT model. Additionally, we also investigated the role of the following Green IT readiness factors: institutional, organisational and value network Green IT. IT managers at all South Africa's HEIs were approached through an online survey. Given the small number of HEIs in South Africa, sample size was necessarily limited but the responses received represent a significant and representative portion of the South African HEIs and encouraging results were found. All Green IT drivers were found to be significant antecedents in the adoption of green IT, although the overall adoption of green IT is relatively low. However, most HEI stakeholders in the HEI value network, i.e. suppliers, investors, competitors and government, do not seem to exert a significant influence on green IT adoption. We condensed these antecedents into a revised Green IT adoption model. Our research instrument and proposed resultant Green IT model should be of interest, not only to HEI stakeholder in South Africa and elsewhere in the world, but also to researchers in the field of sustainability of information technologies and the manufacturers of green and sustainable technologies.

**Keywords:** green IT, adoption drivers, readiness, sustainability, higher education institutions (HEIs), South Africa

## 1. Introduction

People are becoming increasingly aware of the environmental impact of ICT and the necessity to reduce this impact on the environment (Jenkin, Webster & McShane, 2011). ICT components consume vast amounts of electricity during their lifetime and ICT carbon emissions are estimated to be equal to that of the aviation industry (Hanne, 2011). This awareness has resulted in a call for organizations to address the sustainability of the information technology and communication infrastructure (Jenkin et al. 2011). Although data-centre sustainability accounts for a significant portion of IT sustainability, client side IT equipment is often overlooked and is one of the primary contributors to carbon emissions of ICT. For example, the amount of carbon dioxide emitted over the average lifetime of a single desktop computer is said to be 1096kg (Paruchuri 2011). Discarded ICTs, known as electronic waste or e-waste, are one of the major and fastest growing contributors to waste disposal. It is thus imperative that a comprehensive approach to adoption of Green IT is employed in order for it to be successful Molla & Cooper 2010).

The adoption of Green IT is said to have additional motivational factors beyond those of standard IT adoption (Molla 2008; Molla & Abareshi 2011). These motivational factors may include economic benefits, regulation requirements, stakeholder obligations and ethical reasons, which all need to be taken into account when exploring and analysing factors that may influence the adoption of Green IT. Few studies have studied the adoption of Green IT from a higher education perspective and apart from research in the Green IS field (Petzer et al. 2011), none seem to have studied Green IT from a South African perspective.

This research aims to address the question, "Which drivers and readiness factors motivate higher education institutions to adopt green and sustainable IT solutions?" The results of this study will assist in providing insight into the reasons behind the adoption of Green IT within the higher educational sector and from an emerging economy perspective. These insights are of use to HEI stakeholders and sustainability researchers alike. The empirical validation of the theoretical framework used here, and the new research instrument which we developed, make a theoretical contribution to the academic research in the field of Green IT evaluation.

## 2. Literature review

There is an increasing call on organizations to address the sustainability of their information technology and communication infrastructure (Cooper & Molla 2010; Jenkin et al. 2011). Until recently information technology sustainability has received very little attention in terms of research (Chen et al. 2008; Molla 2008; Nazari & Karim 2012). As a result of this, there is still no mutual agreement on the exact definition of Green Information Technology (Green IT).

Green IT is often viewed purely from a data-centre perspective (Molla et al. 2008; Petzer et al. 2011). Although the sustainability of the data-centre plays an important role in the sustainability of information technology, it is necessary to adopt a comprehensive approach when addressing environmental sustainability (Murugesan 2008; Molla & Cooper 2010). Client side IT equipment is one of the primary contributors to carbon emissions of ICT with an average of 1096kg of carbon dioxide emitted over the average lifetime of a single desktop computer (Paruchuri 2011). Energy consumption can be significantly reduced by adapting the way in which we use these computers (Murugesan & Gangadharan 2012). This can be achieved through the application of relevant technology for the activity, power management features and powering down the computer when not in use (Murugesan 2008; Harmon & Auseklis 2009). The majority of ICT components end up in landfills once they have reached their end of life (Murugesan 2008). These discarded components, labelled electronic waste or e-waste, are one of the major and rapidly growing contributors to waste disposal.

The design and manufacturing of sustainable ICT can also assist in reducing the overall carbon footprint of ICT. By reducing the amount of raw materials, increasing the use of non-toxic materials and by recycling parts, manufacturers may assist in reducing their impact on the environment. Additionally, the design of energy-efficient technologies can also help in reducing the overall energy consumption of ICT.

Inevitably the decision to adopt sustainable ICT comes down to either the individual or the organization. Although IT adoption and the motivation of individuals and organization have been researched at length, the adoption of Green IT is said to have additional motivational factors other to that of standard IT adoption. This has prompted the development of Green IT-specific models and frameworks. Although research in the area of Green IT adoption is still young, a number of studies have attempted to explain the adoption of Green IT from various viewpoints (Molla 2008; Nazari & Karim 2012; Schmidt & Erek 2010). However, few of these studies have studied the adoption of Green IT from a higher education perspective and, apart from research in the Green IS field (Petzer et al. 2011), none seem to have studied Green IT from a South African perspective.

### 2.1 Defining green IT

In order to accurately assess the status of Green IT, it is important to have a clear understanding of the meaning and extent of Green IT, and the closely associated but different concept of Green IS. Green IT, also referred to as Green for IT or Green IT 1.0, is the application of sustainability to the design, manufacturing, use and disposal of IT. It is perceived to be the more mature and original form of Green IT. Lamb (2009) defines Green IT as, "Using IT more efficiently to achieve reductions in energy consumption, and therefore, considering the acquisition of energy-efficient IT solutions." This definition highlights two areas of Green IT: Sourcing of environmentally sustainable ICT equipment and efficient usage of ICT equipment. However, Green IT does not only refer to the economics and energy-efficiency of information technology but also environmental sustainability concerns within the design and manufacturing phases as well as indirect costs such as disposal and recycling (Murugesan 2008). The majority of ICT emissions are not a direct result of the ICT equipment but rather a result of the entire lifecycle of these components (Murugesan & Gangadharan 2012). Wallace and Webber (2009) offer a slightly enhanced approach and define Green IT as, "*the reduced environmental impact from running an Information Technology (IT) department*". They continue by highlighting three primary characteristics of Green IT: energy efficiency, correctly suited equipment and proper disposal of retired equipment. Although this covers a large portion of Green IT, they fail to take into account the design and manufacturing of the ICT equipment. Murugesan's (2008) definition incorporates additional components of the ICT lifecycle, such as the design and manufacturing together with the usage and the disposal of ICT equipment: "*the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment*" (S Murugesan, 2008).

However, this earlier definition still fails to take into account the sourcing of energy-efficient ICT (Molla et al., 2008). Molla et al. (2008) therefore suggest a more comprehensive approach and define Green IT as: “A systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of IT products and services in order to reduce IT, business process and supply chain related emissions, waste and water use, improve energy efficiency and generate tangible and intangible green economic rent” (Molla et al., 2008). This is a more holistic definition which covers each of the areas within Green IT and as a result of this we have chosen to adopt this definition for this research.

As research has progressed, a new area has become increasingly prominent, referred to as Green IS. Butler (2012) refers to Green IS as IT software applications that focus on sustainability and the effect of people, processes and technology. It facilitates a reduction in overall emissions of an organization. The application of Green IS can vary based on the context in which it is used. Butler (2012) lists various functions of Green IS including monitoring and reporting on GHG emissions, controlling waste, toxic and hazardous materials use, management of energy-consuming buildings, redesigning business processes (including logistics) to make them more energy efficient. Thus Green IS can contain elements of Green IT but Green IT does not necessarily contain elements of Green IS (Ijab 2010; Butler 2011).

As Green IT is still a relatively new topic, there has been very little empirical research in this area until recently. One study in Sweden made use of a comparative case study on the adoption of Green IT between a municipality and a higher education institution (Nazari & Karim 2012). The results of the two case studies showed a definite contrast in the factors influencing the adoption of Green IT. Petzer et al. (2011) did a study on the adoption of Green IS from a South African perspective. Given the few similarities between Green IT and Green IS this research may offer some insight into the reasons behind the adoption of Green IT in South Africa. This study provided empirical evidence that adoption of Green IS is more due to economic benefits rather than regulatory or ethical reasons (Petzer et al. 2011). Other than this research, there appears to be no research around the adoption of Green IT from a developing country perspective and more specifically from a South African perspective.

## **2.2 Green IT adoption and drivers**

This section explores the potential drivers of Green IT as outlined in the existing literature.

*Economic Drivers*, namely cost reduction is one of the more significant drivers of Green IT, particularly in a South African context (Petzer et al. 2011). As a result of the rising cost of energy, the most recognized method of cost reduction in the ICT environment is through the reduction of energy consumption (Murugesan 2008; Murugesan & Gangadharan 2012).

*Regulatory* drivers such as regulatory and government compliance play an important role in the intention of organizations to adopt Green ICT. Certain regulatory acts require organizations to report their carbon emissions if they are above a certain level (Molla 2008; Murugesan & Gangadharan 2012). However, legislation around the adoption of Green IT is less of a concern in a South African context as there are no repercussions due to the absence of compulsion (Petzer et al. 2011)

*Market opportunity* drivers include the growing awareness of ICT's impact on the environment as well as ICT as a solution to the impacts of ICT on the environment. Businesses now have the opportunity of not only implementing sustainable ICT solutions, but also supplying green ICT equipment, products and software (Unhelkar 2011; Murugesan & Gangadharan 2012).

*Social, cultural and political* pressures can become a significant driving force in the awareness and subsequent adoption of Green IT. This may happen when the society becomes aware of the degradation of the environment and realizes the importance thereof, thus driving the organization to change their approach (Murugesan & Gangadharan 2012). Organizations may also be compelled to adopt and implement Green IT solutions as a result of the requirements of the *industry* i.e. other organizations. Once one organization chooses to adopt sustainable methods, other associated organizations will invariably be driven towards the adoption of sustainable practices (Murugesan & Gangadharan 2012). Molla & Abareshi (2011) merge the

market opportunity driver, industry drivers as well as the social, cultural and political drivers into so-called *response drivers*.

*Self-Motivation* can be seen as the *ethical* driver in the implementation of Green IT. Organizations can implement Green IT based on overall perception and beliefs of the organization and in order to do a common good. This can be due to a realisation of the cost benefit, to instil employee confidence or even to aspire towards a better brand image (Murugesan & Gangadharan 2012).

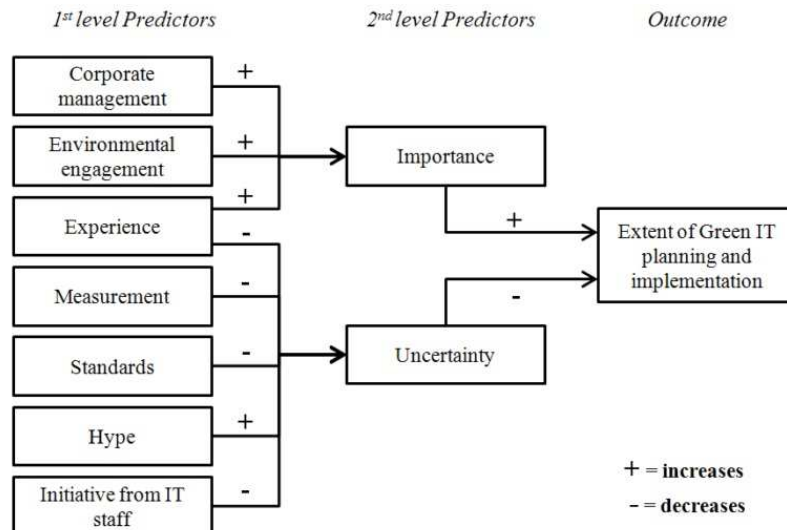
## 2.3 Green IT adoption models

A number of Green IT adoption models have been developed based on the existing literature on IT adoption. Nazari et al. (2009) (Figure 1) combine the TOE framework and DOI model in order to identify factors influencing the adoption of Green IT at an organizational level. This framework highlights three sets of factors that may influence the adoption of Green IT: Innovation, Organizational and Environmental Factors.



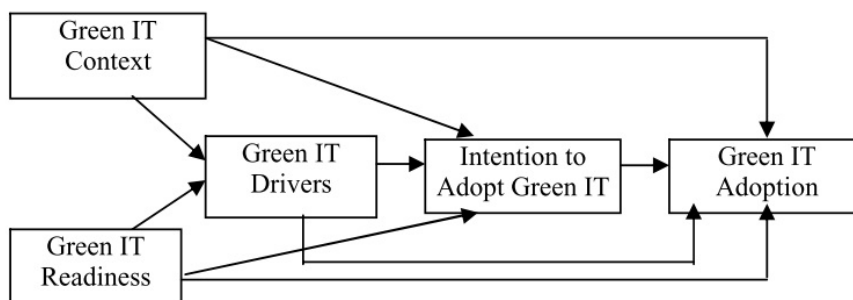
**Figure 1:** Green IT Adoption Model (Nazari & Karim, 2009)

Another Green IT adoption framework, posited by Schmidt & Ereik (2010) (Figure 2) hypothesizes that the extent of Green IT planning and implementation is influenced positively by the perceived importance but negatively by uncertainty around Green IT. The framework suggests a number of first level predictors which can either positively or negatively influence the importance of IT (corporate management, environmental engagement, experience) and uncertainty surrounding Green IT (experience, measurement, standards, hype and IT staff initiative) (Schmidt & Ereik 2010).



**Figure 2:** Green IT Adoption Model (Schmidt & Ere, 2010)

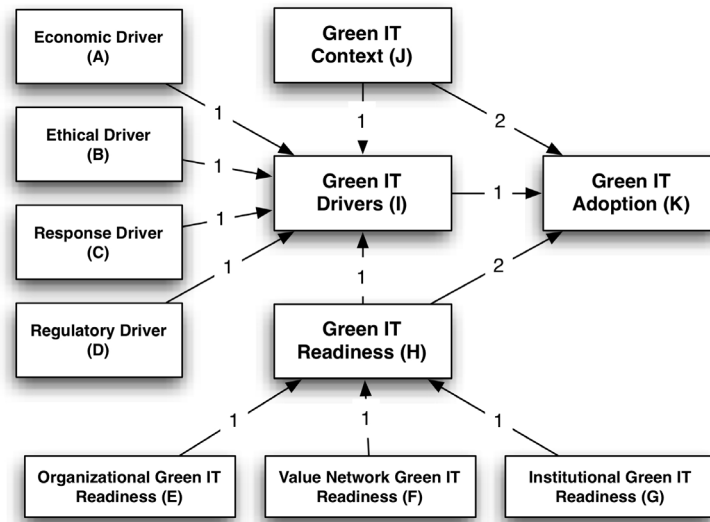
Molla (2008) poses a new theory relating to the adoption of Green IT based on existing innovation and adoption models. His Green IT Adoption Model (GITAM) (Figure 3) poses that an organizations intention to adopt Green IT and the adoption of Green IT, is influenced by factors such as Green IT Readiness, Green IT Context and Green IT Drivers. The Green IT context assesses the existing characteristics of the available technology adoption models. Based on the TOE model, the GITAM framework divides these contexts into a technological, an organisational and an environmental context. The Green IT Readiness is an assessment of an organizations readiness to adopt Green IT (Molla 2008). Based on the PERM model (Molla & Licker 2005), Green IT Readiness is categorized into the perceived organization Green IT Readiness, the perceived value network Green IT Readiness and the perceived Institutional Green IT Readiness. Molla (2008) identifies three drivers of Green IT: economic, regulatory and ethical. Molla and Abarreshi (2011) pose an additional driver that may influence the adoption of Green IT: the eco-responsiveness driver which refers to other external pressures such as social, cultural and political pressures, industry pressure and new market opportunities.



**3:** GITAM: The basic model (Molla 2008)

### 3. Research methodology

The purpose of this research is descriptive as well as exploratory. A positivist stance and deductive approach were adopted. The theoretical framework for this research is based on the GITAM model developed by Molla (2008), although the intention to adopt was not measured explicitly. Figure 4 below shows the final research model, with each of the arrows representing a proposed impact for which a corresponding hypothesis was formulated.



**Figure 4:** Logical mapping of hypotheses against the proposed model

This leads to the following hypotheses:

A1: Economic benefits affect the adoption of Green IT in HEIs in South Africa positively.

B1: Overall perception and ethical beliefs of an institution affect the adoption of Green IT in HEIs in South Africa .

C1: External pressures affect the adoption of Green IT in HEIs in South Africa .

D1: Government and Professional bodies affect the adoption of Green IT in HEIs in South Africa .

E1: The perception of an institutions Green IT readiness affects the perception of an institution's *overall* Green IT Readiness in HEIs in South Africa .

F1: The perception of an institution's value network Green IT readiness affects the perception of an institution's *overall* Green IT Readiness in HEIs in South Africa

G1: The perception of an institution's institutional Green IT readiness affects the perception of an institution's *overall* Green IT Readiness in HEIs in South Africa

H1: The perception of an institution's *overall* Green IT Readiness affects the Green IT drivers in HEIs in South Africa

H2: The perception of an institution's *overall* Green IT Readiness affects the adoption of Green IT in HEIs in South Africa

I1: Green IT Drivers affect the adoption of Green IT in HEIs in South Africa

K: The overall level of Green IT adoption in HEIs in South Africa is fairly low

H: The overall Green IT Readiness of HEIs in South Africa is low

The survey questionnaire instrument that was used for this research accommodates questions for each of the factors that may influence the adoption of Green IT. The Green IT driver section of the survey questionnaire was adapted from an existing instrument developed by Molla & Abareshi (2011) on the adoption of Green IT from a motivational perspective as well as one self-developed question. The Green IT Readiness section of the survey questionnaire was predominantly adapted from an existing instrument developed by Molla & Licker (2005) on the adoption of ecommerce in developing countries, together with other instruments developed by Schmidt & Ereik (2010) and Molla & Cooper (2010). Green IT adoption was operationalized as the use of server virtualization, storage virtualization, storage consolidation, having an environment-friendly IT procurement policy, having a policy on managing electronic waste and measuring the environmental impact of IT. Most questions were re-phrased for a higher-education context. Where pre-developed questions were not available for the construct that was being measured, the questions were self-developed. The final questionnaire is available from the authors on request. The research was targeted at the information technology staff in two to three IT departments at each of South Africa's 23 public higher education institutions. The survey was launched end-July 2013 and follow-ups were done via email and telephone to encourage responses.



