Quantifying the Financial Value of Cloud Investments: A Systematic Literature Review

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***Abstract*—The importance of demonstrating the value achieved from IT investments is long established in the Computer Science (CS) and Information Systems (IS) literature. However, emerging technologies such as the ever-changing complex area of cloud computing present new challenges and opportunities for demonstrating how IT investments lead to business value. This paper conducts a multidisciplinary systematic literature review drawing from CS, IS, and Business disciplines to understand the current evidence on the quantification of financial value from cloud computing investments. The study identified 53 articles, which were coded in an analytical framework across six themes (measurement type, costs, benefits, adoption type, actor and service model). Future research directions were presented for each theme. The review highlights the need for multi-disciplinary research which both explores and further develops the conceptualization of value in cloud computing research, and research which investigates how IT value manifests itself across the chain of service provision and in inter-organizational scenarios.**

***Keywords*—Return on Investment; Total Cost of Ownership; Cost-Benefit Analysis; Systematic Literature Review.**

I. Introduction

Over the last five years, interest in digital transformation (DX) has grown dramatically. Whether this is merely a reconstitution of extant literature on information technologies (IT), innovation or something entirely new remains to be seen; however there would seem to be a growing consensus that it relates to a strategic shift in organizations driven by four primary technologies – social media, big data analytics, mobility and cloud computing [1, 2]. Reference [1] predicts that by 2019, nearly 75% of IT spending worldwide, growing at twice the rate of the total IT market, will be spent on such technologies or associated services. As a horizontal technology, cloud computing plays a key enabling role in the success of these building block technologies and emerging combinatory innovations such as the Internet of Things (IoT). There is widespread agreement by industry analysts that cloud computing is here to stay in the foreseeable future with worldwide spending on public cloud services alone forecast to grow to US$203bn – US$483bn by 2020, with a compound annual growth rate of up to 21.5% over the period 2015-2020 [3-5].

Reference [6, p.2] defines cloud computing as: "[…] a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

The essential characteristics of the cloud – i.e. on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service - provide a wide range of technical, operational and strategic benefits to organizations including cost savings and increased mobility, flexibility, productivity and innovation [7]. Despite the wide range of benefits, recent research by [3] suggests that 14% of total spending on cloud by IT decision-makers (representing approximately 13% of customers) is based on lower total cost of ownership (TCO) rather than strategic return-on-investment (ROI). Similarly, a survey of chief financial officers (CFOs) on behalf of Google, suggests that cost savings are a major factor in cloud adoption including costs related to hardware, software, system backup and data recovery and IT labor [8]. Anecdotal evidence suggests that the calculation of the financial value of investments in cloud computing is of interest and importance for both cloud service providers (CSPs) and cloud consumers. There is widespread use of online tools by CSPs for calculating TCO and [9] emphasized the utility of TCO and ROI tools in separating the marketing hype from the reality when making a decision to adopt cloud computing.

It has been long established in IS literature that demonstrating the value of investing in IT is an important contribution of the IS discipline [10]. This paper provides an academic literature review on the quantification of the financial value of investments in cloud computing in order to (1) provide an overview of the research status on the topic, and (2) provide recommendation on how research should proceed. Our study is primarily situated in the IT value research literature as it deals with the economic impacts of IT and its manifestations [11].

The IT variable of interest is cloud computing in its various manifestations (Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS)) and we are concerned with measuring the firm-level IT economic impacts of short-frame endogenous variables with clear causal chains including the measurement of technical optimizations, cloud migration and native cloud adoption.

In line with IS research on IT innovation diffusion and assimilation, we are concerned with firm-level value from the perspective of multiple actors in the wider cloud computing community including CSPs, independent software vendors (ISVs) and organizations seeking to adopt cloud computing. We recognize that IT decision makers may have a systems provider and/or a technology leader profile and therefore may represent a cost or investment center [12]. Following [13], we pursue both an interdisciplinary and multidisciplinary approach to our study reflecting the tapestry of cloud computing adoption decision-making. As such, we review IS, computer science, and business literature relating to cloud computing to maximize the quality, relevance and contribution of our research to each discipline. We present our

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review as an analysis of the literature by discipline type and include both descriptive and a multi-level thematic analysis.

