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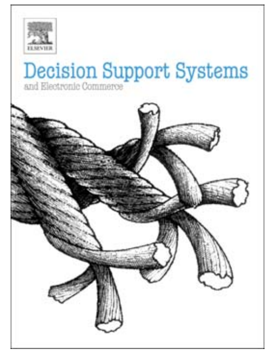

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Cloud Computing and Its Impact on Economic and Environmental Performance: A Transaction Cost Economics Perspective

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Abstract

For many organizations, managing both economic and environmental performance has emerged as a key challenge. Further, with expanding globalization organizations are finding it more difficult to maintain adequate supplier relations to balance both economic and environmental performance initiatives. Drawing on transaction cost economics, this study examines how novel information technology like cloud computing can help firms not only maintain adequate supply chain collaboration, but also balance both economic and environmental performance. We analyze survey data from 247 IT and supply chain professionals using structural equation modeling and partial least squares to verify the robustness of our results. Our analyses yield several interesting findings. First, contrary to other studies we find that collaboration does not necessarily affect environmental performance and only partially mediates the relationship between cloud computing and economic performance. Secondly, the results of our survey provide evidence of the direct effect of cloud computing on both economic and environmental performance.

Keywords: Cloud computing; Collaboration; Economic performance; Environmental performance

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1. Introduction

Optimizing economic and environmental performance initiatives has received increasing attention among researchers and professionals [25, 33, 83]. The increasing need to examine ways to balance and optimize economic and environmental performance is especially prevalent given the emergence of regulatory and market pressures to monitor and reduce the impact of businesses on the natural environment [111]. For example, the U.S. government in the past decade has placed a heightened emphasis on organizations reducing carbon emissions as a way to mitigate global climate change. This has led large organizations, including ExxonMobil, to disclose their carbon emissions data regularly on their websites [31]. Further, consumer groups such as Green America, a U.S. based non-profit, have successfully attempted to persuade consumers to boycott products due to an organization's lack of environmentally friendly production or supply chain operations [101]. These examples illustrate the importance for organizations to manage environmental as well as economic performance. However, current research lacks actual examples of tools and strategies that organizations can use to balance both types of performance.

Some studies suggest that economic and environmental performance can be managed by enhancing relationships among suppliers. Relational capabilities including forging proper incentives, sharing information and setting common goals tend to align behaviors among supply chain partners, thereby leading to greater social and environmental performance [69]. By managing environmental performance a firm can positively enhance aspects of economic performance as well [69]. Ultimately, this may lead to a reciprocal relationship between firms investing greater economic resources in environmental initiatives. However, in order for relationships to enhance both economic and environmental performance, organizations must strategically develop and align technical and relational capabilities. When firms use information technology (IT) to explore and exploit relational opportunities, greater strategic and operational benefits arise [81]. Limited research has been conducted on specific IT like cloud computing, which has benefits associated with not only optimizing relational capabilities between firms, but also increasing economic and environmental performance. The evidence of these benefits have prompted organization to switch from on-premise installations to cloud based services [37].

This study builds on transaction cost economics (TCE) to examine ways in which cloud computing can help firms develop greater relationships within their supply chain networks and how it can directly and indirectly impact economic and environmental performance by reducing transaction costs throughout the supply chain. TCE is driven by the central concept that transactions take place in a context where actors are limited by bounded rationality and must work to make transactions in an economically efficient manner [99, 102]. Economic efficiency refers to the actor's ability to minimize transaction costs as much as possible [105]. We build on TCE to hypothesize the effects of cloud computing on both economic and environmental performance. In addition, we examine the effects of collaboration (via cloud computing) on both economic and environmental performance. We also assess the reciprocal relationship between both economic and environmental performance.

Our study seeks to answer the question of how to enhance both a firm's economic and environmental performance through the use of the cost saving IT cloud computing. Current research in supply chain management suggests that while the majority of literature seeks to answer the question of whether or not environmental initiatives pay, more research is needed to address the question of how to actually enhance environmental performance [67]. To the best of our knowledge this will be one of the first empirical studies to examine cloud computing's direct impact on environmental performance. Further, although some research exists on cloud computing, the majority of this research is conceptual in nature. We wish to provide researchers a theoretically driven model through TCE and empirically validate it through survey evidence. We propose that cloud computing provides a new way of enhancing and balancing not only economic, but environmental performance as well. This also provides researchers an insight into the use of cloud computing to facilitate collaboration.

In addition to our research contributions, we also provide several managerial insights into how cloud computing can be used to reduce transaction risk within the supply chain. First, this study provides supply chain professionals an empirically validated tool to balance both economic and environmental performance initiatives. Second, with increasing supply chain complexity due to globalization it is now more important than ever for organizations to understand how to effectively manage collaboration with their supply chain partners. We provide empirical validation for the effectiveness of cloud computing to enhancing collaboration via enhanced information sharing, goal congruence, incentive alignment, resource sharing, collaborative communication and joint knowledge creation.