## 4. Data analysis and results

All data analysis was completed using the statistical tool R. Of the 48 responses that were received, 28 incomplete responses and 1 erroneous response were discarded and a total of 19 complete responses remained.

### 4.1 Sample description

Out of the 23 higher education institutions that were contacted, only 9 institutions provided valid responses to the survey. However, six of the seven South African provinces that have HEIs are represented, with no province having more than two HEIs. Thus the sample is geographically very representative. The distribution of individual responses from institutions (most HEIs had two individual responses) was similar, apart from the Western Cape Province, which had averaged 3 individual responses per university.

### 4.2 Instrument validity

As the research instrument consists of multi-point questions and summated scales and as some of the questions were self-developed, it was necessary to validate the reliability of the instrument before proceeding with data analysis (Cronbach 1951). Cronbach's alpha was used to measure the internal consistency reliability of items within the instrument. In order to get an accurate representation of the instruments reliability an additional three measures were analysed, including Guttman's lambda 6 (Guttman 1945; Kadijevich 2003), standardized alpha based on correlations (Schmitt 1996) and the average inter-item correlation (Kuder & Richardson 1937; Gulliksen 1945). Using George and Mallory's (2003) rule of thumb for the assessment of the results, any item with a Cronbach's alpha below 0.7 was reassessed and as a result three items (ETH3, RES2 and COM4) were dropped from the instrument. Once these items had been dropped, the Cronbach alpha of the remaining items was above 0.7 (Table 1).

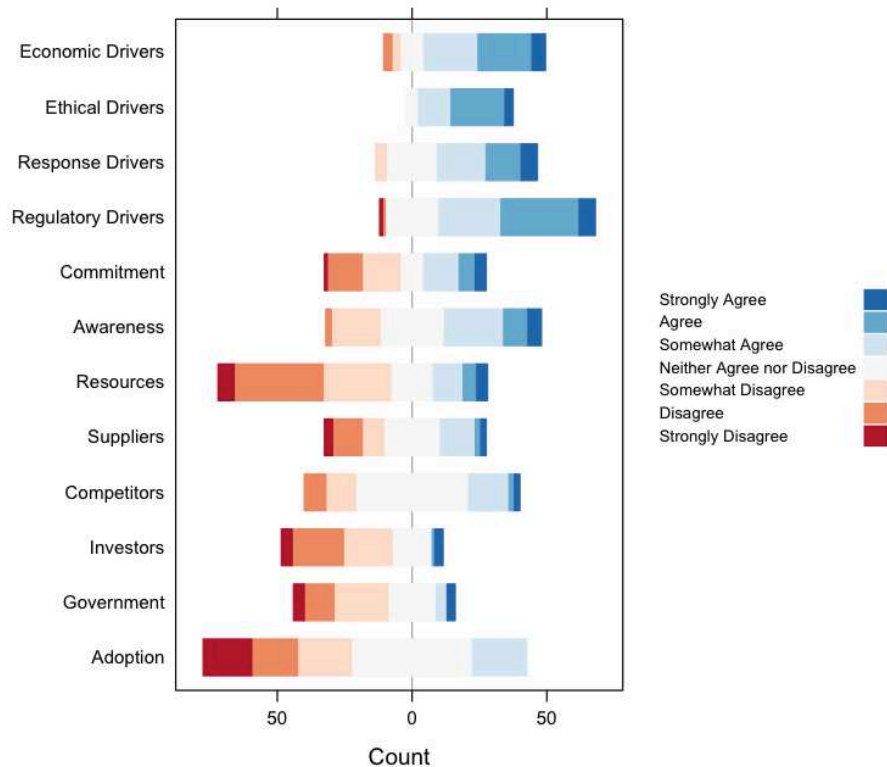
**Table 1:** Instrument validity

Instrument validity for instrument variables				
Variable	Cronbach's alpha	Standardized alpha	Guttman's Lambda 6	Average inter-item correlation
Economic Drivers	0.9159	0.9167	0.8911	0.7857
Ethical Drivers	0.7326	0.7326	0.5780	0.5780
Response Drivers	0.7340	0.7145	0.7400	0.4548
Regulatory Drivers	0.7236	0.7386	0.7490	0.4140
Commitment	0.7340	0.7145	0.7400	0.4548
Awareness	0.8364	0.8408	0.8251	0.5691
Resources	0.9044	0.9109	0.9285	0.6717
Suppliers	0.9345	0.9406	0.9207	0.8407
Competitors	0.8597	0.8608	0.8689	0.6073
Investors	0.9224	0.9281	0.9229	0.8114
Government	0.8564	0.8572	0.8040	0.6668
ADOPTION	0.7174	0.7544	0.8190	0.3385

Unfortunately, the sample size was too small to do validity analysis by means of exploratory factor analysis.

### 4.3 Exploratory data analysis

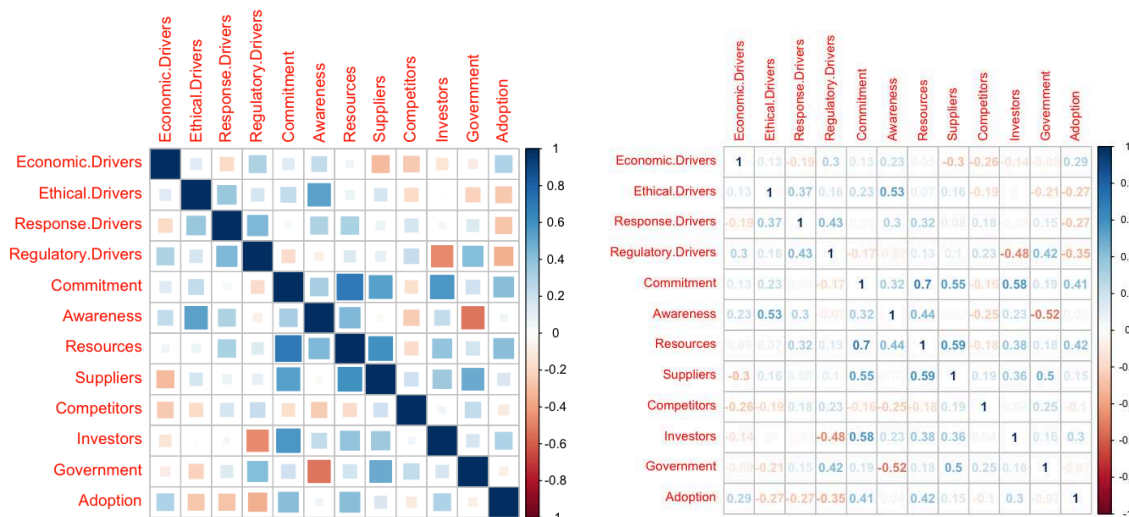
Tukey's (1977) exploratory data approach was used to present the data. A diverged stacked bar chart was produced; this chart is preferred to pie or normal bar charts which make the data difficult to interpret without a common baseline (Robbins & Heiberger 2011). Figure 5 shows that responders seem to agree to a greater percentage with Green IT Drivers, which is weighted to the right of the plot, shown in blue. In contrast, responders generally tend to disagree to a greater percentage with the Green IT readiness constructs and the adoption construct, shown to the left of the plot, in red (Figure 5). This may possibly indicate a low level of Green IT readiness as well as Green IT adoption as the questions for both readiness and adoption are phrased around the state to which institutions have implemented the construct (Figure 5).



**Figure 5:** Diverged and stacked bar chart of the responses to the instrument constructs

#### 4.4 Correlation analysis

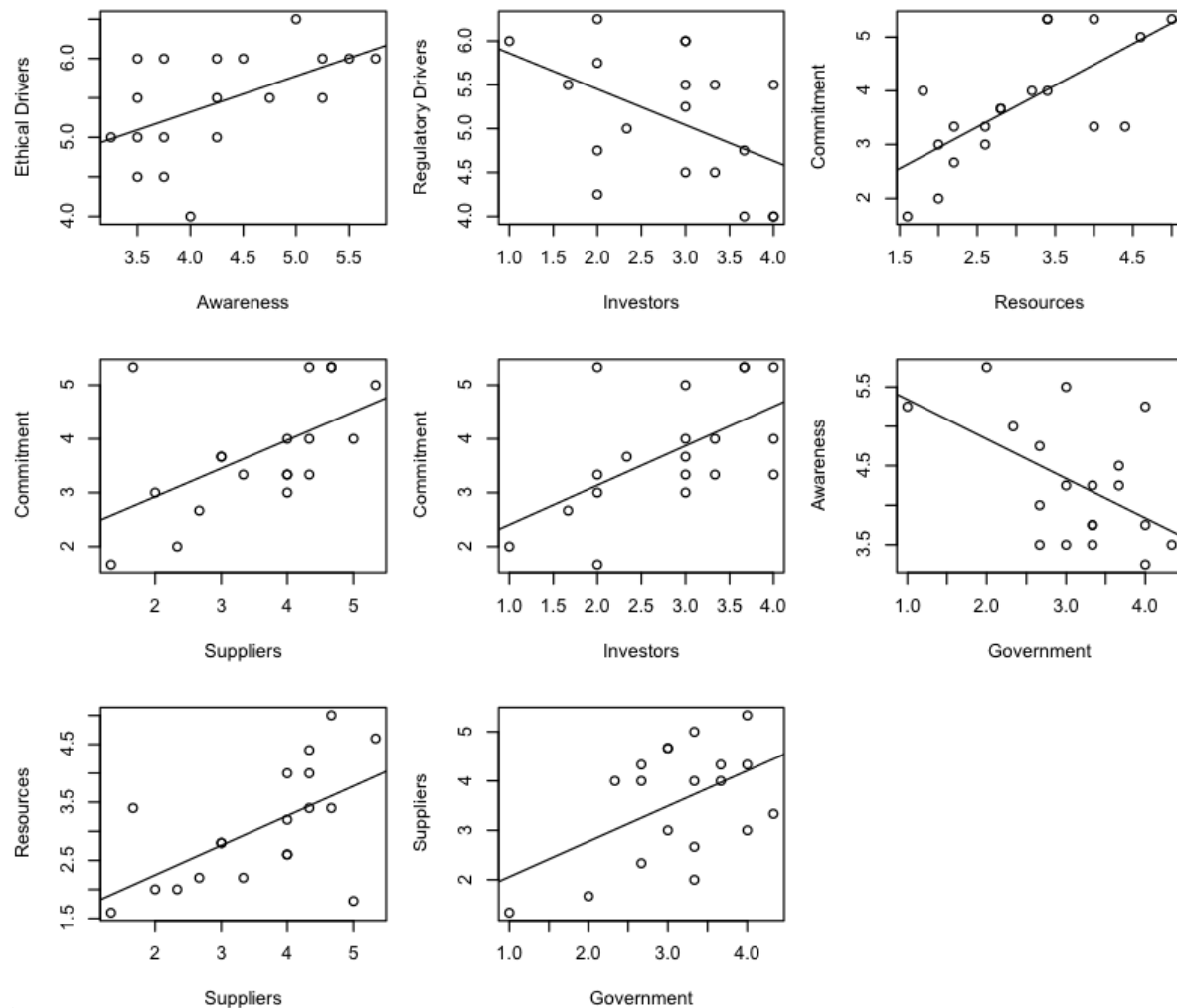
Correlation matrices between individual items and between constructs were created using Pearson's correlation coefficients to identify any relationships (Sedgwick 2012). Figure 6 shows the correlations between constructs and a graphic representation. The left matrix gives the actual correlation coefficients below the diagonal and the corresponding p-values above the diagonal; the right matrix gives a visual interpretation with blue for positive and red for negative correlations; size and intensity of the cell block indicate magnitude.



**Figure 6:** Pearson's correlation matrix for constructs

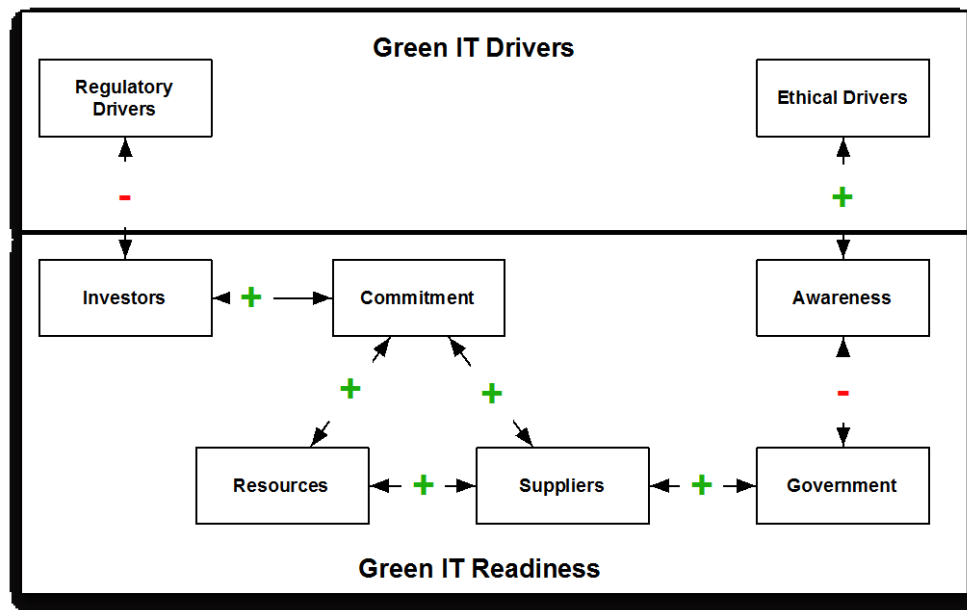
Figure 6 shows significant positive and negative correlations between constructs. There are some strongly significant positive correlations within Green IT Readiness between constructs Organizational Green IT Readiness, Value Network Green IT Readiness and Institutional Green IT Readiness. A significant positive correlation is also evident between Commitment and Resources, between Commitment and Suppliers and between Resources and Suppliers. Additionally, within Green IT readiness, a significantly positive relationship

exists between Commitment and Investors and a significant negative correlation exists between Government and Awareness. The scatter plots for the constructs with significant correlations are shown in Figure 7.



**Figure 7:** Scatterplots for significantly correlating constructs shown in the refined model.

This results in a more finely tuned proposed sub-model of antecedents driving Green IT adoption as shown in Figure 8.



**Figure 8:** Significant correlations within green IT drivers

Correlation results show that there are no significant correlations between any of the constructs within Green IT Drivers (Figure 8). There are however two significant correlations between Green IT Drivers and Green IT Readiness, namely a significant positive correlation between Ethical Drivers and Awareness and the significant negative correlation between Regulatory Drivers and Investors. Once the relationships between constructs had been investigated, the hypotheses were tested.

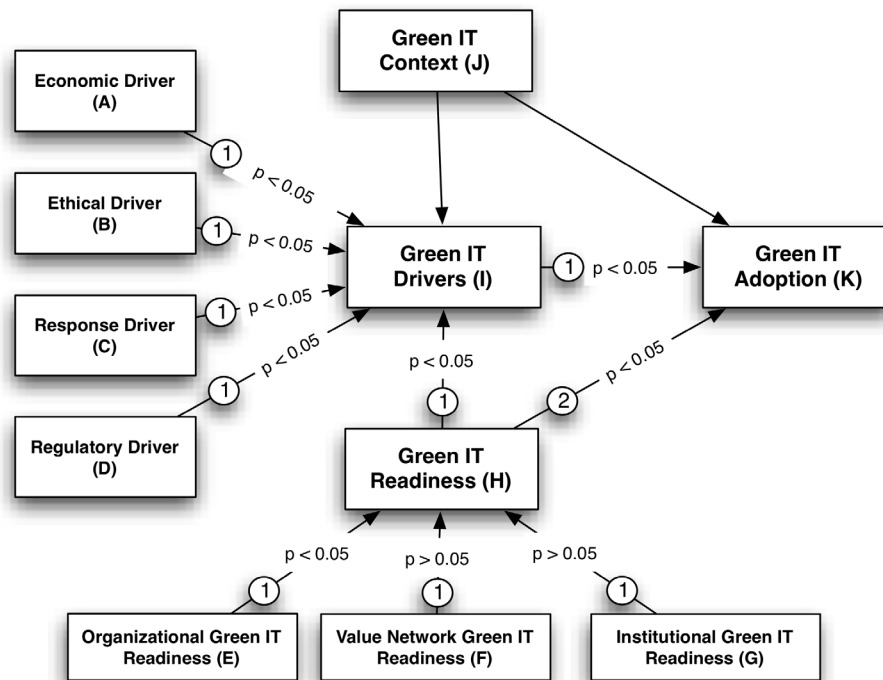
#### 4.5 Hypothesis testing

Given the relatively small sample size of this study, a Fishers exact test was used in addition to the Chi-squared test as a non-parametric approach for hypothesis testing (Lancaster & Seneta 1969; Routledge 1998). Although both Chi-squared and Fishers Exact tests were provided for comparison, final deductions were based on the results of the Fisher's exact test alone. The results from the Fishers exact test showed that for the hypotheses, shown in Table 1, all but two of the hypotheses of this study were significant (Table 2). Note that the hypotheses refer to Figure 4 i.e. H2 is the hypothesis that Green IT Readiness (H) impacts on Green IT Adoption (Arrow 2).