The remainder of the paper is structured as follows. The next section describes the methodology and framework adopted to guide this literature review. It is followed by a descriptive analysis of the literature on the topic of quantifying financial value from investments in cloud computing covering the eight-year period from 2009 to 2016. Then, a thematic analysis of the topic is presented with suggestions for future research. The paper concludes by summarizing our findings and the limitations of this paper.

II. Research Methodology

The objective of this systematic literature review is to present an integrated overview of academic literature on the quantification of the financial value of investments in cloud computing and inform future research both in IS, CS, and other business research. In general, the literature review follows the guidelines and steps provided in [14]. Our literature review is articulated in two phases: (i) data scoping and collection, and (ii) analysis comprising both descriptive analysis, and thematic analysis.

Four repositories were identified in the target fields, namely: IEEE Xplore, ACM, Web of Science and Scopus. Due to the IS focus of this paper, we also included the IS Senior Scholars' Basket of Eight journals and the AIS Electronic Library (AISeL) to ensure high quality IS journals and conferences were included. A number of boundary conditions were imposed on the review. The literature search was limited to cloud computing, three measurement types – i.e. TCO, cost benefit analysis (CBA) and ROI –, and two adoption types (cloud adoption and cloud migration). Return on Management, and Boundary Values and Spending Ratios were discounted for this review because of the less deep level of analysis required by these methods [15]. Information economics was discounted for its limited use in practice mostly due to its complexity and subjectivity [16]. To validate this decision, a preliminary search of the target repositories was conducted with the phrase 'cloud computing' AND key terms for return on management, boundary values, spending ratios and information economics; no results were identified. As such, the search was limited to publications that included the term 'cloud computing' AND any of the following terms or phrases or associated ones – 'total cost of ownership', 'TCO', 'cost optimization', 'cost benefit analysis', 'CBA', 'return on investment', 'ROI', 'cloud adoption', and 'cloud migration'. Our initial search yielded 621 publications on the topic from 2009-2016. Books, PhD theses and industry publications were excluded. Articles were further scrutinized by 5 reviewers with two reviewers independently reviewing each paper and a final list was produced with 53 relevant articles. Papers were primarily omitted on the grounds that their main focus (i) was not concerned with the quantification of an economic value, or (ii) there was no causal chain between the variable being examined and the economic impact. Papers were only included where the original sources could be downloaded. A large proportion of computer science papers were omitted on the grounds of poor quality or discrepancies between the stated measurement objective and the methodology conducted.

A thematic analysis was conducted using a taxonomy of cloud computing, measurement type, adoption type, and actor perspective. The taxonomic analysis was based on the six elements identified by [17] i.e. architecture, services, virtualization management, fault tolerance, security and other elements. As discussed, measurement types were limited to TCO, CBA and ROI. Benefits were coded as either tangible or intangible; costs were coded as upfront, recurring, or termination costs [9]. Adoption types included native adoption or migration from a legacy system to the cloud. Actor perspective was coded against the five actors identified in the NIST Cloud Computing Reference Architecture – cloud consumer, cloud provider, cloud auditor, cloud broker and cloud carrier [18]. Once the final selection of publications was identified, two researchers, independently of each other reviewed each paper, to assign them into the various categories. The research team included IS, computer science and business researchers. There were two key considerations for a multi-disciplinary team: (i) to enable the observation of a holistic trend in the academic literature on the topic, and (ii) make contributions to both IS and computer science disciplines with regards to future research by identifying research gaps.

III. Descriptive Analysis and Discussion

The final publication dataset resulting from the literature search process comprised 53 papers (Table I) from 49 discrete journals (14) or conferences (35) (Table II). The overwhelming majority of publications identified were from computer science. This is somewhat surprising given the economic context of the study and the search criteria employed. However, as will be discussed in the thematic analysis, the prevalence of computer science studies can be explained by the focus on IaaS and emphasis on relatively simplistic tangible operational cost calculations. Only 10 publications were from IS or other business disciplines and were sourced from Scopus. The wide distribution of discrete publication outlets is interesting as there may be many possible explanations. For instance, a research community may not be developing this area, there may be a lack of interest, or other disincentives such as the complexity of the topic or issues with data access.