This study is structured as follows: first, we describe TCE as well as background literature on cloud computing, collaboration, economic and environmental performance. Then we develop our hypotheses and research model. Subsequently, we detail our methodology and results. Finally, we conclude with a discussion of the results, limitations and directions for future research.

2. Theoretical background

TCE, often associated with Williamson's [102, 104] work, is an empirically supported theoretical paradigm known for analyzing transaction risks among organizations [99]. TCE assumes actors of transactions are limited by "bounded rationality" and are subject to the strategic behavior of others [103]. Bounded rationality suggests that while human behavior is intentionally rational, it is often constrained by the capacity to process and communicate [88, 99]. Due to these constraints actors have a difficult time communicating changes to circumstances surrounding a transaction in advance [104]. They inevitably run the risk that circumstances could change, thus causing problems with information flow between parties. According to TCE, parties need to find ways to reduce transaction complications in an economically efficient manner [105]. Economic efficiency refers to the ability of parties to minimize costs of a transaction so that value is maximized for both parties in comparison with the next best alternative for each party [27].

Over the past few decades TCE has been operationalized and examined through a variety of platforms [80]. These platforms include organizational make-or-buy decisions [9, 57, 59, 106], contractual solutions [64, 99], buyer and supplier relationships [10, 13, 52, 66, 79, 93] and sourcing strategy [32]. As indicated above, our aim in this study is to analyze how cloud computing reduces transaction risks associated with supply chain network collaboration and improves both economic and environmental performance.

Because TCE is driven by the central concept that actors in organizations are limited by bounded rationality, and these actors work to reduce transaction complications in an economically efficient manner, we base our hypotheses on the TCE framework. This explains how the economic efficiency of cloud computing reduces the effects of bounded rationality through cost advantages. More specifically, we build on the components of TCE that are crucial to understanding how cloud computing increases collaboration among organizations, and balances economic and environmental performance through economic efficiency.

3. Literature review

3.1. Cloud computing

Cloud computing is a massively scalable, virtualized IT resource that can be scaled according to the type of service, payment options and privatization. The difference between cloud computing and more traditional IT, is through what is referred to as technology brokering. Technology brokering is the practice of exploiting existing technology efficiencies into one single model [32]. Cloud computing, provides the benefits of traditional in-house IT and web-based IT into one large scale utility model that provides massively scalable service and cost savings attributed to rapid deployment of information, and the reduction of expenditures on in-house data storage. Cloud computing is massively scalable in its service, payment and privatization options. Service options include the widely used software-as-a-service (SaaS) and to a lesser extent platform-as-a-service (PaaS) and infrastructure as a service (IaaS) [19]. Payment options can also be scaled to include elastic or pay-per-minute models or fixed and subscription based pricing. Users can also choose to privatize the cloud with a select few organizational partners or use the public cloud that can be accessed by a variety of users. The scaling options of cloud computing provide various ways that organizations can tailor IT in order to fit service, payment and privatization needs of a variety of different supply chain partners. Further, the allowable hybrid strategies that cloud computing offers has been shown to outperform one service only strategies that web-based IT offers [34].

Perhaps more notable to cloud computing is the potential cost savings it offers organizations. Cloud computing is characterized by rapid deployment of information as well as reduced support infrastructure needs [37, 107, 114]. Rapid deployment of information refers to the capability of organizations to provide supply chain partners with real-time information in large quantities with very little processing time involved. The lack of processing time not only provides users with a fast information sharing capability, but also decreases transaction processing and potentially reduces energy expenditures by processing large amounts of data in a smaller period of time. This allows organizations to become more adaptive and agile [17]. Additionally, cloud computing allows organizations to reduce capital expenditures involved in maintaining individual data centers. Cloud computing stores and processes data with ease of access on a cloud infrastructure either managed by a user or controlled by a third party. The costs involved in organizations maintaining their own data centers far exceeds that of third party management companies.

Cloud computing is currently in its infancy in supply chain management research. Some studies have eluded to various supplier relationship and performance benefits including rapid deployment and on demand access to information [5], massively scalable services [56], and green computing potential [36]. However, the vast majority of this research is conceptual in nature. While some empirical cloud computing studies have been conducted on the adoption of cloud computing [i.e., 107], very little empirical research exists on analyzing cloud computing’s implications with regard to improving collaboration and economic or environmental performance.

In this study we focus on the use and reliance on cloud computing in an organizational context. Specifically, we describe the extent of its use to conduct business transactions with supply chain partners and monitor business processes relative to industry standards and key competitors. We will ultimately assess whether cloud computing positively impacts performance and collaboration.

3.2. Collaboration

Supply chain collaboration is defined as two or more supply chain partners working together toward common goals [10, 60, 90]. This definition of collaboration suggests it is the formation of close, long-term relationships where organizational entities work together to share information, resources and risks for mutual benefit [7]. Moreover, collaboration requires planning of activities [6], integrating cross-functional processes [49], enacting supply chain goals [74], coordinating functions [44] and establishing information sharing parameters [11, 50].