**Table 2:** Results for chi-squared test and Fishers exact test for hypothesis testing

Chi-Squared and Fishers Exact Test			
Hypothesis	Fishers Exact p-value	Chi-square	Chi-square p-value
A1*	< 0.05	76.98	< 0.05
B1*	< 0.05	93.54	< 0.05
C1*	< 0.05	60.45	< 0.05
D1*	< 0.05	88.16	< 0.05
E1*	< 0.05	26.77	< 0.05
F1	> 0.05	NA	> 0.05
G1	> 0.05	NA	> 0.05
H1*	< 0.05	43.66	< 0.05
H2*	< 0.05	NA	> 0.05
I1*	< 0.05	77.74	< 0.05
* significant at p = 5%			

According to the hypotheses, these results suggested that the adoption of Green IT in higher education institutions in South Africa is significantly ( $p < 0.05$ ) affected by economic benefits, overall perception and beliefs of an institution, external pressures, government and professional bodies and by the perception of an institutions Green IT readiness. Green IT Drivers as a whole plays a significant role in affecting adoption of Green IT in higher education institutions in South Africa (Figure 8).

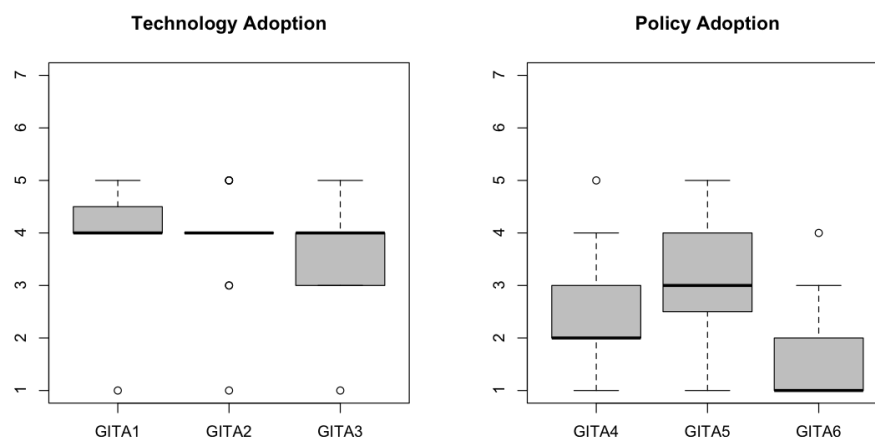


**Figure 9:** Proposed model indicating p-values for hypotheses testing using Fishers exact test

In contrast, the adoption of Green IT in higher education institutions in South Africa is not significantly ( $p > 0.05$ ) affected by the perception of an institution's value network Green IT readiness or by the perception of an institutions institutional Green IT readiness. Nonetheless, results indicate that Green IT Readiness overall affects the adoption of Green IT in higher education institutions in South Africa (Figure 9). Furthermore, the perception of Green IT readiness has a significant ( $p < 0.05$ ) effect on Green IT Drivers. Regardless of the small sample size, the results of the Chi-squared give nearly identical results to the Fishers Exact test, with the exception being that H2 is found to be not significant (Table 2).

#### 4.6 Further model refinement: distinguishing between Technology and Policy Adoption

The box plot for the Adoption constructs indicates that the first three items are fairly similar (GITA1-3) and the last three items are also similar (GITA4-6) (Figure 10). Previous research from which this construct was adopted, defined this split by dividing Adoption of Green IT into two separate entities, namely Green IT Technologies (GITTS) and Green IT Policy and Practice (GITPP) (Molla & Abareshi, 2011).



**Figure 10:** Box plot for Adoption Technology and Adoption Policy constructs.

In order to further explore the anomalies of the box plot (Figure 10), Green IT Adoption was split into two constructs, Green IT Technology Adoption and Green IT Policy Adoption. A Mann-Whitney U-test was run and results indicated that there was a significant difference ( $p < 0.05$ ) between Green IT Policy Adoption and Green IT Technology Adoption (McKnight & Najab, 2010). It is thus suggested that future research adopts a more refined model which separates Green Technology Adoption from Green IT Policy Adoption.

Our sample size is too small to build a definitive final model based on this refinement. The refined model was tested using a stepwise forward and backward selection process of explanatory variables to determine the best fitting model to explain the predicted variable. The best fitting model was chosen based on the lowest Akaike's Information Criterion (AIC) fitted using stepAIC function in R (Bozdogan, 1987).

Using our limited data set, Green Technology adoption was best explained (AIC coefficient = -12.47) using only the drivers, and in particular economic drivers ( $p = 0.05$ ) and regulatory drivers ( $p = 0.01$ ). However, Green Policy adoption was best explained (AIC coefficient = 22.89) using Organisational Green IT readiness ( $p = 0.003$ ) and Institutional Green IT readiness ( $p = 0.02$ ).

## **5. Conclusion, limitations and future research**

The adoption of Green IT in higher education institutions in South Africa has not been investigated to date and results from this study will contribute towards understanding what factors that influence this adoption. This will enable future movements towards implementing Green IT solution in higher education institutions in South Africa, thereby promoting the sustained practice and usage of IT infrastructure and support. As a result of small sample size, the results of this study should be viewed as an explorative study into some of the perceptions of IT staff and managers on the factors driving the adoption of Green IT in higher education institutions in South Africa.

The theoretical framework for this research is based on the GITAM model developed by Molla (2008). An empirical research instrument was developed and tested for reliability. In spite of the small sample size, some very strong correlations between factors were revealed, suggesting that a refinement of the antecedents in the GITAM model is needed (Figure 3). Strong, highly significant positive correlations within Green IT Readiness exist between the constructs Organizational Green IT Readiness, Value Network Green IT Readiness and Institutional Green IT Readiness. The significant positive correlation between Commitment and Resources, between Commitment and Suppliers and between Resources and Suppliers seem to suggest that institutions that are committed to Green IT, may have the necessary resources for Green IT and as well the necessary supplier relationships.

In addition to the strong correlative trends which were found, all but one of the hypotheses put forward were accepted. Results indicated that all constructs of the perception of Green IT Drivers have a statistically significant influence on the adoption of Green IT in higher education institutions in South Africa. The perception of an institution's value network Green IT readiness and the perception of an institutions institutional Green IT readiness did not appear to affect the adoption of Green IT. Therefore, suppliers, investors, competitors and government does not appear to play an important role in influencing the adoption of Green IT within higher education in South Africa. Unfortunately, currently the actual level of Green IT Adoption and Readiness within higher education institutions in South Africa appeared to be fairly low. In the absence of normative pressure, a significant acceleration of Green IT implementation beyond cost-driven rationales may require a legislative or financial incentive.

From our data, Green IT adoption appeared to split into two categories: Technology Adoption and Policy Adoption. Tentative results of model testing on these individual items appeared to have drastically different antecedents indicating that in future studies it may be beneficial to split the measurement of Green IT adoption for future studies.

These findings need to be confirmed through further studies with a larger sample size and possibly with more of a qualitative approach. Additionally, it will be interesting to have an international comparison to see which factors and relationships are dependent on country, regional and developing economy contexts. Hopefully comparisons can also be made with regions where Green IT adoption is higher as different drivers and



pressures may exhibit themselves at different levels of sustainability maturity. These studies would also lead to further empirical validation and possible refinement of the research instrument proposed here.

## References

- Bozdogan, H. (1987). Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. *Psychometrika*, 52(3), 345–370.
- Butler, T. (2011) "Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS", *The Journal of Strategic Information Systems*, Vol. 20, No. 1, pp 6–26.
- Butler, T. (2012) *Institutional Change and Green IS: Towards Problem-Driven, Mechanism-Based Explanations*, Springer, New York.
- Chen, A., Boudreau, M.-C. & Watson, R.T. (2008) "Information systems and ecological sustainability", *Journal of Systems and Information Technology*, Vol. 10, No. 3, pp 186–201.
- Cooper, V. & Molla, A. (2010) "Conceptualizing Green IT Organizational Learning (GITOL)", *Green IT Working Paper series*, Vol. 1, No. 3, pp 1–12.
- Cronbach, L.J. (1951) "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16, No. 3, pp 297–334.
- Gulliksen, H. (1945) "The relation of item difficulty and inter-item correlation to test variance and reliability", *Psychometrika*, Vol. 20, No. 4, pp 79–91.
- Guttman, L. (1945) "A basis for analyzing test-retest reliability", *Psychometrika*, Vol. 10, No. 4, pp 255–282.
- Hanne, F. (2011) "GREEN-IT: Why Developing Countries Should Care?", *International Journal of Computer Science*, Vol. 8, No. 4, pp 424–427.
- Harmon, R. & Auseklis, N. (2009) "Sustainable IT services: Assessing the impact of green computing practices", *PICMET 2009 Proceedings*, pp 1707–1717.
- Ijab, M.T. (2010) "Seeking the "Green" in "Green IS": A Spirit, Practice and Impact Perspective", *Pacific Asian Conference on Information Systems*, Vol. 46, pp 433–443.
- Jenkin, T. a., Webster, J. & McShane, L. (2011) "An agenda for "Green" information technology and systems research", *Information and Organization*, Vol. 21, No. 1, pp 17–40.
- Kadijevich, D. (2003) "Examining Mathematics Attitude", *Trends in International Mathematics and Science Study in*, Vol. 1, No. 1, pp 64–73.
- Kuder, G.F. & Richardson, M.W. (1937) "The theory of the estimation of test reliability", *Psychometrika*, Vol. 2, No. 3, pp 151.
- Lancaster, H. & Seneta, E. (1969) Chi-Square Distribution, *Encyclopedia of biostatistics*.
- McKnight, P., & Najab, J. (2010). Mann-Whitney U Test, *Corsini Encyclopedia of Psychology*.
- Molla, A. et al. (2008) "E-readiness to G-readiness: developing a green information technology readiness framework", *19th Australasian Conference on Information Systems*, pp 669–678.
- Molla, A. (2008) "GITAM : A Model for the Adoption of Green IT", *Australasian Conference on Information Systems*, pp 658–668.
- Molla, A. & Abareshi, A. (2011) "Green IT adoption: A motivational perspective", *Proceedings of the 15th Pacific Asia Conference on Information Systems (PACIS)*, pp 1–14.
- Molla, A. & Cooper, V. (2010) "Green IT Readiness: A Framework and preliminary proof of concept", *Australasian journal of information systems*, Vol. 16, No. 2, pp 5–23.
- Molla, A. & Licker, P.S. (2005) "eCommerce adoption in developing countries: a model and instrument", *Information & Management*, Vol. 42, No. 6, pp 877–899.
- Murugesan, S. (2008) "Harnessing Green IT: Principles and Practices", *IT Professional*, Vol. 10, No. 1, pp 24–33.
- Murugesan, S. & Gangadharan, G. (2012) *Harnessing green IT: Principles and practices*, John Wiley and Sons, Chichester.
- Nazari, G. & Karim, H. (2012) "Green IT adoption: The impact of IT on environment: A case study on Green IT adoption and underlying factors influencing it", *Proceedings of 17th Conference on Electrical Power Distribution Networks (EPDC)*, pp 1–7.
- Paruchuri, V. (2011) "Greener ICT: Feasibility of successful technologies from energy sector", *13th International Conference on Advanced Communication Technology (ICACT)*, pp 1398–1403.
- Petzer, C., McGibbon, C. & Brown, I. (2011) "Adoption of Green IS in South Africa", *Proceedings of the South African Institute of Computer Scientists and Information Technologists Conference on Knowledge Innovation and Leadership in a Diverse Multidisciplinary Environment SAICSIT*, pp 330.
- Robbins, N. & Heiberger, R. (2011) "Plotting Likert and Other Rating Scales", *Proceedings of the 2011 Joint Statistical Meeting*, pp 1058–1066.
- Routledge, R. (1998) Fisher's exact test, *Encyclopedia of biostatistics*.
- Schmidt, N. & Ereik, K. (2010) "Predictors of Green IT Adoption : Implications from an Empirical Investigation", *Americas Conference on Information Systems*, pp 1–11.
- Schmitt, N. (1996) "Uses and abuses of coefficient alpha.", *Psychological assessment*, Vol. 8, No. 4, pp 350–353.
- Sedgwick, P. (2012) "Pearson's correlation coefficient", *British Medical Journal*, Vol. 345.
- Unhelkar, B. (2011) *Handbook of Research on Green ICT: Technology, Business, and Social Perspectives*, IGI Global, Hershey.

## Appendix: Survey Instrument

The following key test items relating to the Green IT model were used in the survey questionnaire (answers on a 7-point Lickert scale).

### DRIVERS

How important are the following factors in driving your institution towards implementing Green IT?

<b>ECONOMICAL</b>	ECO1	Cost of server energy consumption
	ECO2	Efficiency of powering the ICT infrastructure
	ECO3	Cost of desktop energy consumption
<b>ETHICAL</b>	ETH1	Your institution's sustainability strategy
	ETH2	Corporate Social Responsibility
	ETH3	Senior management commitment
<b>RESPONSE</b>	RES1	The actions of your institutions competitors
	RES2	Pressure or marketing from ICT vendors
	RES3	Market incentives
	RES4	Pressure from investors (students, stakeholders, organizations, etc.)
<b>REGULATORY</b>	REG1	Government energy efficiency regulations
	REG2	Encouragement from industry associations
	REG3	Greenhouse gas regulations
	REG4	Regulations on discarding e-waste

### READINESS

Please indicate to what extent you agree or disagree with the following statements?

<b>COMMITMENT</b>	COM1	Your institution has a clear vision on Green IT
	COM2	Your institution's vision of Green IT is widely communicated and understood throughout your institution
	COM3	Your institution's Green IT implementations are strategy-led
	COM4	Senior management supports your institution's Green IT initiatives and implementations
<b>AWARENESS</b>	AWA1	Your institution is aware of its competitors' Green IT implementations
	AWA2	Your institution recognizes the benefits enabled by Green IT
	AWA3	Your institution has thought about whether or not Green IT has impacts on the way business is to be conducted in its industry
	AWA4	Your institution has considered whether or not businesses in its industry that fail to adopt Green IT would be at a competitive disadvantage
<b>RESOURCES</b>	REC1	Your institution has sufficient experience with Green IT
	REC2	Your institution has sufficient staff to implement Green IT
	REC3	Your institution has sufficient technical resources for the monitoring of energy costs of IT (PC's, printers, notebooks, etc.)
	REC4	Your institution has sufficient technical resources for measuring the impact of Green IT
	REC5	Your institution has a designated budget for Green IT
<b>SUPPLIERS</b>	SUP1	Your institution's has sufficient support from the local IT industry to support the move to Green IT
	SUP2	Your institution's suppliers have sufficient experience with Green IT
	SUP3	Your institution's suppliers are able to supply the necessary technology in order to assist the move towards Green IT
<b>COMPETITORS</b>	COMP1	Your institution's competitors have sufficient experience with Green IT
	COMP2	Your institution's competitors have implemented Green IT solutions

<b>INVESTORS</b>	COMP3	Your institution's competitors attract investors based on their green credentials
	COMP4	Your institution's competitors have established Green IT policies
	INV1	Students base their decision to enroll in your institution based on its green credentials
	INV2	Your institution's investors choose to invest in your institution based on its green credentials
<b>GOVERNMENT</b>	INV3	Your employees choose to work for your institution based on your institutions green credentials
	GOV1	The government demonstrates strong commitment to promote Green IT
	GOV2	Your institution believes that there are effective laws to enforce Green IT Adoption.
	GOV3	The government encourages Green IT adoption

#### **ADOPTION**

To what extent has your organization implemented the following?

<b>ADOPTION</b>	GITA1	Server virtualization
	GITA2	Storage virtualization
	GITA3	Storage consolidation
	GITA4	Environment-friendly IT procurement policy
	GITA5	Policy on managing electronic waste
	GITA6	Measuring the environmental impact of IT

# Digital Archiving, Green IT and Environment. Deleting Data to Manage Critical Effects of the Data Deluge

Geert-Jan van Bussel<sup>1</sup>, Nikki Smit<sup>2</sup> and John van de Pas<sup>3</sup>

<sup>1</sup>HvA Amsterdam University of Applied Sciences, School of Economics and Management, Amsterdam, The Netherlands

<sup>2</sup>BECIS Information Management, Amsterdam, The Netherlands

<sup>3</sup>Saxion University of Applied Sciences, School of Creative Technology, Deventer, The Netherlands

[g.j.van.bussel@hva.nl](mailto:g.j.van.bussel@hva.nl)

[nsmitter@gmail.com](mailto:nsmitter@gmail.com)

[j.h.vandepas@saxion.nl](mailto:j.h.vandepas@saxion.nl)

**Abstract:** The development of the World Wide Web, the emergence of social media and Big Data have led to a rising amount of data. Information and Communication Technologies (ICTs) affect the environment in various ways. Their energy consumption is growing exponentially, with and without the use of 'green' energy. Increasing environmental awareness has led to discussions on sustainable development. The data deluge makes it not only necessary to pay attention to the hard- and software dimensions of ICTs but also to the 'value' of the data stored. In this paper, we study the possibility to methodically reduce the amount of stored data and records in organizations based on the 'value' of information, using the Green Archiving Model we have developed. Reducing the amount of data and records in organizations helps in allowing organizations to fight the data deluge and to realize the objectives of both Digital Archiving and Green IT. At the same time, methodically deleting data and records should reduce the consumption of electricity for data storage. As a consequence, the organizational cost for electricity use should be reduced. Our research showed that the model can be used to reduce [1] the amount of data (45 percent, using Archival Retention Levels and Retention Schedules) and [2] the electricity consumption for data storage (resulting in a cost reduction of 35 percent). Our research indicates that the Green Archiving Model is a viable model to reduce the amount of stored data and records and to curb electricity use for storage in organizations. This paper is the result of the first stage of a research project that is aimed at developing low power ICTs that will automatically appraise, select, preserve or permanently delete data based on their 'value'. Such an ICT will automatically reduce storage capacity and reduce electricity consumption used for data storage. At the same time, data disposal will reduce overload caused by storing the same data in different formats, it will lower costs and it reduces the potential for liability.