Fig. 1 and 2 present a visualization of the number of publications by year. This is consistent with other systematic literature reviews related to cloud computing. For example, [19] identified similar trends commencing in 2009 and rising consistently over the period. It is too early to tell whether the publications in 2015 represent the beginning of a new stream of research or an outlier. The majority of the publications were found in conference proceedings, however the temporal analysis also shows a growing number of journal publications.

TABLE I FREQUENCY DISTRIBUTION OF THE PUBLICATIONS BY DISCIPLINE

Discipline Type	# of Publications	% of Publications
Computer Science	42	79%
Information Systems	10	19%
Other Business	1	2%
Total	53	100%

TABLE II FREQUENCY DISTRIBUTION OF THE PUBLICATIONS BY SOURCE AND PUBLICATION OUTLET TYPE

Database	# of Publications	#of Journals	# of Conferences
IEEE	29	2	25
ACM	13	7	6
Scopus	11	5	4
Total	53	14	35

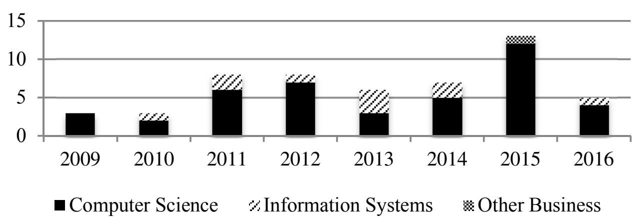

Fig. 1 Frequency of Publication Discipline By Year

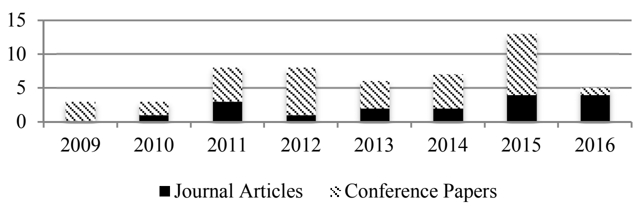

Fig. 2 Frequency of Outlet Type By Year

The majority of research reviewed was empirical however this is skewed by the computer science research which was substantially based on experimentation. Examples of empirical analysis are [20], who present a methodology for the cost optimization of IaaS application, and [21], who present a cloud computing brokerage model to identify the most cost-efficient tariff for IaaS services. Examples of non-empirical analysis are [22], who present a general mathematical model for ROI estimation, and [23], who propose a taxonomy of the costs associated with application migration to the cloud. Table III summarizes the literature by discipline and research evidence type.

TABLE III FREQUENCY DISTRIBUTION OF PUBLICATIONS BY EVIDENCE TYPE

Discipline Type	Empirical		Non-Empirical		Total	
	#	%	#	%	#	%
Computer Science	34	64	8	15	42	79
Information Systems	7	13	3	6	10	19
Other Business	0	0	1	2	1	2
Total	41	77	12	23	53	100

IV. THEMATIC ANALYSIS AND DISCUSSION

A thematic analysis was conducted using a taxonomy of cloud computing, measurement type, adoption type, and actor perspective.

This taxonomic analysis of the literature was conducted based on [17] and is presented in Table IV. By architecture, [17] refer to one of three cloud service deployment models i.e. public, private, hybrid (and federated) or other e.g. community cloud. The majority of papers dealt with public cloud use cases or the architecture case remained unstated. This is unsurprising in the computer science literature where granular innovations can apply to public, private, community and other clouds. However, in many cases, unstated may be interpreted, mistakenly or otherwise, as public cloud. There is a need for researchers to state clearly whether their research applies to one, multiple or all service deployment types as the business and economic model underpinning these are substantially different and thus may result in different IT value. A number of papers presented integrated frameworks for calculating ROI for all deployment models [24] or considered both public and private clouds [25-28]. One paper, [29] dealt with Business Process as a Service, a relatively niche deployment model often categorized as SaaS [30].