Because of increasing supply chain complexity, there is a need for organizations to enhance efficiency and responsiveness by looking for new ways to collaborate with partners. Firms are continuously working on achieving high levels of collaboration to leverage resources of their suppliers and buyers [51]. This managerial need has propagated a plethora of research in collaboration among supply chain partners. Specifically, current research addresses both the antecedents and consequences of collaboration. Many studies associate high levels of buyer-supplier collaboration with design quality and process efficiency [108], process innovations [96] and reduction in operational costs [39]. Other studies focus on antecedents of goal congruence, complementary capabilities, inter-firm coordination [108] and contractual specificity [109]. However, as mentioned previously, new literature on collaboration continues to use a definition of collaboration that is similar in context to integration and even coordination. Moreover, many studies focus primarily on collaboration as defined by either process focus or relational focus dimensions. The majority emphasize process focused categories while ignoring relational communication and knowledge creation. Their lack of specificity can cause conflicts and misunderstanding between supply chain partners, thus minimizing the fundamental goal of collaboration [11]. In this study we borrow from the Cao and Zhang [11] who define collaboration through both process and relational dimensions including: information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative communication and joint knowledge creations [11].

3.3. Economic and environmental performance

Organizations are facing increasing pressure to enhance not only environmental initiatives, but also economic performance for shareholders [53]. Economic performance is an important driver for organizations that wish to implement environmental initiatives, because economic issues related to costs are often the strongest barriers to implementing those initiatives. Thus, we focus on balancing economic and environmental performance.

Past research incorporates various definitions of economic performance and often uses it interchangeably with the terms “business” or “firm” performance [113]. Unlike many of the previous studies mentioned, this study does not focus on merely aggregate corporate performance dimensions like share price and market share, but on operational level economic and financial performance measurements including sales growth, operating earnings, return on assets and return on investments [110].

In this study we are not only concerned about assessing economic performance, but balancing economic with environmental performance. Many organizations throughout the world face competitive, regulatory and community pressures to balance both economic and environmental performance [92]. As a result, a plethora of research is dedicated to examining the question of whether or not it pays to be green and work toward improving environmental performance. Various studies have provided a foundation for sustainability research by finding the positive association between efforts to improve environmental performance and its impact on economic performance [62, 68, 77] quality and cost performance [73], consumer market performance [30], stock market performance [45], manufacturing performance [47] and innovations [72]. To a lesser extent, some studies have also assessed different critical success factors for improving environmental performance including exports and sales to foreign customers [12], product design and process improvement [97], inter-firm linkages facilitated by proximity [24], and closer bonds between buyers and suppliers [22, 26]. However, the majority of this research only takes into account certain aspects of environmental performance with either cost-based or demand-based measurements.

Selecting meaningful and effective measures for environmental performance is vital due to the increased costs of environmental operations as well as market, regulatory and public pressures to adopt voluntary initiatives and international standards [4, 63, 91]. Unfortunately, environmental issues are often complex and difficult to quantify. Comparing the environmental impacts of firms with economic activities can be problematic when the availability and quality of environmental data is poor [63]. In this study we take into account demand-based (exploiting business opportunities brought about by stakeholder demands) and cost-based (dimensions relating to organizations reducing their cost structures) measures [63]. Demand-based measurements include a focus on reduction of solid waste, consumption of hazardous/harmful and toxic materials, resource consumption, improvement in environmental reputation and environmental certification. Cost-based measurements include decreasing cost for materials purchasing, energy consumption, waste treatment and waste discharge.

4. Model

Collaboration requires organizations to have some level of confidence in one another. In order to maintain an adequate level of confidence it is important for each organization to minimize transaction risks. TCE proposes that organizations should strive to minimize risks to actors associated with strategic behavior and changes in transaction of circumstances [99]. Within the TCE framework there are three attributes of transactions which are vital in this regard: level of asset specificity, level of performance measurement difficulty and level of uncertainty. Following this there are a variety of ways that cloud computing can reduce transaction risks and thereby enhance collaboration and its dimensions through asset specificity, ability to assess performance, and low levels of uncertainty.

Level of asset specificity is the extent to which investments tie the actor to the other party. Resources are asset-specific if their value is limited to only the relationship for which they were acquired [99]. Private cloud computing can uniquely provide for enhanced asset specificity between a buyer and supplier. Private cloud computing offers the same amount of massive scalability of services and computing power but is only accessible by one organization. This organizations can allow other users to gain access but only with a secure connection and usually with a pre-determined password. While, typically assets are defined as physical entities, knowledge and information is also definitive of an organizational resource. For example, a buyer can use cloud computing as a mechanism for communications with various suppliers. This buyer can also use private cloud computing as a means of communicating secure information (such as private process knowledge) to just one of their strategic suppliers. Knowledge capital accumulated through the private cloud enhances asset specificity within this relationship between the buyer and their supplier. The ease of which information can be shared and also kept secure using private cloud computing enhances the asset specificity between a buyer and their supplier network. While this has evoked some security concerns in the past couple of years [5, 56], many organizations believe privatizing the cloud offers a sense of security, reducing perception of security problems thereby improving satisfaction as long as perceived value is present [28] .