**Keywords:** data deluge, digital archiving, archival retention levels, information value chain, green archiving, green IT

## 1. Setting the stage: Data Deluge, Digital Archiving and Green IT

### 1.1 Data Deluge

The development of the World Wide Web, the emergence of social media and Big Data have led to a rising amount of data (Armitage and Roberts, 2002; Segaran and Hammerbacher, 2009; Manyika, 2011). The seemingly infinite opportunities to process and publish data, global electronic communications, an explosion in devices located at the periphery of the network, including embedded sensors, smartphones, and tablet computers, aerial sensory technologies, software logs, cameras, microphones, radio-frequency identification readers, wireless sensor networks, and a large-scale digitization of cultural heritage such as film, music, art, images, maps, and text, have caused an unprecedented global growth in the amount of data. This growth has been analysed in several research projects, but the comparison of their results is difficult because of the different definitions and research methods used (Lyman and Varian, 2003; Hilbert and López, 2011; Gantz and Reinsel, 2012). This research agrees on one basic fact: the astonishing growth rate in the amount of data in the world. To summarize the results, it is confirmed [1] that the data storage capacity doubles every 40 months, and [2] that the annual growth rate in the amount of data is almost 40 %, creating a 'data deluge'. This data creates new opportunities for analytics in human genomics, health care, oil and gas, search, surveillance, finance, and many other areas (Golden, 2010), but is also putting great pressure on the infrastructures of information and communication technologies (ICTs) (Van Bussel and Henseler, 2013).

## **1.2 Digital Archiving**

The use of collaborative technologies in organizations to streamline business processes also creates huge amounts of data (Jacobs, 2009). These data are used and generated by knowledge workers who engage in peer-to-peer knowledge sharing across organizational boundaries. The storage, dissemination and processing of this data require complex ICT systems. These ICT systems present security and durability challenges that pose a major threat for information quality (Bearman, 2006). Digital data are fragile. They are easily altered without recognition. They require storage media that have relatively short life spans, and access technologies that are changing extremely fast. For some data types, such as multimedia, it is almost impossible to be used outside the proprietary environments in which they were generated (Hodge, 2000). These problematic challenges threaten the trustworthiness of organizational records, that data that are meant to be (and used as) evidence for policies, decisions, products, actions and transactions. Organizations have to respond to increasing societal demands for the trustworthiness of these records, mostly for privacy, accountability and transparency reasons. That is why Digital Archiving (DA) is important for organizations.

DA ensures that the informational and evidential 'value' of records is utilized in business processes to improve performance. It provides an ICT infrastructure to (indefinitely) store (identified and trusted) records and keep them accessible. It ensures that (privacy) laws and regulations are respected and audits periodically the possibility to reliably reconstruct the past. DA manages the four dimensions of information to allow for such a reconstruction. Those four dimensions are [1] quality, [2] context, [3] relevance, and [4] survival. The quality dimension is focused on the quality requirements of data and records to realize 'immutable mobiles' (Latour, 1990). 'Immutable mobiles' allow for the repeated use of data and records for consultation and for reconstruction of past happenings. Context provides meaning to the data and records: metadata are captured that give information about the organizational, technological, and societal environment in which the data and records were generated. Data and records are only relevant if they fit the organizational objectives of performance and accountability. The survival dimension concerns the security and durability challenges, which have to be overcome to realize access, retrieval, and preservation over time for all 'immutable mobiles' (Van Bussel 2012ab). DA's purposes are to reduce the costs of transactions, to enlarge the speed of access to organizational experiences, to help in decision-making, to share knowledge, and to realize accountability.

The deluge of data is threatening DA's possibilities to realize its purposes (Van Bussel, 2012ab; Van Bussel and Henseler, 2013).

## **1.3 Green IT**

ICT has not always worked to the benefit of environmental sustainability, although there are many ICTs that have positive environmental effects, such as GPS systems and online mapping software, which lead to more efficient travel and, as a result, reduce emissions of carbon dioxide (Tomlinson, 2010). The origins of an environmental approach to ICTs can be traced back to the beginning of the 1990s, when the reduction of the use of hazardous materials, the maximization of energy efficiency, and the recyclability or biodegradability of defunct products and factory waste became hot items in computing (Jacob and K.G, 2012; Esfahani et al, 2015ab).

Green IT (Brooks et al, 2012) is defined by Murugesan (2008: 25-26) as 'the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems - such as monitors, printers, storage devices, and networking and communications systems - efficiently and effectively with minimal or no impact on the environment'. ICTs affect the environment in various ways. Its production requires electricity, raw materials, chemical materials and large amounts of water, and supplies (often toxic) waste (Robinson, 2009). Computers and peripherals are changed two or three years after purchase (Murugesan, 2008). In 2006, global production of E-waste was estimated at 20-50 million tonnes per year (UNEP, 2006). In rich countries, E-waste represents some 8 percent of municipal waste (Widmer et al, 2005). It is the fastest growing municipal waste stream (EPA, 2011). Most of this E-waste is not recycled, because those items tend to go out with the normal household waste and do not receive special treatment (Ladou and Lovegrove, 2008). Some 80 percent of collected E-waste is exported to poor countries and ends up in landfills and informal dumps (Schmidt, 2006). These dumping sites are poisoned and groundwater is polluted (Murugesan, 2008).

Green IT has been introduced to minimize environmental effects of ICTs, to save costs and for corporate social responsibility (CSR). There are four paths along which the environmental effects of ICTs should be addressed: green use (reducing the energy consumption of ICTs and use them in an environmentally sound manner),

green disposal (refurbish and reuse old ICTs and properly recycle unwanted ones), green design (designing energy efficient and environmentally sound ICTs), and green manufacturing (manufacturing ICTs with minimal or no impact on the environment) (Murugesan, 2008). Green IT can also develop, according to Donnellan, Sheridan, and Curry (2011), solutions that align IT processes with the principles of sustainability and stimulate innovative technologies to deliver green benefits across an organization. In that way, end user satisfaction, management restructuring, regulatory compliance, fiscal benefits, and return on investment (ROI) can be addressed. In the opinion of Visalakshi et al. (2013: 64), Green IT may be 'simple, plain, common sense'. The positive effects of Green IT are extensively studied in academic literature (Harmon and Auseklis, 2009; Brooks et al, 2012; Lei and Ngai, 2013; Subburaj et al, 2014; Esfahani et al, 2015ab).

The energy consumption of ICTs (as well as the corresponding energy costs) are growing exponentially as a result of the data deluge. From 2000 to 2005 consumption of electricity in data centers doubled, while electricity consumption worldwide grew by (only) 16.7 percent per year (Koomey, 2008). From 2005 to 2010, the consumption of electricity in data centres alone jumped with 56 percent (Koomey, 2011; Cook, 2012). This increase in electricity consumption results in increased carbon dioxide emissions. According to Dubey and Hefley (2011), each PC or laptop in use generates about four tons, each server about eight tons of carbon dioxide every year, although there are many possibilities to lower those emissions (Boccaletti et al, 2008). The use of 'renewable' energy resources (water, wind, solar, geothermal, tidal, wave, and biofuel resources) could affect these emissions positively (WNA, 2015), but in 2014 the use of renewable energy resources for electricity generation is still quite low. The U.S. Energy Information Administration estimates that in 2012 almost 21 percent of the world electricity generation was from the use of renewable energy resources, with a projection for nearly 25 percent in 2040 (EIA, 2012; EIA, 2014). This means that carbon dioxide emissions will be a problem in the foreseeable future. Curbing back data storage could have very positive effects on energy use. In 2008, storage networks were responsible for 15 percent of total ICT energy costs (HP, 2008). This percentage had, in our estimate, doubled in 2011, given the increasing need for data storage as a result of multiplication of data, social media, and fear of not being compliant (Van Bussel, 2012a). Studies have shown that electricity costs can approach 50 percent of the overall energy costs for an organization (Harmon and Auseklis, 2009). In January 2013, an average in-house server in the USA costs \$731,94 in electricity (Hammond, 2013).

Summarizing: ICTs have a large energy footprint. The electricity use for ICTs has shown remarkable growth, which resulted in rising costs for electricity consumption. The data deluge (and the use of more and more ICT resources to manage this deluge) threatens [1] to drown all positive effects of Green IT and [2] to raise energy costs exponentially.

## **2. Research question, objective, and methodology**

### **2.1 Research Question**

Market research firm IDC estimated in 2007 that the amount of annually generated data exceeded the storage space globally available (Gantz and Reinsel, 2007). The data deluge is threatening to prevent both DA and Green IT to reach their objectives. To keep data and records accessible over time, to allow for Green IT to reach its environmental effects, and to prevent energy costs from rising unnecessarily, it becomes vital to curb data storage.

The bulk of all preserved data and records is stored on hard disks, consuming more electricity than necessary. Although electricity use of servers can be largely reduced by using them efficiently keeping the powered-up servers utilized and keeping as many as possible powered-down, this does not work in archiving and storage infrastructures. Research has shown that search and data mining activities for access will spread fairly evenly across all servers, making it impossible to keep servers powered-down (Adams et al, 2011; Adams et al, 2012). For curbing data storage, it will be necessary to appraise data and records value (over time), to implement data and records value appraising methods and tools, and to completely and permanently delete data and records that have lost their economic, social, cultural, financial, administrative, fiscal and/or legal value (Robyns, 2014; Niu, 2014).

The research question we want to answer in this paper is if it is possible to methodically reduce the amount of stored data and records in organizations based on the value of information, using the Green Archiving Model we have developed. Reducing the amount of data and records in organizations helps in allowing them to fight



the data deluge and to realize the objectives of both DA and Green IT. At the same time, methodically deleting data and records should reduce the consumption of electricity for data storage. As a consequence, the organizational cost for electricity use should be reduced.

## **2.2 Research Objective**

We have tested the viability of our Green Archiving Model in previous research with two exploratory case studies. In Van Bussel and Smit (2014) we stated that this model could be used to increase awareness in organizations for the environmental aspects of data storage and that the objectives of DA and Green IT could be realized using the model. The objective of this paper is to ascertain that our Green Archiving model can be used to methodically reduce the amount of stored data and records based on their value and that it can be used to reduce the costs for consumption of electricity for data storage.

Green Archiving intends to raise awareness of the environmental effects of ICTs (like increased carbon dioxide emissions) and to the effects of the data deluge on the accessibility of data and records. It tries to define solutions for [1] the rising amount of data and records and [2] the constantly rising costs of electricity. Green Archiving integrates Green IT with two leading theories of DA: the theories concerning the Information Value Chain (IVC) and Archival Retention Levels (ARLs). Both theories can be used to reduce the amount of stored data and records based on assigned information values. Operationalizing Green Archiving, organizations curb power consumption, lower needs for storage capacity by permanently deleting data and records based on their value, and develop 'low power' ICTs (Forrest, Kaplan and Kindler, 2008). That way, Green Archiving realizes the objectives of Green IT and curbs data storage, allowing DA to realize its objectives of fast accessibility of past experiences, transparent accountability, data and records-driven decision-making, knowledge-sharing, and reducing costs of transactions (Barosso and Hölzle, 2007; Schwarz and Elffers, 2010; Orgerie et al, 2014; Van Bussel and Smit, 2014; Pine and Mazmanian, 2015). Green Archiving is a relatively new subject and is not extensively studied yet within the context of information and archival sciences.

## **2.3 Research Methodology**

This paper is based on the research project that was first reported on in Van Bussel and Smit (2014). We are using here the results mentioned in that paper, with additional results from one of the exploratory case studies used. We have added also results from an extensive research in existing case studies on DA, Green IT and data deduplication. Our exploratory research was a combination of desk research, qualitative interviews with information technology and information management experts, a focus group and two exploratory case studies. We researched scientific literature with an ICT, information management and archival science perspective. We collected literature with a key word search in Google Scholar, Microsoft Academic Search and in the Digital Library of the University of Amsterdam (indexes on IT, information science / management, archival science / management). The key words used in this search were: 'Green Computing', 'Green IT', 'IT power use', 'IT power costs', 'information value', 'archival appraisal', 'archival disposal' and 'environmental awareness'. The findings of this desk research were used, discussed and criticized in: [1] individual, semi-structured interviews with ten ICT, information management and archival science experts (three scientists, two consultants, three CTO's, and two storage industry specialists); [2] a focus group, consisted of six (other) experts (two Green Computing consultants, two information managers and two storage managers). We used the information acquired through desk research, interviews and focus group to develop a provisional Green Archiving model. In Van Bussel and Smit (2014), this model was then tested for validity in two small exploratory case studies.

## **3. Exploring the stage: Composing the Green Archiving Model**

### **3.1 Green IT Components**

Analyzing literature, published case studies, interviews and focus group discussion, we discern six components of Green IT research. The first is product longevity (Visalakshi et al, 2013; Agarwal and Nath, 2011). As Walker (1995: 21) already stated, 'product's longevity is influenced by the durability of its component parts; its capacity to be repaired, maintained and upgraded; and its aesthetic qualities'. Product longevity helps in ensuring an intelligent utilization of resources in manufacturing processes, which account for 70 percent of the natural resources used during a computers lifecycle (Mingay, 2007). The second component of Green IT is software and deployment optimization (Ahamad and Ravikanth, 2012; Badbe, 2014; Choudhary, 2014), that influences the amount of computer resources required for any given computing function. It is a way for saving energy

that includes algorithmic efficiency, resource allocation, virtualization, and terminal servers. Virtualization is a very popular method of optimization in archiving and storage environments. With it, many virtual versions of devices or resources (servers, storage devices, networks or operating systems) could be made, using only one actual device or resource, making it much more energy efficient (Ren et al, 2015). The third component is power management (Schlomann et al, 2015; Kashyap et al, 2015; Visalashki et al, 2013). Even with a turned off monitor, a computer will consume as much energy as a powered but idle computer. Almost one-third of the energy consumption of an organization's PC population is wasted as a result of PC's that are unused but still turned on. With power management, it is possible for organizations to annually save up to \$60 per computer (Gunaratne et al, 2005). This translates also in a reduction in the pollution emissions from reduced electrical generation. Materials recycling (Shalini and Prasanthi, 2015; Visalashki et al, 2013; Kwon et al, 2006), the fourth component, refers to recycling or reuse of computers or electronic waste, including finding other uses for ICTs, or having them dismantled, allowing for the safe extraction of materials for reuse in other products. Recycling ICTs can keep harmful materials such as lead, mercury, and chromium out of landfills (Murugesan, 2008). Telecommuting, often referred to as teleworking, occurs when paid workers work away from their normal place of work, usually from home. It is not clear if the reduction of a company's energy consumption matches the rise in energy consumption at home in order to work remotely, but reducing the amount of cars moving employees back and forth will produce a carbon dioxide emission reduction (Asgari and Jin, 2015; Srivastava et al, 2015; Thompson, 2009). The last, sixth component, low power IT (or energy-efficient computing) (Hopper and Rice, 2008; Düben et al, 2014; Ahmad and Ranka, 2012; Lee et al, 2013) has been designed to use less electronic power. The increasing electricity costs are forcing hardware developers to rethink their technologies. A variety of approaches have been proposed to trade the accuracy of the hardware fabric in return for savings in resources used such as energy, delay, area and/or yield and, therefore, lead to reduced costs. The components software and deployment optimization, telecommuting, and low power IT are important for reducing power consumption for data storage.

### **3.2 Archival retention levels and information value chain**

Information and Archival science are interdisciplinary fields concerned with the analysis, collection, classification, storage, retrieval, dissemination, appraisal, disposal and preservation of data. They use methods and techniques to appraise and select organizational data for long-term (or indefinite) preservation or to permanently delete appraised data (Shepherd and Yeo, 2003; Xie, 2013; Smallwood, 2013). Appraisal is the process of establishing the 'value' of data and records, qualifying that value, and determining its duration. The primary objective of appraisal is to identify the data and records to be continuously preserved for an unlimited period of time (Duranti, 1994). Appraisal establishes the value of organizational data over time, be it economic, social, cultural, financial, administrative, fiscal and/or legal value (Cook, 2013). Many appraisal approaches are based on content evaluation of records (very impractical in an electronic age of information overload), causing a de-contextualization. Shepherd and Yeo (2003: 151) stated that appraisal 'should be based on analysis of organizational purposes and the systems that support them'. The focus of appraisal is moved from the data and records to the organizational contexts that created them. In the appraisal process, 'judgements of value' are made to decide what to keep and what to destroy. Penn (2014) re-interprets appraisal through the philosophical frameworks of axiology and demonstrates that the concept of value has a wider resonance than has been previously considered. Appraisal always results in retention schedules, which assure that all data and records are retained and disposed according to their quantified value: the time (in years) that data and records should be retained, according to considerations of organizational risks and assigned economic, social, cultural, financial, administrative, fiscal and/or legal value. Minimizing risks (especially those of litigation) also means systematic disposal immediately after the expiration of the assigned retention period (Shepherd and Yeo, 2003). Two theories of archival science offer tools for appraising data and records: the theories of Archival Retention Levels (ARLs) (Den Teuling, 2001) and Information Value Chain (IVC) (Van Bussel, 2012ab).