TABLE IV TAXONOMIC ANALYSIS OF LITERATURE

Category	Topic	References
Architecture	Public	[23-29, 31-48]
	Private	[24-28]
	Hybrid or Federated	[24, 49-52]
	Unstated	[18, 20-21, 53-68]
Virtualisation Management	Resource Provisioning	[44, 48, 69]
	Resource Scheduling	[20, 39, 43, 54, 60-63, 67-68]
	Resource Monitoring	[55]
	VM Placement	[50, 58, 65]
	VM Migration	[28, 49, 52]
Fault Tolerance	Other	-
Security	Security	[70]
Other	Other	[18, 21, 31, 37-38, 42, 47, 51, 53, 56-57]
Services	IaaS	[18, 20-23, 25, 28, 31-33, 36-40, 43-45, 47-51, 52-58, 60-63, 65, 67-72]
	PaaS	[23, 72]
	SaaS	[41-42, 46, 64, 66]
	Other	[24, 26-27, 29, 59]

Note: Taxonomic analysis based on [17]

Reference [17] defines virtualization management as any activity related to the abstraction of logical resources away from their underlying physical resources. Analysis of papers using this lens provides a greater understanding of the IT artifacts being examined. 18 of the 53 papers analyzed were coded as being from high-level architectural perspective i.e. at the cloud computing level. The remaining 35 papers focused on low level IT artifacts. These primarily deal with aspects of virtualization management including resource provisioning (3), resource scheduling (13), resource monitoring (1), VM placement (3) and VM migration (3), security (1) and other (11). No specific papers on fault tolerance as the primary artifact or theme were identified. The other category includes a variety of studies including the impact on cost and ROI from trade-offs between compute and storage [31], techniques such as control flow paths [56], different types of hardware e.g. gateways [53] as well as various use cases such as database-as-a-service [42] and brokers [21]. It is important to note that such technical papers have been included in this review because the authors of each paper can demonstrate or posit clear causal links between either cost optimization or revenue maximization and as such are relevant in the context of the business value of IT literature. The granularity of computer science research provides the opportunity to reimagine IT business value research by focusing on sub-system technical strategies and IT innovations at an extremely low level of granularity in a solution stack. In this case, cloud computing provided such artifacts that can be clearly linked across the causal chain to economic factors. As a handful of cloud service providers account for over 63% of the public cloud services market [73], the implementation of such sub-system IT innovations may have a disproportionate impact on system performance and cost efficiency. As a result, it may be worthwhile considering the need for not only firm-level IT value but system-level, or even sub-system-level IT-value, where such value is generated in interstices between actor groups as opposed to in isolation. In such a case, in addition to the more practical approaches to value quantification discussed above, there may be a need to develop contingency models of popular methods (e.g. TCO, ROI and CBA) and to encourage validation and modification for different use cases e.g. actor perspective, firm- and system-level scenarios, native vs. migration scenarios, service models (IaaS, PaaS, SaaS), and deployment models (public, private, hybrid and community). For example, ROI is very different for cloud startups than large enterprises as the former are heavily subsidized in their early growth.

The results of the taxonomic analysis by service model suggest an emphasis on IaaS research. Again, this is consistent with other results as the workings of IaaS are well-understood, more replicable in a lab or through simulation, more comparable with legacy solutions, and relatively more transparent. Previously, it was suggested that system development methods and by inference such sub-system-level innovation focusing on early parts of long causal chain would not satisfy the requirement in IT value research [11]. However, many of the sub-level innovations identified in this review do include early stage endogenous variables with clearer causal chain linkage between the endogenous variable (e.g. virtual machine allocation), and an economic impact (e.g. lower energy costs). In contrast, as you move up the cloud computing service stack, primarily due to the chain of service provision, heterogeneity and complexity increase, as does opacity. As a result, isolating the impact of one variable becomes increasingly difficult and this represents a disincentive for research. This may explain the lack of cloud computing research in the IT value literature and represents a significant gap in research for both computer scientists and IS researchers. While computer science researchers may be accused of being too granular, the same cannot be said of IS researchers. A separate but related and aforementioned issue, primarily in IS and other business research, is the conflation of all deployment levels as “the cloud”. Again, such generalizations merely conflate research and thus provide potentially misleading findings but certainly un-nuanced ones. The focus on IaaS research also affects potential generalizability and impact. The number of IaaS cloud service providers is relatively small; the public cloud, in particular, is dominated by Amazon Web Services, Microsoft, Google and IBM [73].