The level of performance measurement difficulty is the extent to which the transaction between parties can offer the same costs and benefits to the other party. Usually, performance measurement difficulties occur due to information asymmetry - when one party is better informed than the other [99]. Cloud computing reduces the potential for asymmetry through both rapid deployment and on-demand access. Rapid deployment allows supply chain partners to share real-time demand information, thus enabling partners to coordinate supply chain planning. Enhanced supply chain planning achieves objectives required for enhancing decision synchronization. Further, when downstream supply chain partners provide upstream partners with real-time demand, responsiveness to the consumer market increases, and service level problems decrease through joint knowledge creation [78]. Rapid deployment of information via cloud computing also offers enhanced computing power. It improves their capability to analyze terabytes of high performance SAS and fiber channel storage data in reduced time [19], improving transmission frequency for collaborative communication. Moreover, cloud computing's on-demand access allows organizations to gain access to information through a variety of different media. This is unlike traditional electronic data interchange (EDI) which often requires a common platform on either end [61]. On-demand access thus enhances the mode of transmission improving on the collaborative communication dimension.

The level of uncertainty refers to unanticipated environmental changes in which the transaction is embedded [99]. Cloud computing reduces uncertainty through its ability to share information on a variety of platforms regardless of the location or type of platform offered to each organization. This reduces the risk of mode of transaction, where environmental circumstances such as a lack of a common platform on either end can disrupt collaborative communication. Moreover, cloud computing offers both organizations the option of virtualization, whereby they no longer need to invest in their own data centers to store and transmit information. Both can leverage the use of cloud computing to minimize efforts to maintain their own data centers. Therefore, we hypothesize:

H1. Cloud computing is positively associated with collaboration.

In addition to minimizing transaction risks TCE suggests that firms need to conduct operations (and/or transactions) in an economically efficient manner. While economic efficiency is generally referred to as the reduction of costs [102, 105], it can also refer to improving a firm's reputation among various stakeholders as well as profitability [87]. Cloud computing has the potential to decrease costs, while at the same time improving a firm's profitability and reputation.

One of the more notable benefits of cloud computing is its ability to reduce operations costs through reduction in energy use. This is in part due to the potential to scale payment options via a pay-per-use service, where organizations are incentivized to reduce the amount of time spent using the specific platform in order to minimize cost. Cloud computing also has rapid deployment of information, where organizations can analyze large amounts of data in a shorter period of time, thereby reducing both operations costs and use of IT platforms. Further, cloud computing substantially reduces the amount of energy usage on a larger scale through virtualization or the elimination of having to house data centers. Amazon found that data centers comprise on average 3% of the total budget in operating costs, and maintenance of these servers comprise 42% of the total budget which includes power consumption and cooling infrastructure amortized over a 15 year period [38]. Data centers are comprised of tens of thousands of network devices, services and users which utilize a significant amount of energy and can cost a large amount of operating earnings. Cloud computing eliminates the need for organizations to house their own data centers, reducing the amount of operating expenses, thereby improving operating earnings.

Just as cloud computing can reduce operating costs via virtualization, it can also improve return on assets. With virtually no data centers to maintain or possess, organizations reduce the total amount of assets, while seemingly improve relations with suppliers via collaboration. Further, the inter-organizational collaborative benefits offered via the cloud can translate into enhanced service level [78], ultimately impact the relationship with the customer, and potentially improve sales growth in the long-term. Cloud computing also may indirectly impact sales growth through its cost savings driven by its pay-per-use options and virtualization.

Cloud computing's direct impact on return on investment is brought about through economic efficiency in transactions. The cost of the investment is far less substantial than the gain in comparison to traditional IT like EDI which often requires common platforms on either end [61] and requires organizations to maintain their own data centers. Further, cloud computing offers substantially more computing and collaborative opportunities via rapid deployment of information, thus enhancing the gain while reducing the cost by eliminating data centers and offering a pay-per-use or subscription-based service. Based on cloud computing's potential impact on the cost structure of an organization we hypothesize:

H2. Cloud computing is positively associated with economic performance.

According to the tenets of TCE, organizations must not only strive to improve the economic efficiency of external transactions to reduce opportunistic risk, but also internal transactions as well [76]. While cloud computing provides an effective platform for inter-organizational collaboration, it also enhances intra-organizational collaboration. Organizations can use the cloud and privatize information for only intra-organizational communication purposes. Individuals can access this information in a fast and cost effective way without data security breaches if the cloud is privatized. The rapid deployment and on-demand access to information enhances inter-departmental communication which can aid in the reduction of scrap waste [40]. This not only results in minimizing the amount of solid waste an organization produces, but negatively impacts the costs for materials purchasing. Moreover, one of the most direct ways to reduce disposal costs such as organizational fees for waste treatment and discharge is by reducing the amount of waste the organization produces. Cloud computing enhances inter-department communication which can reduce scrap through better understanding of consumer market demands in product manufacturing.