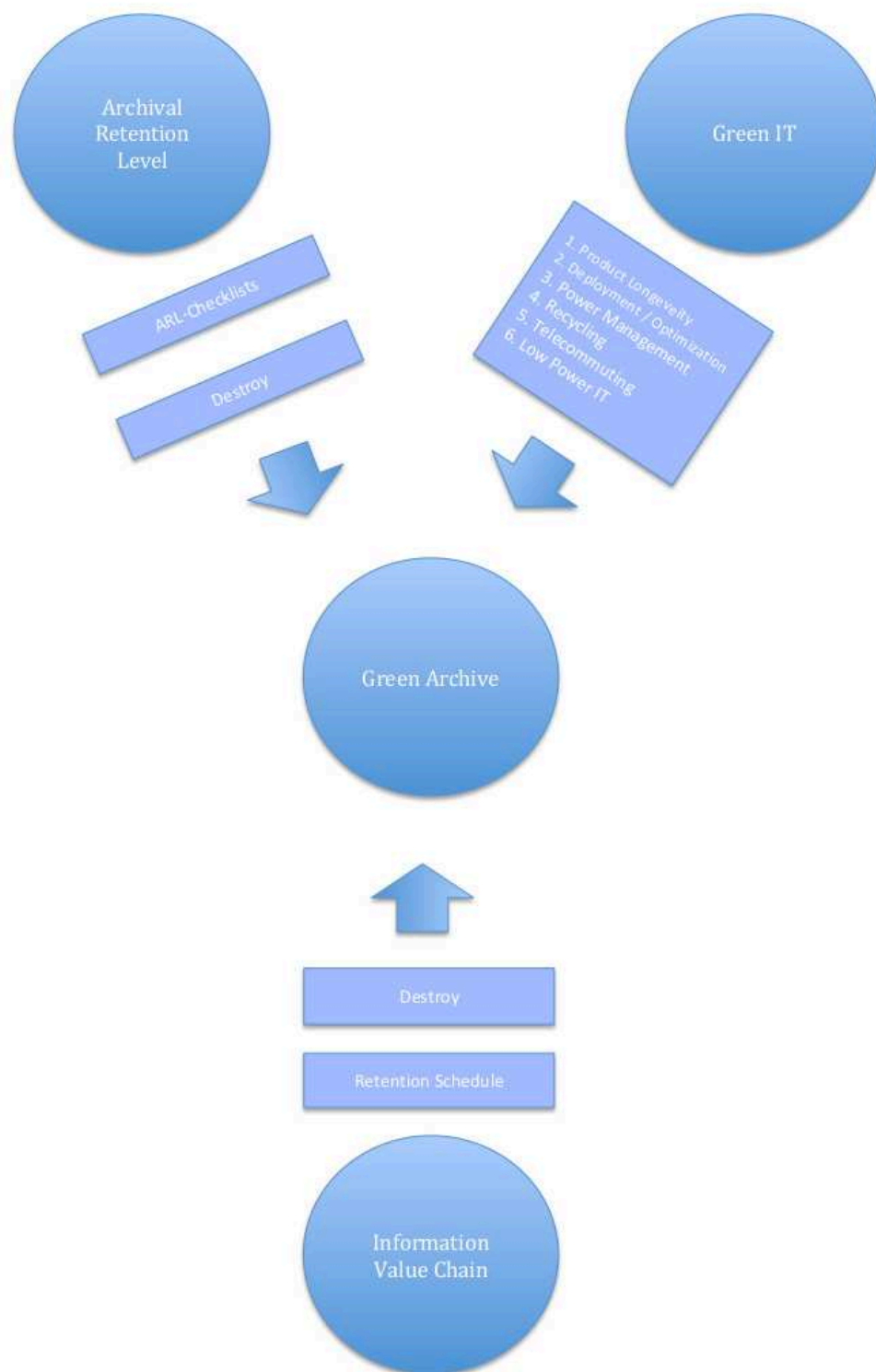
The first theory concerns itself with designating ARLs in organizations to store and retain data that is unique, authentic, relevant and contextual. The ARL theory is part of appraisal methods that consider organizational contexts and purposes more important than the specific content of data and records. ARLs define detailed functional (organizational) responsibilities for the retention, storage and archiving of unique, authentic, relevant, and contextual data and records (Smit, 2012). Data value is appraised according to the organizational level that is responsible for the collection, analysis, processing, and storage of that specific data. This organizational level is the designated ARL. At the ARL the data are retained as long as the retention schedule permits. This schedule makes the economic, social, cultural, financial, administrative, fiscal and/or legal value of the

data and records (retained at every ARL) explicit and defines its archival value: a time (in years) after which this information should be irreparably destroyed. Identical data retained at other functional levels within the organization and without a new business objective (duplicates) can be immediately deleted, permanently and irreparably. When using ARL's, it will be necessary (to prepare for litigation procedures) to capture data about the organizational level these duplicates are being kept and the persons who have accessed them (Van Bussel and Henseler, 2013). In digital environments, these duplicates can be stored in different forms and places and in various business processes, not being the designated ARL (Paul and Baron, 2007). The effect of using ARL's on the organizational need for storage capacity will be substantial, as published case studies indicate. In hospitals, for instance, an average organization's duplicate rate in 2009 was typically between 5-10 percent (McClellan, 2009). Deduplication lets an organization keep 20 times more data in a given amount of storage (Geer, 2008). The practical experiments of Mandagare et al (2008) show that between different deduplication techniques the space savings amount for almost 30 percent, which was confirmed in Dutch (2008) and Proofpoint (2013). Using ARL checklists can reduce the amount of data stored up to a minimum of 30 percent, which has direct effects on costs and needed storage capacity. The organizational use of ARLs can be seen as contextual data deduplication.

The IVC theory defines the utilization of the informational and evidential value of data and records in business processes to improve trusted information management and the performance of business processes (Van Bussel 2012ab). The IVC includes all processes of information management and manages data generation, data identification, data capture, data storage, data processing, data distribution, data structuring, data publication, data (re-) use, data appraisal, data selection, data disposal, data retention, data security, data auditing and data preservation. DA uses this chain to reach its purposes: to reduce the costs of transactions, to enlarge the speed of access to organizational experiences, to help in decision-making, to share knowledge, and to realize accountability. For the purpose of this paper, only the processes of data appraisal, data selection and data disposal are important. In the data appraisal process the short- and long-term (or indefinite) value of data and records is defined in order to retain and preserve them for later (re-)use. As stated above, this data appraisal defines the archival value and results in a retention schedule. In the data selection process, data and records are collected and set aside according to the agreed upon retention schedule. In the data disposal process, the set aside data and records are completely, permanently and irreparably deleted (Shepherd and Yeo, 2003). Organizational retention schedules are used to operate those processes. Almost 75 percent of all data and records in an organization can be permanently deleted over time (Archieflandsverordening, 2007). The value of Big Data, for instance, degrades rapidly over the short term. Retaining that data for a long time, hoping it may become valuable or needed some day, is unnecessarily costly and indefensibly risky (Gascon, 2013). In a retention schedule, such a Big Data data set will be appraised to be destroyed after its last use. Normally that would mean up to one year after the moment that specific Big Data data set was last used.

### **3.3 Green Archiving Model**

Combining the components of Green IT with the data reducing components of DA, allowed us to develop a Green Archiving model. As our earlier research showed (Van Bussel and Smit, 2014), that model can be used: [1] to increase awareness in organizations for the environmental effects of the use of ICTs, [2] to reduce the amount of stored data and records, [3] to reduce power consumption for data storage and, ultimately, [4] to reduce greenhouse gas emissions and E-waste in realizing all components of Green IT. This paper concentrates on the aspects [2] and [3] of the model. Aspect [1] was added to the objectives of the Green Archiving Model when conducting interviews with Digital Archiving and Green IT specialists and exploring the research question within a focus group. In their professional experience, the specialists encountered an extremely low organizational awareness of the environmental effects of ICTs and a lack of knowledge about the electricity use needed for storage and the associated organizational costs. Aspect [4] of the model will be part of further research; there are many case studies confirming the fact that Green IT reduces carbon dioxide emissions and E-waste (Murugesan, 2008; Schmidt, 2006). In future case studies we want to research the total effects of the application of the Green Archiving Model. The model of Green Archiving we developed is shown in figure 1.



**Figure 1:** Green archiving model: combination of Green IT, ARL and IVC

## **4. Testing the stage: experimenting with the Model**

### **4.1 Purpose**

The Green Archiving Model has four objectives. In Van Bussel and Smit (2014), we ascertained in a case study in the Dutch Music Institute (Nederlands Muziek Instituut) that the Green Archiving Model was viable and that it could be used in organizations to increase awareness of the environmental effects of ICTs (objective 1). In that paper, we also presented some provisional results in reducing the amount of data (objective 2), and in curbing power use for data storage (objective 3), using a case study in a Dutch international trade organization. We are presenting more definite results of using the Green Archiving Model here, especially concentrating on objectives 2 and 3, following additional research in this trade organization and already published case studies. The fourth objective (reducing carbon dioxide emissions and reducing E-waste) will be addressed in future research.

### **4.2 Exploratory research**

We organized three different exploratory case studies in a small international trade corporation in Maastricht (The Netherlands), working with subsidiaries in Europe, Asia and South America. These three case studies were: [1] a scan of the ICT infrastructure of the corporation using the model (November-December 2013), [2] a pilot study by the corporation's IT department on the effects of ARL Schedules (March-May 2014), and [3] a pilot study by the corporation's Chief Information Officer on the effects of a Records Schedule on the globally stored data and records (January-March 2015). In [1] the Green Archiving model was enthusiastically received. Green Computing was well known within the IT department, but only the components Software Deployment and Optimization (virtualization of storage servers) and Power Management were implemented. The results of this implementation of these components were comparable to those described by Dubey and Hefley (2011). The IT department admitted that it should be more aware of other Green Computing components. CSR was extremely important for the corporation and implementing other components of Green Computing would be a significant contribution to CSR. The IT department planned to look into the possibilities of Telecommuting and Product Longevity. When we did the exploratory scan, the organization didn't use ARL checklists, but (for this case study) agreed to experiment with them in its corporate headquarters. After a scan of the headquarters' file systems, the IT department estimated that almost 35 % of their IT storage capacity of 18 TB was used for duplicate files. It acknowledged that the use of ARL checklists would have a significant effect on the IT storage capacity. Retention Schedules were used only for the data stored in their document and records management applications, but the IT department acknowledged that both applications were not yet generally in use. Rigorous use of those schedules would certainly have an effect on the IT storage capacity, but the IT department could not quantify those effects yet. In [2] the IT department organized a pilot study on the effects of ARL Schedules in their global information management environment. It analysed all file systems and database management systems, storage area networks and mail systems in the global operations of the corporation. In this pilot study, the corporation realized the functional responsibilities in the organization structures of their subsidiaries were not clearly defined. It developed a new information management structure based on the IVC theory and integrated it in their business process models. The ARL analysis confronted the IT department with ICTs that were implemented within their subsidiaries without their knowledge. Global data storage capacity was 45 TB (including the headquarters' 18 TB storage capacity). The conclusion of this pilot study was that the use of ARL checklists would diminish global data storage capacity with 30 percent. 37 percent of the company's data storage capacity was used for duplicate files. The IT department calculated that such a reduction of the amount of data would result in less electricity use for data storage and would diminish electricity costs with 25 percent. These results correspond with the results of data deduplication mentioned earlier in this paper. In case study [3] the office of the Chief Information Officer analysed the retention schedules in use in their records and document management applications. They were limited to data and records captured within the document and records management software that was not globally implemented yet. The Chief Information Officer decided to use the European Document Retention Guide 2013 (De Brauw, 2013) as a way to analyse the possibilities of further reducing the data and records stored. The Chief Information Officer concluded that almost 10 percent (3.5 TB) of all data and records stored in February 2015 could be disposed of immediately, because they had no 'value' anymore for the organization as all possible retention periods had passed. Based on the Guide only 5 percent of all data would have to be retained for longer than twenty years. The IT department calculated that using ARLs and Retention Schedules for all data and records in the organization would curb data storage with almost 45 percent and would reduce electricity costs with 35 percent. The



conclusion of the Chief Information officer was that methodical use of the value of information (as expressed within the Retention Schedule used) would improve storage efficiency, reduce the amount of stored data and records, diminish litigation risks, and reduce electricity costs. The Green Archiving model seems to be a viable model for organizational use.

## 5. Conclusions and future work

In this paper, we studied the possibility to methodically reduce the amount of data and records stored in an organization based on their 'value' and using the Green Archiving Model. The case study showed that the model can be used to reduce [1] the amount of data (45 percent, using ARLs and Retention Schedules) and [2] the electricity consumption for data storage (resulting in a (calculated) cost reduction of 35 percent). These case studies indicate that the Green Archiving Model is a viable model to methodically reduce the amount of stored data and records and to curb electricity use for storage in organizations. That way, it facilitates DA and Green IT to reach their objectives. These case studies only provide us with provisional results. They need to be confirmed in further research. We are planning extensive case studies to research the environmental effects of Green Archiving and the scientific viability of our model. The ultimate goal of this research project is the development of a low power ICT that will automatically appraise, select and preserve or permanently delete data and records. Such an ICT will automatically reduce storage capacity and curb electricity consumption used for data storage. At the same time, data disposal will reduce overload caused by storing the same data in different formats, it will lower costs and it reduces the potential for liability.

## References

- Adams, I., Miller, E.L., and Rosenthal, D.S. (2011). *Using Storage Class Memory for Archives with DAWN, a Durable Array of Wimpy Nodes*. Technical Report UCSC-SSRC-11-07, Santa Cruz: University of California.
- Adams, I.F., Storer, M.W., and Miller, E.L. (2012). 'Analysis of workload behavior in scientific and historical long-term data repositories', *ACM Transactions on Storage (TOS)*, vol. 8, no. 2, art. 6: 1-27.
- Agarwal, S. and Nath, A. (2011) 'Green Computing - a new Horizon of Energy Efficiency and Electronic waste minimization: a Global Perspective', *CSNT '11 Proceedings of the 2011 International Conference on Communication Systems and Network Technologies*, Washington: IEEE, pp. 688-693.
- Ahamad, S.F., and Ravikanth, P.V. (2012) 'Green Computing Future of Liveliness', *International Journal of Computational Engineering Research (IJCER)*, vol. 2, no. 4, pp. 41-45.
- Ahmad, I., and Ranka, S. (2012) *Handbook of energy-aware and Green Computing*, London: Chapman & Hall/ CRC,
- Archieflandsverordening 2007, MvT, National Archives of the Netherlands Antilles.
- Armitage, J. and Roberts, J. (2002) *Living with Cyberspace. Technology and society in the 21st century*, London, New York: Continuum.
- Asgari, H., and Jin, X. (2015) 'Toward Comprehensive Telecommuting Analysis Framework: Setting the Conceptual Outline', *Transportation Research Board 94th Annual Meeting*, No. 15-0282.
- Badbe, V.C. (2014) 'Green Computing Approaches', *International Journal of Computer Technology and Applications*, vol. 5, no. 6, pp. 3042-3049.
- Barroso, L.A. and Hözl, U. (2007) 'The case for energy-proportional computing', *IEEE Computer*, vol. 40, no. 12, pp. 33-37.
- Bearman, D. (2006) 'Moments of risk. Identifying threats to electronic records', *Archivaria*, vol 62, Fall, pp. 15-46.
- Boccaletti, G., Löffler, M., and Oppenheim, J. M. (2008) 'How IT can cut carbon emissions', *McKinsey Quarterly* vol. 37, October, pp. 37-41.
- Brooks, S., Wang, X., and Sarker, S. (2012) 'Unpacking Green IS: A Review of the Existing Literature and Directions for Further Research', Vom Brocke, J., Seidel, S. and Recker, J. (eds.), *Green Business Process Management. Towards the Sustainable Enterprise*, Heidelberg: Springer, pp. 15-37.
- Choudhary, S (2014) 'A survey on green computing techniques', *International Journal on Computer Science and Information Technology*, vol.5, no. 5, pp. 6248-6252.
- Cook, G. (2012) *How clean is your cloud ? Catalysing an energy revolution*, Amsterdam: Greenpeace International..
- Cook, T. (2013) 'Evidence, memory, identity, and community: four shifting archival paradigms', *Archival Science*, vol. 13, no. 2-3, pp. 95-120.
- De Brauw Blackstone Westbroek (2013) *European Document Retention Guide 2013*, Amsterdam: Iron Mountain..
- Den Teuling, A. (2001) 'Selectie in de praktijk', Ketelaar, F.C.J., Den Teuling, A.J.M. and Van Wijngaarden, J. (eds.), *Archiefbeheer in de praktijk*, Alphen aan den Rijn: Samsom, pp. 4020/1-55.
- Donnellan, B., Sheridan, C. and Curry, E. (2011) 'A Capability Maturity Framework for Sustainable Information and Communication Technology', *IEEE IT Professional*, vol. 13, no. 1, pp. 33-40.
- Düben, P.D., Joven, J., Lingamneni, A., McNamara, H., De Micheli, G., Palem, K.V. and Palmer, T.N. (2014) 'On the use of inexact, pruned hardware in atmospheric modelling', *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, vol. 372, pp. 1-16, DOI: 10.1098/rsta.2013.0276.
- Dubey, S., and Hefley, W.E. (2011) 'Greening ITIL: Expanding the ITIL lifecycle for Green IT', *Proceedings of Portland International Conference on Management of Engineering and Technology (PICMET 2011)*, Washington: IEEE, pp. 1-8.