The analysis of measurement types reflects the anecdotal evidence reported from the marketplace with regards to TCO. Table V shows that 70% of publications (37) employed or referenced some form of TCO measurement followed by 19% (10) for CBA and 11% (6) for ROI. This can be explained by the technological focus of the computer science research, the relative simplicity of TCO calculation, and anecdotal popularity, and thus familiarity, of TCO in the wider cloud and IT sector generally. Surprisingly, no ROI studies on cloud computing were found in the IS literature review and only limited cost benefit analyses. The use of relatively simplistic calculative techniques raises the potential need for greater training for computer scientists in such methodologies, more multidisciplinary researchers, more interdisciplinary research or more practical approaches to calculating value.

TABLE V FREQUENCY DISTRIBUTION OF PUBLICATIONS BY MEASUREMENT TYPE

Discipline Type	TCO		CBA		ROI		Total	
	#	%	#	%	#	%	#	%
Computer Science	30	57	7	13	5	9	42	79
Information Systems	7	13	2	4	1	2	10	19
Other Business	0	0	1	2	0	0	1	2
Total	37	70	10	19	6	11	53	100

TABLE VI PUBLICATIONS BY MEASUREMENT TYPE

Discipline Type	References
TCO	
Computer Science	[18, 25-26, 28-29, 32, 34, 37-40, 43-44, 48, 50-59, 61, 63, 65. 67, 71, 74-75]
Information Systems	[21, 23-24, 33, 35, 46, 49, 69]
Other Business	
CBA	
Computer Science	[20, 23, 31, 36, 47, 60, 62]
Information Systems	[41, 66]
Other Business	[27]
ROI	
Computer Science	[42, 45, 64. 70, 72]
Information Systems	[22]
Other Business	

The most concerning aspect of the literature review with regards to measurement type does not surface from mere tabulation. Our research uncovered that there are significant methodological flaws in approaches to TCO, ROI and CBA, particularly in the computer science literature. Operational costs tend to focus on one or more dominant economic impact e.g. energy costs and largely focus on a small number of contributory factors to those costs. The overwhelming emphasis in research for each of the three methods examined was on recurring costs and upfront costs to a much lesser extent. No research was identified on termination costs which is surprising given reported concerns regarding vendor lock-in and off-boarding costs [7]. Further examination of the termination phase in cloud computing and associated decision-making could be fruitful from an inter-organizational perspective examining such themes as (dis)incentives and bargaining power, but also the destruction of IT value. Operationalization of benefits is poorly done generally, and with regards to intangible benefits, not done at all. This highlights an opportunity and a challenge for computer science, IS and wider business researchers to work together so that practice can benefit from this intellectual effort. In addition, it potentially opens up the opportunity to revisit the extant research base on business IT value and to explore the need to renovate extant theory and findings in the context of digital transformation.

A key insight from this analysis is the overwhelming focus by both CS and IS researchers on direct operational costs which were considered in all the publications. Most research focuses on the recurring costs (savings) compared to on-premise or colocation to a lesser degree. Many of the researchers conflate all costs rather than distinguish between different cost types. In contrast, benefits are not addressed to the same extent as costs and, where addressed, is focused on tangible operational benefits linked to the direct operational costs that can be estimated by experimentation in computer science research. The quantification of the organizational benefits of cloud computing adoption, are addressed by a very small selection of research and represents a significant gap in both IS and wider business research. This reductive approach to value measurement in financial outcomes may be a reflection of the early stages of cloud computing research and the emphasis on computer science papers in the dataset.