One of the more notable environmental impacts of cloud computing is the potential reduction of energy usage via its virtualization capability. Organizational data centers account for a large portion of energy usage throughout the U.S. [14]. Cloud computing's potential to eliminate individually housed organizational data centers will not only reduce energy costs, but also reduce overall resource consumption. While not all applications of cloud computing are found to be energy efficient, applications like Excel and Outlook, which are common software platforms for inventory and demand information sharing, consume less energy and emit less greenhouse gases than a traditional IT counterpart [100]. Based on cloud computing's ability to reduce scrap and energy resource consumption we hypothesize:

H3. Cloud computing is positively associated with environmental performance.

According to TCE, organizations should focus on minimizing their transaction risks and increasing economic efficiency [105]. Cloud computing has both of these capabilities incentivizing greater collaboration between supply chain partners. This enhanced collaboration will not only impact economic performance dimensions, but environmental performance dimensions as well. Cloud computing has the potential to increase ROI, ROA, sales growth and operating earnings both directly and indirectly through its ability to reduce transaction risks by minimizing costs and incentivizing greater collaboration between supply chain partners.

However, TCE suggests one of the main transaction risks brought about by bounded rationality among actors in organizations is the chance for opportunism. Frequent collaboration can minimize this transaction risk by enhancing social capital and reciprocity between organizations [48]. The relationship between collaboration and economic performance is not new in literature. Various studies have solidified the potential for collaboration between supply chain partners and economic performance dimensions [11, 82]. This includes literature using TCE as a theoretical background to explain the benefits of collaboration on firm performance. Thus, in this study we wish to verify the hypothesis:

H4. Collaboration is positively associated with economic performance.

What has not been assessed is how cloud computing not only directly impacts economic performance, but also indirectly impacts economic performance via enhanced collaboration. Cloud computing offers not only cost savings via its rapid deployment and on demand access to information and virtualization, but also enhances the opportunity for organizations to improve incentive alignment required for effective collaboration [56]. A higher level of collaboration provided by cloud computing ultimately improves economic performance. Thus, we hypothesize:

H5. Collaboration mediates the relationship between cloud computing and economic performance.

Similar to the relationship between collaboration and economic performance, the relationship between collaboration and environmental performance is not novel in literature. Previous studies have verified the positive association between collaboration and various environmental performance dimensions [89, 95, 110]. For example, some studies have discussed the various dimensions of collaboration including knowledge integration and information sharing [29] which are linked to environmental aspects of operations management including pollution prevention [46, 51]. Further, many green initiatives require expansive collaboration including suppliers and customers working together toward the reduction of carbon emissions from material flows in the supply chain as well as production processes [95]. Thus, we wish to verify the hypothesis:

H6. Collaboration is positively associated with environmental performance.

Current literature is missing discussion of ways to enhance the collaboration required for greater environmental performance. Cloud computing can be used as a means to increase various dimensions of collaboration required for environmental performance initiatives. For example, cloud computing's rapid deployment of information enhances speed of collaboration required for rapid changes in environmental circumstances. This can improve demand data information sharing and result in the reduction of hazardous materials handling through timely and accurate materials tracking and reporting. It can also reduce inventory buildup and thereby reduce unwanted or waste materials. Cloud computing can also enhance efficiency in external auditing and ongoing reviews [20] needed for environmental certification including ISO 14001 certification and overall improvement in organization environmental reputation. Therefore, we hypothesize:

H7. Collaboration mediates the relationship between cloud computing and environmental performance.

5. Methodology

We chose to conduct survey analysis for a few different reasons. Our focus in this study regards a contemporary IT used to facilitate communication between organizations. When contemporary events or technologies are analyzed, it is often advantageous for the researcher to pursue empirical methods such as survey, case study, and experiments. However, unlike case study and experiments, our research questions seek to address a larger context of individuals and organizations and their use of cloud computing in perpetuating both economic and environmental performance.

5.1. Sample and data collection

During the summer of 2013 a pre-test of our survey was conducted with 34 MBA students from a northeastern public university. An examination of validity and reliability was conducted. Students' feedback was also collected prior to making modifications in order to improve readability and accuracy of the survey instrument. After pre-testing and modification of the survey, emails were sent out to 1,000 IT and supply chain professionals throughout the United States. Emails, names and titles of respondents were collected from a third party organization (jigsaw.com – now data.com) after searching for "IT" and "supply chain management" professionals in middle management or above. A preliminary email was sent inviting respondents to participate in an online survey hosted by the authors' university. In order to increase response rate we offered to make a $1 donation for every completed survey to an undergraduate scholarship. After discarding responses with missing values, a total of 97 responses were collected.