- Duranti, L. (1994) 'The concept of appraisal and archival theory', *The American Archivist*, vol. 57 (Spring), pp. 328-344.
- US Energy Information Administration (EIA) (2012) 'International Energy Statistics'. Online.  
Available: <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=6&pid=29&aid=12> (26 May 2015)
- US Energy Information Administration (EIA) (2014) 'International Energy Outlook 2013'. Online.  
Available: <http://www.eia.gov/forecasts/archive/ieo13/electricity.cfm> (26 May 2016)
- US Environmental Protection Agency (EPA) (2009) *Electronic Waste Management in the United States through 2009*, Washington D.C.: EPA.
- Esfahani, M.D., A.A. Rahman and N.H. Zakaria (2015a) 'The Status Quo and the prospect of Green IT and Green IS. A systematic literature review', *Journal of Soft Computing and Decision Support Systems*, vol. 2, no. 1, pp. 18-34.
- Esfahani, M.D., A.A. Rahman and N.H. Zakaria (2015b) 'GreenIT/IS Adoption as Corporate Ecological Responsiveness. An Academic Literature Review', *Journal of Soft Computing and Decision Support Systems*, vol. 2, no. 1, pp. 35-43.
- Forrest, W., Kaplan, J.M. and Kindler, N. (2008) 'Data Centers: How to cut Carbon Emissions and Costs', *McKinsey on Business Technology*, vol. 8, no. 14, pp. 4-14.
- Gantz, J.F. and Reinsel, D. (eds.) (2007) *The expanding digital universe. A forecast of worldwide information growth through 2010*, Framingham (Ma.): IDC.
- Gantz, J. and Reinsel, D. (2012) *The Digital Universe in 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East*, Framingham (Ma.): IDC.
- Golden, B. (2010) 'Cloud computing: How big is big data? IDC's answer', *CIO*, May 7.
- Geer, D. (2008) 'Reducing the Storage Burden via Data Deduplication', *Computer*, vol.41, no. 12, pp. 15-17.
- Gunaratne, C., Christensen, K. and Norsman, B. (2005) 'Managing energy consumption costs in desktop PCs and LAN switches with proxying, split TCP connections, and scaling of link speed'. *International Journal of Network Management*, vol. 15, pp. 297-310.
- Hammond, T. (2013) 'Toolkit: Calculate datacenter server power usage'. Online.  
Available: <http://www.zdnet.com/toolkit-calculate-data-center-server-power-usage-7000013699/> (26 May 2015)
- Harmon, R.R. and Auseklis, N. (2009) 'Sustainable IT Services: Assessing the Impact of Green Computing Practices', *Proceedings of Portland International Conference on Management of Engineering and Technology (PICMET 2009)*, Washington: IEEE, pp. 1707-1717.
- Hilbert, M. and López, P. (2011) 'The world's technological capacity to store, communicate, and compute information', *Science*, vol. 332, no. 6025, pp. 60-65.
- Hodge, G.M. (2000) 'Best practices for Digital Archiving. An Information Life Cycle Approach', *D-Lib Magazine*, vol. 6, no. 1. Online. Available: <http://www.dlib.org/dlib/january00/01hodge.html> (26 May 2015).
- Hopper, A. and Rice, A. (2008) 'Computing for the future of the planet', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 366, pp. 3685-3697, DOI: 10.1098/rsta.2008.0124.
- HP (2008) 'Groen computergebruik: energie besparen en helpen de aarde te beschermen'. [Online].  
Available: [http://m.hp.com/be/nl/hp-news/details.do?id=48932&articletype=news\\_release](http://m.hp.com/be/nl/hp-news/details.do?id=48932&articletype=news_release) (26 May 2015).
- Gascon, D. (2013) 'Are you a Data Hoarder? Really, are you?', *Compliance, Governance & Oversight Council, CGOC*. Online.  
Available: <https://www.cgoc.com/blog/are-you-data-hoarder-really-are-you> (25 May 2015).
- Jacob, J.S. and P. K.G (2012) 'EDPAC: event-driven power aware pervasive computing for effective power utilization in Green Computing', *International Journal of Advanced Information Technology*, vol. 2, no. 1, pp. 55-64.
- Jacobs, A. (2009) 'The pathologies of Big Data', *Communications of the ACM*, vol 52, no. 8, pp. 36-44.
- Ren, J., Li, L., Chen, H., Wang, S., Xu, S., Sun, G., Wang, J. and Liu, S. (2015) 'On the deployment of information-centric network: Programmability and virtualization'. *International Conference on Computing, Networking and Communications (ICNC), Proceedings*, Garden Grove (CA.): IEEE, pp. 690-694.
- Kashyap, P., Naik, A., and Patel, P. (2015) 'Green Computing', *International Journal of Research*, vol. 2, no. 4, pp. 940-944.
- Koomey, J.G. (2008) 'Worldwide electricity used in data centers', *Environmental Research Letters*, vol. 3, no. 034008 (July-September), doi:10.1088/1748-9326/3/3/034008).
- Koomey, J.G. (2011) *Growth in data center electricity use 2005-2010*, Oakland (Ca.): Analytics Press
- Kwon, Y.C., Sang, W.L. and Moon, S. (2006) 'Personal computer privacy: Analysis for Korean PC users', *Advances in Information and Computer Security*, Berlin-Heidelberg: Springer, pp. 76-87.
- Ladou, J., and Lovegrove, S. (2008) 'Export of electronics equipment waste', *International journal of occupational and environmental health*, vol. 14, no. 1, pp. 1-10.
- Latour, B. (1990) 'Postmodern? No, simply amodern! Steps towards an anthropology of science', *Studies In History and Philosophy of Science*, vol 21, no. 1, pp. 145-171.
- Lei, C.F. and Ngai, E.W.T. (2013) 'Green IT Adoption: An Academic Review of Literature'. *PACIS 2013 Proceedings*. Paper 95.
- Lee, S.M., Park, S-H. and Trimi, S. (2013) 'Greening with IT: practices of leading countries and strategies of followers', *Management Decision*, vol. 51, no. 3, pp. 629-642.
- Lyman, P. and Varian, H.R. (2003) *How much information?*, , Berkely: School of Information Management and Systems, University of California.
- Mandagere, N., Zhou, P., Smith, M.A. and Uttamchandani, S. (2008) 'Demystifying data deduplication', *Proceedings of the ACM/IFIP/USENIX Middleware'08 Conference Companion*, Leuven (Belgium), pp. 12-17.
- Manyika, J. (ed.) (2011) *Big Data. The next frontier for innovation, competition and productivity*, McKinsey Global Institute.
- McClellan, M.A. (2009) 'Duplicate Medical Records: A Survey of Twin Cities Healthcare Organizations', *AMIA Annual Symposium Proceedings*, Bethesda (Mi.): AMIA, pp. 421-425.

- Mingay, S. (2007) *Green IT: The New Industry Shock Wave*, Gartner.
- Murugesan, S. (2008) 'Harnessing Green IT: Principles and Practices', *IEEE IT Professional*, vol. 10, no. 1, pp. 24-33.
- Niu, J. (2014). 'Appraisal and Selection for Digital Curation', *International Journal of Digital Curation*, vol. 9, no. 2, pp. 65-82.
- Orgerie, A.C., De Assuncao, M.D. and Lefevre, L. (2014) 'A Survey on Techniques for Improving the Energy Efficiency of Large Scale Distributed Systems', *ACM Computing Surveys*, vol. 46, no. 4, pp. 1-35.
- Paul, G. and Baron, J. (2007) 'Information Inflation. Can the legal system adapt?', *Richmond Journal of Law & Technology*, vol 13, no. 3, pp. 1-41.
- Penn, ESM (2014) *Exploring archival value: an axiological approach*. Doctoral thesis, UCL (University College London). Online. Available: <http://discovery.ucl.ac.uk/1455310/> (26 May 2015)
- Pine, K. and Mazmanian, M. (2015) 'Emerging Insights on Building Infrastructure for Data-Driven Transparency and Accountability of Organizations', *iConference 2015 Proceedings*, Newport Beach (Ca.), pp. 1-13
- Proofpoint (2013) 'Archive and Governance ROI Tool'. Online. Available: <http://www.proofpoint.com/products/archive-governance/roi-tool/index.php> (26 May 2015).
- Robinson, B.H. (2009) 'E-waste: an assessment of global production and environmental impacts', *Science of the total environment*, vol. 408, no. 2, pp. 183-191.
- Robyns, M. C. (2014). *Using Functional Analysis in Archival Appraisal: A Practical and Effective Alternative to Traditional Appraisal Methodologies*. Plymouth: Rowman & Littlefield.
- Schmidt, C. W. (2006) 'Unfair trade e-waste in Africa', *Environmental Health Perspectives*, vol. 114, no. 4, A232.
- Shalini, K., and Prasanthi, K.N. (2013) 'Green Computing', *Journal of Telematics and Informatics*, vol. , no. 1, pp. 1-13.
- Schwarz, M., and Elffers, J. (2010) *Sustainism is the new modernism. A cultural manifesto for the sustainism era*, New York: Distributed Art Publishers.
- Segaran, T. and Hammerbacher, J. (2009) *Beautiful Data: The Stories Behind Elegant Data Solutions*, Sebastopol (Ca.): O'Reilly Media.
- Shepherd, E. and Yeo, G. (2003) *Managing records. A handbook of principles and practice*, London: Facet Publishing.
- Schlomann, B., Eichhammer, W., and Stobbe, L. (2015) 'Energy saving potential of information and communication technology', *International Journal of Decision Support Systems*, vol. 1, no. 2, pp. 152-163.
- Smallwood, R.F. (2013) *Managing electronic records: Methods, best practices, and technologies*, Hoboken (NJ): John Wiley & Sons, Hoboken (NJ), chapter 7.
- Smit, N. (2012) *Green Archiving. Digitale archivering en het milieu*, Amsterdam: Reinwardt Academy (BCM Thesis).
- Dutch, M. (2008) *Understanding data deduplication ratios*, SNIA Data Management Forum.
- Srivastava, K., Sethumadhavan, A., Raghupathy, H., Agarwal, S., and Rawat, S. R. (2015) 'To Study the Indian Perspective on the Concept of Work from Home', *Indian Journal of Science and Technology*, vol. 8, no. S4, pp. 212-220.
- Subburaj, S., Kulkarni, S. and Jia, L. (2014) 'Green IT: sustainability by aligning business requirements with IT resource utilisation', *International Journal of Communication Networks and Distributed Systems*, vol. 12, no. 1, pp. 30-46.
- Thompson, J.T. (2009) 'Three approaches to green computing on campus', *EDUCAUSE Quarterly Magazine*, vol. 32, no. 3. [Online]. Available: <http://www.educause.edu/ero/article/three-approaches-green-computing-campus> (26 May 2015).
- Tomlinson, B. (2010) *Greening through IT. Information Technology for environmental sustainability*, Cambridge (Ma.): MIT University Press.
- UNEP (2006) *Call for Global Action on E-waste*. United Nations Environment Programme, s.l.
- Van Bussel, G.J. (2012a) *Archiving should be just like an Apple™ en acht andere, nuttige (?) stellingen*, Amsterdam: Amsterdam University Press.
- Van Bussel, G.J. (2012b) 'Reconstructing the Past for Organizational Accountability', *The Electronic Journal of Information Systems Evaluation*, vol. 15, no. 1, pp. 127-137.
- Van Bussel, G.J. and Henseler, H. (2013) 'Digital Archiving and e-Discovery: Delivering evidence in an age of overload', John, B., Nkhoma, M. and Leung, N. (eds.), *Proceedings of the 4<sup>th</sup> international conference on Information Systems Management and Evaluation (Ho Chi Minh City, May 2013)*, Reading (GB): ACPI, pp. 281-288.
- Van Bussel, G.J. and Smit, N. (2014) 'Building a Green Archiving Model: Archival Retention Levels, Information Value Chain and Green Computing', Devos, J. and De Haes, S. (eds.), *Proceedings of the 8th European Conference on IS Management and Evaluation. ECIME 2014. University of Ghent, 11-12 september 2014*, Reading (GB): ACPI, pp. 271-277.
- Visalakshi, P., Paul, S. and Mandal, M. (2013) 'Green Computing', *International Journal of Modern Engineering Research (IJMER). Proceedings of the National Conference on Architecture, Software systems and Green computing (NCASG), Paiyanoor (India), May 3, 2013*, pp. 63-69.
- Walker, S. (1995) 'The environment, product aesthetics and surface', *Design Issues*, vol.11, no. 3, pp. 15-27.
- Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M. and Boni, H. (2005) 'Global perspectives on e-waste', *Environmental Impact Assessment Review*, vol. 25, no. 5, pp. 436-458.
- World Nuclear Association (WNA) (2015) 'Renewable energy and electricity'. Online. Available: <http://www.world-nuclear.org/info/Energy-and-Environment/Renewable-Energy-and-Electricity/> (26 May 2015).
- Xie, S.L. (2013) 'Preserving Digital Records: InterPARES findings and developments', Lemieux, V. (ed.), *Financial Analysis and Risk Management. Data Governance, Analytics and Life Cycle Management*, Berlin-Heidelberg: Springer, pp. 187-206.



# **‘Privacy Lost - and Found?’ The information value chain as a model to meet citizens’ concerns**

**John van de Pas<sup>1</sup> and Geert-Jan van Bussel<sup>2</sup>**

<sup>1</sup>**Saxion University of Applied Sciences, School of Creative Technology, Deventer, The Netherlands**

<sup>2</sup>**Digital Archiving & Compliance, HvA Amsterdam University of Applied Sciences, School of Economics and Management, Amsterdam, The Netherlands**

j.h.vandepas@saxion.nl

g.j.vanbussel@hva.nl

**Abstract:** In this paper we explore the extent to which privacy enhancing technologies (PETs) could be effective in providing privacy to citizens. Rapid development of ubiquitous computing and ‘the internet of things’ are leading to Big Data and the application of Predictive Analytics, effectively merging the real world with cyberspace. The power of information technology is increasingly used to provide personalised services to citizens, leading to the availability of huge amounts of sensitive data about individuals, with potential and actual privacy-eroding effects. To protect the private sphere, deemed essential in a state of law, information and communication systems (ICTs) should meet the requirements laid down in numerous privacy regulations. Sensitive personal information may be captured by organizations, provided that the person providing the information consents to the information being gathered, and may only be used for the express purpose the information was gathered for. Any other use of information about persons without their consent is prohibited by law; notwithstanding legal exceptions. If regulations are properly translated into written code, they will be part of the outcomes of an ICT, and that ICT will therefore be privacy compliant. We conclude that privacy compliance in the ‘technological’ sense cannot meet citizens’ concerns completely, and should therefore be augmented by a conceptual model to make privacy impact assessments at the level of citizens’ lives possible.

**Keywords:** privacy, privacy enhancing technology, digital archiving, information value chain, big data, information management

---

## **1. Introduction: Privacy and cyberspace**

Privacy and Information & Communication Technologies (ICTs) are often portrayed as opposites (Pogue, 2011; Morozov, 2013, Hofstetter, 2014). In this paper we will be exploring some interactions between ICTs and Privacy, with particular attention to the transition of privacy’s conceptual definition in the real world into cyberspace. Although concerns over citizens’ privacy are by no means new, the issue has manifested itself prominently with the emergence of the “Internet of Things”, “Big Data” and “Smart Cities”, and public outrage following releases of documents by Snowden and Wikileaks. Hundreds of articles and books have been published by scientists, professionals, journalists, politicians and bloggers on this subject, giving some indication that statements like “You have zero privacy anyway – get over it” (Sprenger, 1999) may have to be reassessed.

Within the next few years, according to Mayer-Schönberger and Cukier (2013), we will be witnessing the final breakthrough of Big Data as a transforming force in our society. Information harvesting systems, fed by the upcoming abundance of all kinds of sensory systems that continuously capture information regarding human-environment interaction will lead to new privacy challenges. Data, traditionally captured in organizational ICTs, are breaking loose from its constraints and are absorbed into a “cloud”. While Big Data is most commonly associated with the stockpiled personal information of users of ICTs, the (predictive) data analysis technologies applied to that data are its true smartness (Siegel, 2013). These developments will make keeping information private and confidential particularly challenging (Wang and Petrison, 1993; Lahlou et al, 2005; Leese, 2013). Although the implementation of ICTs results, almost like a “Law of Nature”, in privacy infringement most of the times, Morozov (2013) points out that organizations developing ICTs do make choices. Organizations processing data define functionalities at the start of software development processes, and may decide to respect citizens’ privacy in their operations. Facilitating ICTs with proper and fail-proof systems to guarantee citizens’ privacy during information processing has, however, been described as hugely challenging (Flaherty, 1989; Solove et al, 2006; Etzioni, 2007; Spiekermann 2009; Kosinski et al, 2013). This can be traced back to the elusive character of the term “privacy”. Privacy is a social concept from the real world, that has been translated into laws and regulations, and is interpreted by people in social environments. ICTs, on the other

hand, are part of cyberspace, ruled by technology, which is based upon modelled versions of real life concepts. Although modelling techniques allow for some overlap between the social, legal and technological realms, at the same time it must be acknowledged that each environment comes with its own sets of rules and limitations. Laws work best in real world environments, where letter and intent can be interpreted because human beings are involved. In information technology, it is possible for literal rules to be applied successfully, but it is difficult to apply the intent of a rule. As a consequence, direct translation of real-world laws to rules regulating global cyberspace may not be possible (Lessig, 2006, Solove, 2004).

## **2. Purpose and research method: an inventory of thought on privacy-aware ICTs**

The subject of this paper was conceived during discussions about ways to find clear and unambiguous standards to make ICTs respectful of citizens' privacy. A keyword search on privacy and system development in both scientific and professional databases (EBSCO Academic Search Premier, Paperity.org and IEEE Xplore digital library) made clear that the debate on privacy-aware ICTs is lively, and covers the concept of privacy, the way that concept is translated into rules and regulations, the risks facing organizations and citizens and the methods and technologies available to make ICTs privacy-aware. While proper attention is being paid to different aspects of ICT development within the boundaries of organizational environments, the perspective of the citizen somehow seems to have got lost by a focus on regulatory and technological aspects by professional and scientific communities.

Although social media and technology pundits state that privacy is dead, a vast majority of citizens still considers personal information confidential. At the same time, an equal majority of citizens expects services to be tailor made, and service providers need detailed information about the user to provide those. Many people more or less willingly provide this information, for in many cases refusing to do so entails denial of service. However the citizen explicitly or tacitly expects the service provider to act responsibly when processing confidential and sensitive data for service personalisation. Commercial use of those data for other purposes is generally frowned upon, and, when found out, results in privacy scandals.

This ambiguity is complicating both provision of personalized services and respecting citizens' concerns towards privacy. The availability and use of privacy rules and regulations and the application of privacy enhancing technologies (PETs) have not made privacy infringements a thing of the past. This seems to point towards the conclusion that technological and regulatory measures fail to provide citizens with satisfactory privacy protection in ICTs. To identify possible reasons for this gap between reality and ideal, we have decided to choose a citizen's perspective as the starting point for our analysis of the attempts that are made to translate real life privacy into privacy-aware ICTs. For that purpose, we will use the concept of the information value chain (IVC) (Van Bussel, 2012ab), which describes the information life cycle in conceptual terms. The IVC will allow for a structured way to implement privacy regulations within organizational ICTs. Using that model, we will try to answer the question why, if regulations and technologies are available, privacy breaches by information technology still exist.