A clear relationship can be identified between the measurement methods selected in the research and the cloud adoption types researched. Table VII shows that 68% (38) of papers analyzed for migrations from on-premise or colocation to a lesser degree. Migration research is attractive as the cost items are easier to compare; further data on on-premise and co-location hosting is accessible and easy to simulate or replicate in experiments. Notwithstanding this, there has been significant work done in the area of migration patterns and such research suggests a need for different measurement approaches for different migration patterns [76-78].

TABLE VII FREQUENCY DISTRIBUTION OF PUBLICATIONS BY ADOPTION TYPE

Discipline Type	Native		Migration		Total	
	#	%	#	%	#	%
Computer Science	12	23	30	57	42	79
Information Systems	4	8	6	11	10	19
Other Business	1	2	0	0	1	2
Total	17	32	36	68	53	100

Table VIII presents the findings for actor perspective. Five actors were identified in the literature – cloud consumers (26), cloud providers (20), cloud brokers (2), cloud carriers (4) and cloud auditors (1). Again these are related and help explain earlier findings in relation to measurement type and cost focus. Most research focuses on the perspectives of actor roles and relationships being binary – supply or demand. There would seem to be significant research potential in the wider roles and particularly for cross-sectional analyses by actor type. For example, only one study focused on resource metering and the use of verifiable metering by cloud auditors and cloud consumers to reduce costs [55].

TABLE VIII FREQUENCY DISTRIBUTION OF PUBLICATIONS BY ACTOR PERSPECTIVES

Discipline Type	CCo		CP		CB	
	#	%	#	%	#	%
Computer Science	9	35	6	23	0	0
Information Systems	17	65	14	54	2	8
Other Business	0	0	0	0	0	0
Total	26	49	20	38	2	4
	CCa		CA		Total	
	#	%	#	%	#	%
Computer Science	2	8	0	0	17	32
Information Systems	2	8	1	4	36	68
Other Business	0	0	0	0	0	0
Total	4	8	1	2	53	100

Note: CCo – Cloud Consumer; CP – Cloud Provider; CB – Cloud Broker; CCa– Cloud Carrier; CA – Cloud Auditor.

TABLE IX PUBLICATIONS BY ACTOR PERSPECTIVE

Perspective	References
Cloud Consumer	[22-27, 29, 32-35, 36-38, 40-42, 45-46, 51, 55*, 56*, 59*, 61, 64, 66, 70, 72]
Cloud Provider	[18, 20, 28, 31, 39, 43-44, 47-49, 52 53*, 50, 54, 56*, 57*, 58, 59*, 61-63, 65, 67*, 68-69, 71*]
Cloud Broker	[21, 59*]
Cloud Carrier	[53*; 57*, 67*, 71*]
Cloud Auditor	[55*]

*Note: *Multi-perspective*

Not everything is black and white, or rather blue and white, in the cloud and actors do not fall neatly in to boxes and some influential actors are not recognized particularly well at all e.g. independent software vendors (ISVs) and Systems Integrators (SIs). In addition, actors may play multiple roles. For example, cloud providers are also ISVs, cloud consumers and increasingly cloud brokers [19]; similarly, ISVs are both cloud providers and cloud consumers. Further research which seeks to understand the interplay between different actor types and how they collaborate to achieve IT value could provide some much needed insights not only into how these actors overlap but the causal links between IT investments and co-creation of IT based value and value expansion [11].

Current research avoids this complexity, and therefore the reality and nuances of the chain of service provision, how IT value manifests itself in this chain, and the roles organizations play in the wider cloud computing ecosystem. For example, Oracle is an ISV and has engaged in a form of domain extension, like Microsoft and IBM, in to an adjacent domain i.e. cloud service provision. In this domain, it also makes use of other cloud service providers and ISVs further up the chain of service provision who have specialist services. For example, Oracle is one of Microsoft's largest customers/partners on the Microsoft Azure Marketplace while also being one of its main competitors. This aspect of cloud computing, namely the chain of service provision, as well as hybrid and community cloud deployment models, cloud service brokerage and multi-cloud scenarios lend themselves neatly to contributions on inter-organizational theories of IT value and co-creation of business value.