A second sample was needed in order to elicit a greater sample size and enhance the estimation of our model [84]. During the spring of 2014, the same survey was distributed to IT and supply chain personnel through Survey Monkey (www.surveymonkey.com). Survey Monkey uses regular benchmarking surveys to ensure members are adequately representative of the United States population. After allowing users to designate specific industry or industries as well as job categories, the solicitation process provides email invitations to members in those groups based on a random selection algorithm. Each member is offered small non-cash awards for completion (i.e. charitable donations, sweepstakes). The overall abandonment rate was 33%. Considering the survey process spanned five days, was devoid of follow-up solicitation, and took respondents on average more than 15 minutes to complete, the response rate appears to be favorable [8]. Overall, a total of 247 responses were examined which includes the 97 responses collected from jigsaw.com. Given this sample comprises of both data sets, we conducted an independent samples t-test to ensure no significant differences between each sample. Our statistical analyses indicates no significant differences in results or demographics, thus allowing us to examine our sample further [84].

Table 1 shows the profile of our sample. Given the extensive use of cloud computing throughout various industries, organizational sizes and types of organizations, we wanted to sample from a large and diverse group. Having a diverse sample allowed us to generalize our results to a larger audience. Moreover, while individuals in higher positions within an organization can be useful to assess cloud computing in a strategic context, often it is individuals in middle management or lower management as well as IT specialists who have specific knowledge regarding actual use of cloud computing in facilitating communication across organizations. Thus, we also chose to sample from a variety of different position levels. Based on the information in Table 1, our results are seemingly generalizable to a variety of different organizations and individuals. Moreover, we conducted a one-way ANOVA to assess significant differences between each of the organizational characteristics. We did find significant differences in economic performance between each organizational type (p-value =0.0254) as well as organizational size (p-value < 0.0157). Thus, in our analysis we controlled for these variables. We also examined for non-response bias [2]. No significant differences were found between responders and non-responders. Thus, non-response bias is unlikely to pose a problem in our study.

Table 1
Profile of the sample.

Characteristic	Frequency
Size	
20 employees or less	20.6%
21-100 employees	12.5%
101-500 employees	15.7%
Over 500 employees	51.2%
Type of Organization	
Manufacturer	29.8%
Distributor/Warehouse	10.9%

Service	1.6%
Retailer	57.7%
Position in Organization	
Owner/CEO/President	26.2%
Senior manager	22.6%
Middle manager	27.0%
Junior/Entry-level manager	10.1%
Information technology specialist	13.7%

5.2. Measures

We measured our constructs on a seven-point Likert scale ranging from 1 ("strongly disagree", "not at all", "not in compliance", "significantly below standard", "no reliance", "no extent") to 7 ("strongly agree", "significant", "exceeding compliance", "significantly above standard", "significant reliance", "significant extent"). Cloud computing measures were adapted from Sanders [80]. Measures reflect both organizational use of cloud computing relative to industry standards and key competitors as well as reliance on cloud computing for conducting business and integrating with partners. Collaboration was measured with measures adopted from Cao and Zhang [11]. These measures are reflective of six dimensions of collaboration including information sharing, goal congruence, incentive alignment, resource sharing, collaborative communication, and joint knowledge creation [11]. Economic performance was measured using items adapted from Zhu and Sarkis [110] and Montabon et al. [63]. Items measured various factors in economic performance including return on assets, return on investments, and operating earnings. We also assessed for environmental costs and fees including cost for material purchasing, energy consumption, waste treatment and waste discharge. Finally, environmental performance was assessed using items adapted from Zhu and Sarkis [110] and Montabon et al [63]. Items reflected the extent and level of compliance in terms of reducing solid wastes, decreasing consumption of hazardous materials, reducing resource consumption and improvement in environmental reputation. Table A.1. containing items, factor loadings, composite reliability, Cronbach's alpha, and AVE scores are available upon request.

5.3. Data validity and common method bias

An important assumption in SEM is normality in data [54]. In order to assess for normality we examined the skewness and kurtosis of each item. Skewness ranged (-0.624 – 0.098) and kurtosis ranged (-1.071 – 0.030), all were < 2.0, and thus within the acceptable range, indicating no problems with non-normality. Several tests were conducted in order to assess the reliability and validity of our measurement instrument. We used both exploratory factor analysis (EFA) for scale development and confirmatory factor analysis (CFA) for examining goodness of fit. CFA is useful where measurement models have well developed underlying theory for hypothesized patterns of loadings [35]. Since our model was developed using both existing literature as well as TCE, we chose to perform a CFA. We also chose to perform an EFA, because CFA does not show how well items load on non-hypothesized factors [42]. Given the emergence of cloud computing and its emergence in survey analysis, we used EFA to examine our items.