To do that, we will attempt to follow the translation of privacy-in-real life through the development process into privacy-aware ICTs one step at a time. Starting with Allen (2011), who scrutinizes the transformation of the concept as it passes from its' natural environment through legislation into practical application in ICT environments, and questions whether individuals are in a position to make informed choices on their privacy. Hofstetter (2014) provides a more belligerent viewpoint, as she explores the rise of intelligent machines and their impact on human freedom of choice, stating that the private sphere is under severe pressure and should be protected. Both views could have profound impact on the way ICT's may deliver privacy as intended by the citizen. The way laws may be put into practical application in ICTs is explored in a PhD thesis on the use of PETs by Borking (2010). He discusses methods and techniques available to transform "real-world" law through "programming code" into "cyberspace law". Another, more technological perspective is elaborated by Van Heerde (2010). His PhD thesis provides an overview of available technological solutions to make ICTs privacy-aware by looking at ways they may be configured to yield data processing to the privacy laws and regulations from the real world. The technological perspective is further elaborated by a selection of publications on technological solutions to ICT-induced privacy problems (Zeng et al, 2013; Martínez-Ballesté et al, 2013; Thierer 2013; Kwecka et al, 2014). Spiekermann and Cranor (2009) allow a look from the point of view of system developers, in their excellent overview of the state of affairs regarding engineering practices of privacy-aware systems, and the scope and limits of the technological community developing services in cyberspace.



And finally we will take a look at what is considered the touchstone for the feasibility of implementation of privacy regulations into ICTs: confronting PETs with a privacy-audit, as proposed by Mayer-Schönberger and Cukier (2013).

### **3. Privacy as a socio-cultural factor**

One phrase about the rights of citizens from Warren and Brandeis (1890: 193) has become famous: “[...] now the right to life has come to mean the right to enjoy life, -- the right to be let alone; the right to liberty secures the exercise of extensive civil privileges; and the term "property" has grown to comprise every form of possession -- intangible, as well as tangible”. Describing this ‘right to be let alone’ in legal terms has proven to be a mind-bending effort, partly due to the fact that privacy is a social construct like “trust” or “autonomy”. Defining its meaning is difficult, due to the contextual character of the concept. Privacy depends on the specifics of the situation and the persons involved. What constitutes a breach of privacy is therefore not easily defined in general terms.

In “Unpopular privacy” Allen (2011) describes privacy as an “umbrella” concept incorporating several narrower concepts, including seclusion, solitude, secrecy, reserve, confidentiality and data protection, that denote modes of limiting access to people and personal information. Conly (2013) discusses the relevancy of protection of the public sphere in the context of government policies limiting exchange of information and imposing protective measures on individuals, market organisations and government agencies. Preventing undue disclosure of confidential information is essential when the harm that may be done may extend well beyond simple “personal embarrassment”. Disclosure of personal information may affect our relationships with commercial organizations, it may affect the ability to get or hold jobs, it may happen without our permission, and it may happen through our voluntary activities, which have a reach we cannot foresee. Conly concludes that leaving control of information to the private sphere does not seem to offer adequate protection of personal information. Hofstetter (2014) links the right to confidentiality and secrecy directly with power, as she describes a “private sphere”, based on the right of the individual to have and hold secrets. “Private sphere is the instrument to balance powers” (Hofstetter, 2014: 259). The idea that privacy is both tightly connected to the “private sphere”, but also instrumental to the uses and procedures of information services, points towards mechanisms that exert influence on the outcomes of the discussion on privacy protection in cyberspace.

Spiekerman and Cranor (2009) quote research into attitudes concerning privacy in the general population and reports that roughly 25% of ICT users does not care about privacy; the rest of the population can be divided into a large group of “pragmatists” and a small group of “paranoids”. Lopez (2010) reports roughly the same results of a survey into consumer privacy protection by Accenture, where internet users were asked whether they agreed with the proposition that consumers have a right to control information collected about them and their family. Only a quarter of the participants of that survey disagreed or strongly disagreed. The general view is that roughly 75% of the population does foster between mild and serious concerns about privacy in using ICTs. Finally, Dawes (2008) mentions outcomes from a research project mapping relevant issues concerning e-governance, in which specific attention was paid to human factors in ICT-enriched environments. The expectations of the general public when using ICT-based services were found to extend far beyond the notion of the application of technology. A wide range of social and cultural reactions were given: ‘integrity of self, identity, autonomy, personal choice, privacy, trust, adjustment and learning are essential considerations without regard to any particular technology’. This statement was made in the context of e-government scenario development, but it may safely be assumed that citizens expect comparable levels of respect for the “private sphere” in their interaction with commercial organisations.

### **4. Regulations on privacy**

Privacy regulations are abundant. The European Union privacy guideline 95/46/EC (1995), which protects individuals with regard to the processing and transmitting of personal data, has been in place since the closing years of the 20<sup>th</sup> century. It was amended by Directive 97/66/LC (EU 1997), expanding the scope to electronic services, and ultimately replaced by the Directive on Privacy and Electronic Communications (EU, 2002). Although local and national legislation is also in place, all EU member states should adhere to these regulations. Lessig (2006, p 5) wrote that “In real space, we recognize how laws regulate - through constitutions, statutes, and other legal codes. In cyberspace we must understand how a different ‘code’ regulates - how the software and hardware (i.e., the ‘code’ of cyberspace) that make cyberspace what it is also



regulate cyberspace as it is. [...] this code is cyberspace's 'law'." In cyberspace, in other words, "code is law" (Lessig 2006, p 5). The analysis of this phrase by Borking (2010) is based on the perspective of a real-world privacy authority, and explores ways in which Law, upheld by legal systems in the real world, may translate into *code* in cyberspace. He explores the way data service providers may make their hard- and software compliant to privacy guidelines and regulations. Van Heerde's (2010) information management approach concentrates on the implementation of those legal guidelines and regulations. Although focused on the technological possibilities of privacy-compliant ICTs, Van Heerde (2010) shares Borking's (2010) concerns when discussing the data analysis technologies of Google, Apple, Facebook, Twitter and Amazon, the largest data aggregators worldwide, and the fact that the price citizens pay for "free" services with privacy-sensitive information about themselves. "The market needs urgently to be regulated and, most importantly, to get transparent. [...] Transparency is one of the key foundations of privacy; it must be clear for the user how his or her data is being handled, stored, and to whom it will be disclosed. Asymmetry of power between users and service providers leads to privacy risks for the users, because service providers are in a better position to serve their interests" (Van Heerde, 2010: 6). Service providers, by their actions, shape privacy in the real world as much as real-world law is trying to shape privacy compliance in cyberspace (Tsiavos et al, 2003). Ultimately, both actions are inherent to the way ICTs are built. System developers building the data collection and analysis systems making Big Data possible, determine what users can and cannot do with those ICTs. The "rule of the code" leads to "laws" being enforced by ICTs (Lessig, 2006). This puts law enforcement powers in the hands of the code-writing system developer. In cyberspace, the system developer holds both legislative and executive power, which according to Borking is undesirable, because the code-making process defies proper democratic controls, deemed essential in a constitutional state (Borking, 2010). Information services providers, notwithstanding legal rules and regulations, seem to have the upper hand in the application of privacy regulations as they are major stakeholders in system development projects.

At the other hand, laws and regulations bestow 'ordinary' users with some legal rights that should be respected, as Coles-Kemp and Kani-Zabihi (2010) point out. In their view, the proper path leading to privacy-sensitive systems starts by paying proper respect to citizens' privacy by giving the user control over his or her data, and to support them in decision making on the usage of that data by the service provider. Service providers should empower users to make informed decisions by providing easily understandable information. In ideal terms, this would lead to a dialogue between empowered users and benign service providers, not a monologue with coercive traits from the part of the all-powerful service provider. But Coles-Kemp and Kani-Zahibi admit that the unlevel playing field makes it nigh impossible to exercise this form of what they call 'intuitive privacy: the ability a service user, or data "subject", has to control the disclosure of personal information and the presentation of their on-line identity'.

This imbalance of power is particularly manifest in online environments, where negotiations about the levels of personal information required by the service provider, and to what extent they may be used, are being conducted between highly unequal parties. The single person-user trying to negotiate the use of his or her private information by proposing alternative terms in the privacy policies of Facebook or Google for example, will have a problem. A simple "denial of service" is evoked on the user unwilling to yield to some or all of the privacy policies of the service provider. The playing field between individuals and service providers shows no signs of movement towards dialogue; the imbalance of power is reinforced (Oyomno et al, 2009). Spiekermann and Cranor (2009: 72) connect privacy compliance with acceptance of information systems and strike a note of warning against continued unrestricted privacy infringements by service providers, as they foresee a "customer back-lash over privacy issues. In order to protect companies from such volatility in customer perceptions, shown to be relevant to stock-market valuation, it may be advisable to build systems and follow privacy policies based on some baseline privacy protection".

## **5. Privacy in organizational information systems**

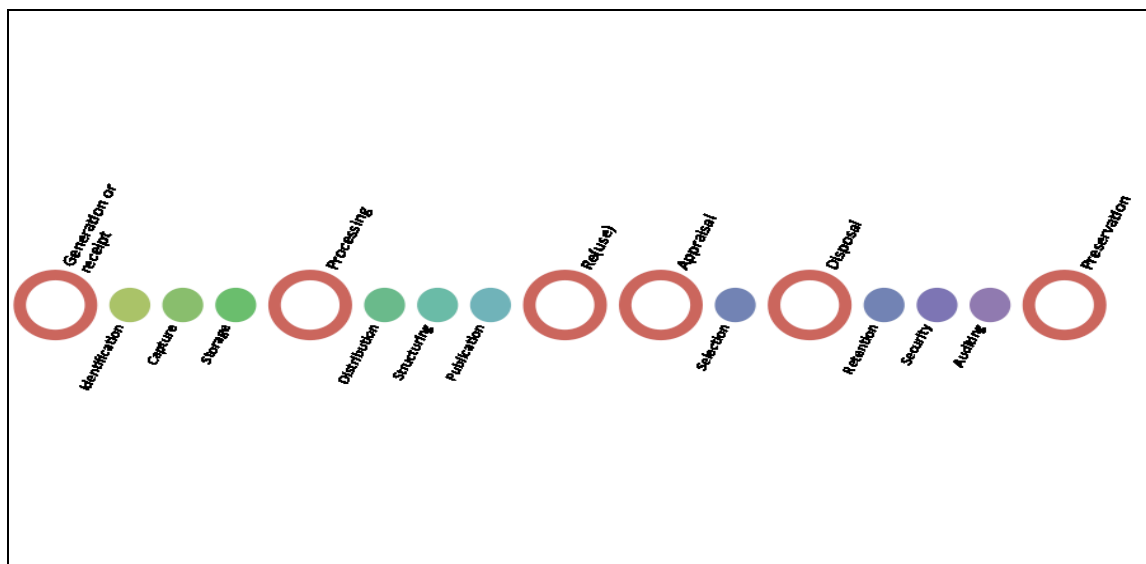
Most organizations consider compliance with privacy guidelines an integral part of their responsibilities. They do accept the public expectation that organizations pay attention to the safe and correct storage, processing and disposal of the personal information they are entrusted with. To some extent, these privacy policies address issues that may arise in organizational information management. Implementation of privacy policies allows organizations to prove appropriate levels of care in the handling of confidential and sensitive information within business processes. Until a few years ago, information retention was deemed a matter of organizations that exploited their own ICTs. As such, both organisations and the general public could foster a

relative sense of control regarding their data. In the pre-networked computing environment, organizations captured their business process information into a digital infrastructure, that rarely crossed the borders of the organization's structure. Generally speaking, this led to the widely supported conviction that organizations might be in control of the information that was collected and retained within their ICTs.

A model of the information flow in and between organizations can be drawn using both inter-organizational business process analysis and information flow analysis. Van Bussel (2012ab) introduced the innovative concept of the information value chain (IVC). The IVC consists of a process model that includes all processes within the information flow within an organization or a chain of organizations on a generic level, independent of the technologies used. The processes identified are: generation or receipt, identify, capture, storage, processing, distribution, structuring, publication, (re-) use, appraisal, selection, disposal, retention, security, auditing and preservation. The IVC (Figure 1) is deemed instrumental in providing proper control on the performance of business processes, the provision of trusted information and the protection of privacy-sensitive data. Whenever privacy issues arise, a single point of interaction can be contacted by a citizen or privacy authority (Davenport and Prusak, 1997), to request mitigating measures, post a formal complaint or claim damages.

Privacy issues in the information processing process must be assessed to identify possible risks for the organization and take proper actions if violations of privacy regulations may take place (Haller, 2012). Privacy risks emerge throughout the complete information value chain, as is shown in Figure 1. Due to aspects of efficiency and practicality, however, in most organizations privacy assessments are restricted to the point at which information enters the ICTs of the organization: the "generation/receipt" stage in the IVC. A privacy risk assessment of the IVC, however, may prove that the risk of privacy infringements emerges at six moments, emphasized in Figure 1 as 'open circles': generation/receipt of information within the organization, processing, (re-)use, appraisal, disposal and preservation of information. To make matters worse: the sort of risks the organization will have to take into account, varies both in the senses of impact and liability. In order to prevent privacy infringements completely and sufficiently, organizations will have to execute a detailed analysis of the impact on privacy aspects of each step in the IVC.

Most organizations have implemented information security procedures in order to protect data integrity and to prevent unauthorized access to the information contained in their ICTs, and sometimes refer to those policies when challenged on the aspect of privacy-compliance. It is relevant to evaluate if the assertion that privacy is guaranteed if security is under control, is correct. Borking (2010) discusses information security oriented measures extensively, referring to the EU funded PISA research project (Privacy Incorporated Software Agent) (EU, 2004). In PISA, researchers investigated the applicability of information security measures on privacy compliance. Table 1 shows the conclusions of that research: information security measures do not lead to compliance to privacy regulations, and therefore would not render ICTs privacy-aware. According to Borking (2010), those results are not surprising: information security and confidentiality surpass lawfulness completely. Whether the information contained in the information system is put there lawfully is *not* subject of the information security policies. It is clear *why* organizations have problems with developing their systems to be compliant to privacy law and regulations. Privacy proves to be too elusive and conceptual to implement in an automated system (Van Heerde 2010).



**Figure 1:** The information value chain (IVC) (Van Bussel, 2012ab) (Open circles: Start of stage, privacy-audit necessary)

		Privacy Criterion								
		Reporting of processing	Transparent processing	'As required' processing	Lawful basis for data processing	Data quality conservation	Rights of the parties involved	Data traffic with countries outside EU	Processing personal data by processor	Protection against loss and unlawful processing of personal data
Information Security	Availability									
	Confidentiality									
	Integrity									

	Very strongly related		Weakly related
	Strongly related		Not related
	Moderately related		

**Table 1:** PISA information security vs privacy (Borking 2010, p 68)

## 6. Building privacy-sensitive ICT systems

If information security measures implemented by organisations do not lead to privacy compliance, other measures need to be considered. In order for an information system to be privacy-compliant, the system development process must pay attention to the elements that may constitute a privacy hazard in an ICT. In this paper, we assume that there is no fundamental difference in system development methodology in public and in private environments. System development methodology is, so to speak, generic in character. Spiekermann and Cranor (2009) provide an integrated overview of methods and techniques available to provide systems under construction with proper privacy compliance. They make a distinction between Privacy-by-architecture and Privacy-by-Policy.

Privacy-by-architecture aims at intervening in the earliest possible stage in a system development project, minimising collection of personal data and implementing technologies that anonymize and protect data during the information life cycle. This means that the system architect analyzes the possible breaches of privacy once the system is delivered and takes proper precautions against it in the drawing board stage. The resulting blueprint for the system should contain specifications in the form of well-defined rules and procedures. That way, a system developer can avert the pitfalls of programming functionalities that inadvertently may breach future users' privacy. Privacy-by-design, in this classification, forms a sub-part of privacy-by-architecture. One of the results of privacy-by-architecture is the conceptual testing and development of Privacy Enhancing Technologies (PETs), that allow for implementation of privacy-compliance in ICTs. PETs have been studied extensively (Wolfe 1997; Seničar et al, 2003; Phillips, 2004; Borking, 2010; Van Heerde, 2010; Zeng, et al, 2013; Kwecka et al, 2014). Van Heerde (2010) shows the possibilities of privacy aware data management, that aims at limiting potential damages caused by a breach of data security by meticulously managing the data stored in ICTs. He concludes that it is 'possible to reason about retention periods so that not only service providers, but also users of those services will be satisfied' (Van Heerde, 2010: 152). The proposed solution is that after the primary use of information, data precision is decreased automatically in interdependent stages, ultimately to degrade the data in an irreversible way (Van Heerde, 2010: 150). Van Heerde points towards five different possible ways of implementing data degradation techniques: service-oriented, ability-oriented, user-oriented, upgradable, and external data degradation. User-oriented data degradation is the only one putting the citizen in charge of the process of data retention, all other options imply built-in system functionality. With the exception of external data degradation, the techniques discussed by Van Heerde all rely on a single point of interaction. The techniques of data degradation may be a solution to privacy issues in these "monolithic", "one point of interaction" ICTs, because the entire life cycle of information is managed within the system itself. However elegant this method of system development may seem, the fundamental problem remains, that the system architect must be able to predict all possibilities for privacy breaches that will, can, may or even might ensue during the entire life-time of a system. Given the rapid developments in information technology, this level of overview must be classified as highly improbable. Besides that, the result of Privacy-by-Architecture will be that the user has no say whatsoever about his or her personal information, which will be seen as a very unwelcome outcome by a majority of citizens (Spiekermann and Cranor, 2009: 77).