VI. Conclusion and Limitations of Research

This paper sought out to explore and present an overview of academic literature on the quantification of the financial value of investments in cloud computing and inform future research both in IS and computer science research. A systematic literature review was designed and conducted identifying 53 discrete publications. In the absence of an existing framework for analyzing the quantification of IT value in cloud computing, we developed an analytical framework that allowed for interrogation of the same topic from two very different research traditions. This review clearly identified a number of gaps in the literature that could prove fruitful for future research in both IS and computer science. In each of the six thematic analyses (measurement type, costs, benefits, adoption type, actor and service model), gaps and avenues for future research were identified. At a higher level, a number of future avenues for research were highlighted including the development and validation of contingency models for cloud computing value quantification and more balanced application of different, more complete and more robust IT value measurement approaches with a particular greater emphasis on intangible costs and benefits. Against the backdrop of the digital transformation narrative, it may be timely for the IS community to review the IT value research base and evaluate the need for renovation. From a methodological perspective, it would be worthwhile to develop a cross-mapping for IS and computer science research to promote greater standardization and comparability of methodology, theory and findings.

This review illustrates the need for a more systematic approach to build a more authoritative and consistent body of research on IT value quantification for cloud computing. The 53 publications reviewed were published in 49 different outlets, 14 journals and 35 conferences. Associations, editorial and conference committees need to consider whether specific initiatives are required to address some of the gaps identified in this review. Given the investment organizations will make in DX projects in the coming years, the research community need to consider similar initiatives for each of the other so-called pillars of the third IT platform – social (and not just social media), mobile and big data analytics – but also emerging accelerator technologies such as IoT, artificial intelligence (AI), cognitive computing, and virtual reality.

Literature reviews are inherently selective and limited in scope and reach; such limitations are further exacerbated by limitations on page length by conferences and journals. A substantial volume of data was collected however page limitations did not allow for a fuller presentation of cross-sectional analysis by actor perspective or other lenses. For example, it would potentially be interesting to classify the research collected by IT profile, function or contingency factors as per [12]. The content reviewed in this paper is limited to a topic, cloud computing, that is both relatively new and changing rapidly. Similarly, we chose to include content from multiple disciplines which have different research traditions and suffer from a form of semantic interoperability – concepts and terms often simply mean different things in computer science literature and IS or business literature. For example, case studies in computer science papers and IS were clearly different. As a result, comparing methodologies proved infeasible however analysis by research evidence provided some insight. We also believe these differences are potential strengths. It is clear that computer science researchers can offer greater nuance to IS or business researchers and vice-versa in the context of cloud computing and the quantification of value. Relatedly, we chose to limit the measurement types to TCO, CBA and ROI, and while the authors are comfortable in this decision, it is clear that there are opportunities to explore the efficacy of other methods and manifestations for measuring IT value in cloud computing [79]. Similarly, within cloud computing, additional analysis on service deployment models (public, private, hybrid, community), multi-cloud scenarios, cloud service brokerage and marketplaces, and emerging service models (e.g. micro-services/containerization and function-as-a-service/serverless computing) may have provided interesting insights but in the case of the latter, it may too early for such a review. While measures were taken to counter subjectivity and bias, multidisciplinary and inter-disciplinary research is restricted by lack of standardization. In particular, judgments were made in the context of quality. Screening by journal quality or author prominence may have resulted in different findings.

In summary, this review highlights a need for greater focus on (i) the expansion of the conceptualization of value in cloud computing research, (ii) how IT value manifests itself across the chain of service provision and in inter-organizational scenarios, and (iii) the need for greater multi- and inter-disciplinary research between IS and computer science researchers and the need to embed IT value concepts in computer science and related disciplines. It is our hope that researchers across the domains of computer science, information systems, and business will leverage this review and begin to address the gaps in current understanding thereby advancing IT value research and providing important practical contributions for those investing in cloud computing.

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