An EFA was conducted using maximum likelihood *promax* method. We chose maximum likelihood due to its ability to compute goodness of fit of the model. Moreover, maximum likelihood is usually the best choice when the data is normally distributed [16, 21]. We also conducted a CFA using AMOS 21.0. In order to assess goodness of fit, it is recommended to justify our indices [86]. Current literature stresses use of fit indices not affected by sample size [43, 88]. Based on this we chose to use common fit indices not tailored to sample size. Based on our results our model appears to have satisfactory fit (χ^2/d.f. =2.02, comparative fit index (CFI) = 0.95, Tucker-Lewis index (TLI) = 0.94, root mean square error of approximation (RMSEA) = 0.06).

In order to examine convergent validity, we looked at the average variance extracted (AVE). All constructs exceeded the 0.50 cut-off [23]. All factor loadings exceeded 0.64. All Cronbach alpha values far exceeded the recommended threshold of 0.7 [65] and composite reliability scores exceeded 0.95 indicating satisfactory internal consistency reliability. Further, the square roots of the AVE values were greater than the correlation coefficients with other constructs indicating satisfactory requirement for discriminant validity (Table 2). Finally, we conducted Harman’s single-factor test to determine whether common method bias might threaten validity [71]. The un-rotated factor solution indicated that the explained variance of the largest factor was 45%. While the results of the Harman’s single factor test is less than 50% and not likely to cause any problems with validity our data was common method bias adjusted, removing any potential threat to the validity of our results.

Table 2
Means, standard deviations and correlations of the constructs.

	Mean	*Standard Deviation*	Cloud Computing	Collaboration	Economic Performance
Cloud Computing	4.05	1.48	1.00		
Collaboration	4.66	1.29	0.49	1.00	
Economic Performance	4.07	1.44	0.62	0.47	1.00
Environmental Performance	4.30	1.48	0.56	0.34	0.69

5.4. Data analysis

We tested the proposed hypotheses using structural equation modelling (SEM) with maximum likelihood estimations. Further, to assure the robustness of our results, we conducted an additional analysis using partial least squats (PLS). Unlike SEM, PLS does not require a variable to be normally distributed or for items of constructs to be reflective [74]. Peng and Lai [70] suggest using PLS as a robustness check of maximum likelihood estimations. While each item was normally distributed, the use of our survey warranted a robustness check using both SEM and PLS.

6. Results

This study used AMOS 21.0 to test the model using SEM as well as SmartPLS [75] to obtain PLS estimates for the robustness check and interaction effects. We first tested the direct effects of cloud computing on collaboration, economic and environmental performance (i.e., H1-H3) and the direct effects of collaboration on economic and environmental performance (i.e., H4, H6). Finally, we used Malhotra et al. [55] as a guide to conduct mediation analysis analyzing the mediating role of collaboration on the relationship between cloud computing on both economic and environmental performance (i.e., H5, H7).

6.1. Structural model

As Figure 1 shows, cloud computing is positively associated with collaboration ($\beta = 0.47$, $p < 0.01$). Cloud computing is also positively associated with economic performance ($\beta = 0.55$, $p < 0.01$), and environmental performance (β = 0.61, p < 0.01). Thus, H1, H2 and H3 are all supported. We also found a positive association between collaboration and economic performance supporting H4 (β = 0.24, p < 0.01) as well. Contrary to previous literature, we did not find support for H6 (β = 0.10, p > 0.10) which hypothesized collaboration is positively associated with environmental performance.