"Notice and choice" is central to Privacy-by-Policy, the second concept distinguished by Spiekermann and Cranor. This approach aims at providing information to users about the information processes the organisation executes, in the form of privacy policies, notices and notifications. Moreover, users themselves are allowed to make proper choices on the primary and secondary uses of their data by the organization. These "choice and consent" centred policies are common practice in information services today. Spiekermann and Cranor (2009) point out that multiple problems are connected with this approach. The most obvious being the application of notoriously incomprehensible and extremely extensive privacy policy documents that are close to illegible to the vast majority of users. It is, however, the most popular privacy-approach to date, because it does not interfere with business models that rely on extensive use of personal information.

## 7. Providing privacy in an era of "cloud" and "big data"

The massive application of supply chain and ERP systems, leading to information integration across organizations (Srinivasan and Dey, 2014), turned data silos into data nodes in networked environments. Further stimulated by the sharing of information through social media (McAfee, 2006), data ownership can hardly be claimed anymore. In networked environments the problem of privacy compliance thus gets more complicated, as private information is exposed to covert acquisitions without the owner's knowledge or consent. It is predicted that users will increasingly be victim of significant privacy breaches that are intractable, costly to repair and increase the reluctance to engage (Oyomno et al, 2009). As the majority of data in a mobile world is transported between different ICTs in which different sets of information are stored and processed, no 'single point of entry' to the management and retention of data remains. For those purposes Van Heerde (2010) puts forward external data degradation, but does not elaborate on this solution. In his opinion, external data degradation is achieved by binding degradation policies to data, and make network components degradation-aware. Network switches and routers can check the policy attached to each data item, and block or even remove a data item from the stream if it does not comply with the degradation policy. Zeng et al. (2013) have tested a working proof-of-concept prototype of this kind of PET on user data in 'the cloud'. Their Self Destructing Data System (SeDaS) protects data from attackers who retroactively obtain, through legal or other means, a user's stored data and private decryption keys. The prototype irreversibly

destroys sensitive information, such as account numbers, passwords and notes, without any action on the user's part.

Martinez-Ballesté et al (2013) add a holistic approach to the issue of privacy protection in networked environments, necessary because of the emergence of smart cities, that can only be achieved if massive amounts of information about individual citizens, their movements and their lives are harvested and processed. In smart cities, information-driven technologies are being applied to enhance effectivity and efficiency of transportation, energy, sustainability, e-governance, economy and communications, with many new, as yet inconceivable services expected to be developed in the near future. The privacy-corrosive potential of these "smart city" technologies is acknowledge, and Martinez-Ballesté et al list technologies available today to mitigate these negative effects: pseudonymizers, RFID privacy techniques, privacy-aware video surveillance, private information retrieval techniques, location masking, cloaking, anonymization, statistical disclosure control and privacy-preserving data mining. In addition, a likewise promising concept has been developed in Van Blarckom et al (2003), who provide seven principles of PET: limitation in the collection of personal data; identification, authentication, authorisation; standard techniques used for privacy protection; pseudo-identity; encryption; biometrics; and auditability. These principles can be associated with the Common Criteria (CC) for Information Technology Security Evaluation (ISO/IEC 15408, 2009). A final method worth mentioning to protect users' privacy is making use of a trusted third party, operating as an "identity protector" (IDP), which allows for privacy-aware fulfillment of the IVC. Borking (2010) shows the workings of this IDP in the technological environment of an ICT, by which he provides an overview of privacy-aware processing of data. Table 2 shows our combination of both PET principles and CC with the technologies mentioned.

CC	PET Principles	Technological Solutions
Security / Privacy Audit	Audit Ability	
Communication	Encryption	RFID privacy techniques
Cryptographic Support	Encryption	RFID privacy techniques
User Data Protection	Limitation in the collection Identification, authentication, authorization Standard Techniques	anonymisation cloaking location masking private information retrieval techniques privacy-aware video surveillance privacy-preserving data mining statistical disclosure control
Identification and Authentication	Identification, authentication, authorization Biometrics	anonymization cloaking location masking privacy-preserving data mining private information retrieval techniques statistical disclosure control
Security Management		
Privacy		
Anonymity	Standard Techniques	anonymization privacy-aware video surveillance privacy-preserving data mining private information retrieval techniques statistical disclosure control
Pseudonymity	Pseudo-identity	Pseudonymizers
Unlinkability	Standard Techniques	anonymization cloaking location masking statistical disclosure control
Unobservability	Standard Techniques	privacy-preserving data mining private information retrieval techniques

**Table 2:** PET principles, CC and technological solutions

Although the technologies are available, and in most cases even in place, many of those technologies are not applied to protect the privacy of citizens (Martinez-Ballesté et al, 2013). This conclusion is in line with Mayer-Schönberger and Cukier (2013), who state that providing proper privacy to citizens in an age of ubiquitous computing and Big Data remains to be a mind-bending problem. Traditional methods for privacy-safeguarding are no longer feasible. Mayer-Schönberger and Cukier (2013) propose privacy assessments, backed up by real authority that may impose the rule of privacy law on the organizations reaping the (huge) benefits of Big Data analysis. The assessments' workings revolve around a formal assessment, that offers tangible benefits to service providers: they will be free to pursue secondary uses of personal data in many instances without having to go back to individuals to get their explicit consent. Implementing these assessments based on the IVC and the six steps therein to be audited could minimize privacy breaches. Table 2 indicates that this proposal for privacy assessments is correct. As neither Spiekermann and Cranor (2009) nor Monreale et al (2014) give any guarantee that PET (especially in Smart City and Big Data environments) will save citizen's privacy, it is possible that audits are the only methodology left that might work.

## 8. Discussion: will it work?

Service providers are not completely 'free' in their actions. The environment in which they operate is changing rapidly, because of massive transformation of business models. Since the breakthrough of social media services, more emphasis has been laid on the exploitation of personal information of system users. But at the same time, social media users provide information about people in their personal environment, thereby unwittingly disclosing information that may be of a highly sensitive nature. The use of cloud environments and predictive analytics undo the privacy protection that PET aim to provide. Service providers require personalisation of services to meet users' demands, and this makes return on investment in cyberspace utterly dependent on harvesting and processing huge amounts of personal data. Sensitive information is instrumental to the success of the internet companies. Without the obligation for users to give up their informational privacy, few current business models would remain profitable. Privacy rules and regulations pose a serious threat to the business models of internet companies like Google, Apple, Microsoft and Amazon, whose accumulated billions of dollars make them powerful forces to be reckoned with.

The emphasis on ICT as the solution to possible privacy issues, however, forgoes the notion that this may not solve the entire problem, as social and cultural aspects are inextricably intertwined in the privacy experience of users. Given the conditional and personal factors that defy modelling privacy-enhancing services at a sufficiently detailed level, reinstating some form of negotiation regarding consent to information processing in cloud environments is an idea worth pursuing.

Privacy-aware information management forms a major problem for all parties involved: citizens, information processing organizations and legislators. With the movement from 'ownership-oriented' ICTs to service-oriented 'cloud' environments, finding the right entity that is able to solve privacy issues has become close to impossible. PET allow for legal and technological aspects to be relatively well-attended, but can do so only in isolated parts of the IVC. In real life situations, responsibility rests for some part on assignable actors like the user and the recipient, but may also be shared between parties. Having applied privacy-by-design or privacy-by-architecture procedures and methods does therefore not cover the subject sufficiently and completely. This may be due to the fact that development methods by definition cannot address the inextricable key aspect of privacy, that is found in the sense of control individual subjects have over who may or may not access information about themselves. Looking at the meaning of the term in the social and cultural environment that the subject lives in, it becomes clear that real-life-interactions regarding the sharing of privacy-sensitive information defy proper modelling, because of the highly contextual and volatile character that define social interactions. It may well be concluded that privacy is so inconclusive and implicit that 'a computer' may not be able to grasp the subtleties that are connected to the concept in real life. That may exonerate system developers, by asserting that developing a system that will solve all possible privacy problems by technology alone, is not feasible given the current state of technology.

Maybe we should stop talking about "privacy-aware" systems, as the best we seem to be able to do is developing "access-aware" or "privacy-audited" systems, most of which have not left the proof of concept stage yet. Facing the fact of the current unlevel playing field might be a first step towards true "informed consent", instead of yielding to the "blind trust" systems that are giving citizens almost no control on who may access, process and disclose sensitive and confidential personal information.



## 9. Conclusion and further research

In our view “Intuitive” privacy and ICT privacy policies are clearly at odds, but legislators, service providers and the general public concur in valuing privacy as essential to acceptance of information technology-based services. Providing proper privacy to citizens is therefore no matter of small concern. Making clear to all parties involved that their respective responsibilities cannot be delegated to ICTs is crucial. Governmental, service providers’ and citizens’ concerns should be properly addressed to retain the privacy levels that form the essence of civil liberties and maintain freedom in society. To create a truly privacy-aware IVC, a holistic approach is needed in finding methods to shift control over information back towards the citizen. Taking the IVC from a citizen’s perspective as a starting point would allow for a first step towards a true impact analysis of ICTs on what is considered a building block of free societies.

## References

- Allen, A.L. (2011) *Unpopular privacy. What must we hide?*, Oxford: Oxford University Press.
- Borking, J. (2010) *Privacyrecht is code. Over het gebruik van Privacy Enhancing Technologies*, Deventer: Kluwer.
- Coles-Kemp, L. and Kani-Zabihi, E. (2010) ‘On-line privacy and consent: a dialogue, not a monologue’, *Proceedings of NSPW’10*, Concord (MA), pp. 95-105
- Conly, S. (2013) *Against autonomy. Justifying coercive paternalism*, Cambridge: Cambridge University Press.
- Davenport, T. H. and Prusak, L. (1997) *Information ecology: Mastering the information and knowledge environment*, New York: Oxford University Press.
- Dawes, S.S. (2008) ‘Governance in the information age: a research framework for an uncertain future’ *Proceedings of the 9<sup>th</sup> annual international digital government research conference, Montreal*, pp. 290-297
- Etzioni, A. (2007) ‘Are new technologies the enemy of privacy?’, *Knowledge, Technology & Policy*, vol. 20, no. 2, pp. 115-119.
- EU (1995) *Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data*, [Online]. Available: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:NOT> (23 May 2015).
- EU (1997) *Directive 97/66/EC of the European Parliament and of the Council of 15 December 1997 concerning the processing of personal data and the protection of privacy in the telecommunications sector*, [Online]. Available: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997L0066:EN:HTML> (23 May 2015).
- EU (2002). *Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and electronic communications)*, [Online]. Available: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0058:en:HTML> (23 May 2015).
- EU (2004) *Privacy Incorporated Software Agent: Building a privacy guardian for the electronic age*, [Online]. Available: [http://cordis.europa.eu/projects/rcn/53640\\_en.html](http://cordis.europa.eu/projects/rcn/53640_en.html) (23 May 2015).
- Flaherty, D. (1989) *Protecting privacy in surveillance societies. The federal republic of Germany, Sweden, France, Canada, and the United States*, Chapel Hill: The University of North Carolina Press.
- Haller, K. (2012) ‘Data-Privacy Assessments for Application Landscapes: A Methodology’, In Daniel, F., Barkaoui, K., and Dustdar, S. (eds.), *Business Process Management Workshops*, 2, Vol. 100 (Lecture Notes in Business Information Processing), pp 398-410.
- Hofstetter, Y (2014), *Sie wissen alles. Wie intelligente Maschinen in unser Leben eindringen und warum wir für unsere Freiheit kämpfen müssen*, München: C. Bertelsmann Verlag,
- ISO/IEC 15408-1 (2009) *Information technology -- Security techniques -- Evaluation criteria for IT security -- Part 1: Introduction and general model*, Geneva: ISO.
- Kosinski, M., Stillwell, D. and Graepel, T. (2013) ‘Private traits and attributes are predictable from digital records of human behavior’, *Proceedings of the National Academy of Sciences*, vol. 110, no. 15, pp. 5802-5805.
- Kost, M. and Freytag, J-C. (2012) ‘Privacy analysis using ontologies’, *CODASPY 12 Proceedings of the Second ACM Conference on Data and Application Security and Privacy*, ACM, pp. 205-216
- Kwecka, Z., Buchanan, W., Schafer, B. and Rauhofer, J. (2014) ‘I am Spartacus’: privacy enhancing technologies, collaborative obfuscation and privacy as a public good’, *Artificial Intelligence and Law* (2014), pp. 1-27.
- Lahlou, S., Langheinrich, M. and Röcker, C. (2005) ‘Privacy and trust issues with invisible computers’, *Communications of the ACM*, vol. 48, no. 3, pp. 59-60.
- Leese, M. (2013) ‘Blurring the dimensions of privacy? Law enforcement and trusted traveler programs’, *Computer Law & Security Review*, vol. 29, no. 5, pp. 480-490.
- Lessig, L. (2006) *Code, version 2.0.*, New York: Basic Books.
- Lopez, B. (2010) ‘Privacy rights in the age of street view’, *SIGCAS Computers and society*, vol. 40, no. 4, pp. 62-69
- Martínez-Ballesté, A., Pérez-Martínez, P. A., and Solanas, A. (2013) ‘The Pursuit of Citizens’ Privacy: A Privacy-Aware Smart City Is Possible’, *IEEE Communications Magazine*, vol. 51, no. 6, pp. 136-141.
- Mayer-Schönberger, V., and Cukier, K. (2013) *Big data. A revolution that will transform how we live, work and think*, London: John Murray.

- McAfee, A. (2006) 'Enterprise 2.0: the dawn of emergent collaboration', *MIT Sloan Management Review*, vol. 47, no. 3, pp. 21-28.
- Morozov, E. (2013) *To save everything, click here. The folly of technical solutionism*, New York: PublicAffairs.
- Monreale, A., Rinzivillo, S., Pratesi, F., Giannotti F. and Pedreschi, D. (2014) 'Privacy by design in big data analytics and social mining', *EPJ Data Science*, vol. 10, pp. 1-26
- Oyomno, W., Jäppinen, P. and Kerttula, E. (2009) 'Privacy implications of context-aware services', *Proceedings of COMSWARE 2009, June 16-19* Dublin, Ireland, pp. 1-9
- Phillips, D. J. (2004) 'Privacy policy and PETs. The influence of policy regimes on the development and social implications of privacy enhancing technologies', *New Media & Society*, vol. 6, no. 6, pp. 691-706.
- Pogue, D. (2011) 'Don't worry about Who's watching', *Scientific American*, vol. 304, no. 1, p. 32.
- Rezgui, A., Bouguettaya, A., and Eltoweissy, M.Y. (2003) 'Privacy on the Web: facts, challenges, and solutions', *IEEE Security & Privacy*, vol. 1, no. 6, pp. 40-49.
- Seničar, V., Jerman-Blažič, B., and Klobučar, T. (2003) 'Privacy-enhancing technologies - approaches and development', *Computer Standards & Interfaces*, vol. 25, nNo. 2, pp. 147-158.
- Solove, D.J. (2004) *The Digital Person. Technology and Privacy in the Information Age*, New York, London: New York University Press.
- Solove, D.J., Rotenberg, M., and Schwartz, P.M. (2006) *Privacy, information, and technology*, New York: Aspen Publishers Online.
- Siegel, E. (2013) *Predictive analytics. The power to predict who will click, buy, lie or die*, Hoboken (NJ): Wiley.
- Spiekermann, S. and Cranor, L.F. (2009) 'Engineering privacy', *IEEE Transactions on software engineering*, vol. 35, no. 1, pp. 67-82
- Sprenger, P. (1999) 'Sun on Privacy: "Get Over It"', *Wired*, [online].  
Available: <http://archive.wired.com/politics/law/news/1999/01/17538> (23 May 2015)
- Srinivasan, M. and Dey, A. (2014) 'Linking ERP and e-Business to a Framework of an Integrated e-Supply Chain'. Martínez-López, F.J. (ed.), *Handbook of Strategic e-Business Management*, Berlin-Heidelberg: Springer, pp. 281-305.
- Thierer, A. (2013) 'Privacy, Security, and Human Dignity in the Digital Age: The Pursuit of Privacy in a World Where Information Control is Failing', *Harvard Journal on Law & Public Policy*, vol. 36, no. 2, pp. 409-455.
- Tsiavos, P., Hosein, I.R., and Whitley, E.A. (2003) 'The footprint of regulation: How information systems are affecting the sources of control in a global economy', Korpela, M., Montealegre, R. and Poulymenakou, A. (eds), *Organizational information systems in the context of globalization*, Deventer: Kluwer, pp. 355-370.
- Van Blarckom, G.W., Borking, J.J., and Olk, J.G.J. (2003) *Handbook of privacy and privacy-enhancing technologies. The case of Intelligent Software Agents*, The Hague: Privacy Incorporated Software Agent (PISA) Consortium.
- Van Bussel, G.J. (2012a) *Archiving should be just like an Apple™ en acht andere, nuttige (?) stellingen*, Amsterdam: Amsterdam University Press.
- Van Bussel, G.J. (2012b) "Reconstructing the Past for Organizational Accountability", *The Electronic Journal of Information Systems Evaluation*, vol. 15, no. 1, pp. 127-137.
- Van Heerde, H. (2010) *Privacy-aware data management by means of data degradation. Making private data less sensitive over time*, Enschede: CTIT Twente University
- Warren, S. and Brandeis, L.D. (1890) 'The right to privacy', *Harvard law review*, vol. 4, no. 5, pp. 193-197.
- Wang, P. and Petrison, L.A. (1993) 'Direct marketing activities and personal privacy. A consumer survey', *Journal of Direct Marketing*, vol. 7, no. 1, pp. 7-19.
- Wolfe, H. B. (1997) 'Privacy enhancing technology', *Computer Fraud & Security*, vol. 1997, no. 10, pp. 11-15.
- Zeng, L., Chen, S., Wei, Q., and Feng, D. (2013) 'SeDas: A Self-Destructing Data System Based on Active Storage Framework', *IEEE Transactions on magnetics*, vol. 49, no. 6, pp. 2548-2554.