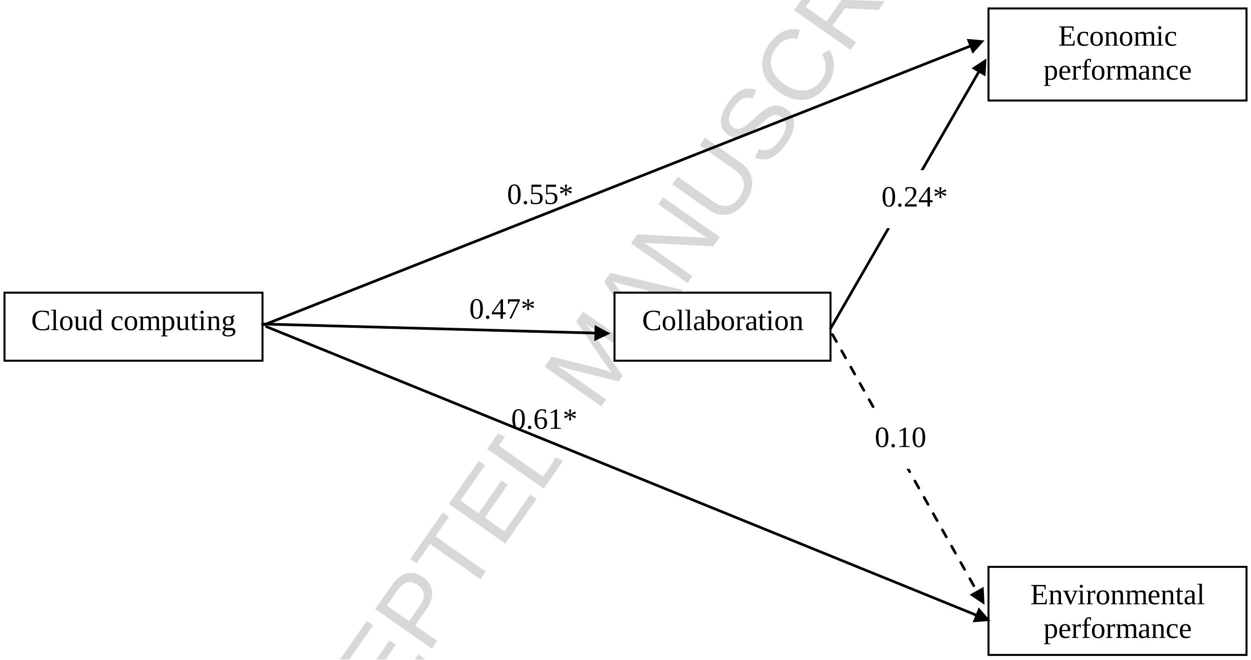

Fig. 1. Results of structural equation model.

* p < 0.01, dashed paths indicate non-significant results.
Model Fit: χ^2/d.f. = 2.02, CFI = 0.95, TLI = 0.94, RMSEA = 0.06.

6.2. Mediation analysis

In examining the mediation of collaboration on the relationship between cloud computing and economic and environmental performance, we followed the guidelines set forth by Malhotra et al. [55]. Malhotra et al. [55] suggest that both size as well as a confidence interval of indirect effects should be reported using bootstrapping as opposed to the Sobel test statistic. Table 3 reports the effect size for both direct and indirect effects as well as its 95% confidence interval (CI) and p-values. As seen in Table 3, the indirect effect between cloud computing and economic performance is statistically significant (β = 0.11, p < 0.01). This provides evidence in support of H5. In order to examine full or partial mediation we follow the

Baron and Kenny [3] approach. Since the direct effect with mediation between cloud computing and economic performance is significant ($p < 0.01$), it appears there is partial mediation present. This provides support for H5. The indirect effect between cloud computing and environmental performance is not statistically significant (p-value > 0.10). Further, collaboration is not significantly associated with environmental performance (p-value > 0.10). Thus, we do not find support for H7.

Table 3
Mediation analysis.

Direct Effects (Without Mediation)	Effect Size (95% CI)	p-value
Cloud computing → Economic performance	0.68 (0.54,0.82)	0.002
Cloud computing → Environmental performance	0.66 (0.50,0.82)	0.001
Direct Effects (With Mediation)		
Cloud computing - Collaboration	0.47 (0.34,0.61)	0.002
Cloud computing → Economic performance	0.56 (0.40,0.75)	0.001
Cloud computing → Environmental performance	0.61 (0.41,0.79)	0.001
Collaboration → Economic Performance	0.24 (0.07,0.40)	0.009
Collaboration → Environmental performance	0.10 (-0.10, 0.29)	0.400
Indirect Effects		
Cloud computing → Economic performance	0.11 (0.03, 0.21)	0.006
Cloud computing → Environmental performance	0.05 (-0.05, 0.14)	0.360

The structural model accounted for 44% of the variance in economic performance, 34% of the variance in environmental performance and 24% of the variance in collaboration (i.e., R2 = 0.44, 0.34 and 0.24, respectively). These R2 values, typical in social science research, can also be interpretable assuming the model has acceptable goodness of fit measures and significant associations between constructs [94]. Overall, the goodness of fit measures showed satisfactory values (χ^2/d.f. = 1.96, CFI = 0.94, TLI = 0.93, RMSEA = 0.06). In order to examine the robustness of the results we also conducted an additional PLS analysis. The PLS estimates did not show any large differences. The path coefficients, significance and R2-value were comparable and lead to similar conclusions. Thus, our results obtained through maximum likelihood estimation appear to be robust.

7. Conclusion

Increasing stakeholder and environmental pressures are key challenges for supply chain professionals in finding tools that can enhance both economic and environmental performance. Moreover, growing complexity in supply chain networks makes leveraging different strategic priorities with other supply chain partners quite difficult. As such, the aim of this study was to identify a tool that could be used to not only positively impact collaboration, but ultimately balance both economic and environmental performance. We found that cloud computing not only positively impacts collaboration among supply chain partners, but also is positively associated with economic and environmental performance. Moreover, we found to a lesser extent collaboration via cloud computing enhances economic performance. These findings both empirically supported and theoretically defined via TCE contribute to both supply chain and operations management literature which continues to address the questions of how to achieve economic competitive advantage [85] and how to create supply chains that are sustainable.

While this study provides a first step, it is important to understand there are various functions and ways to use cloud computing which might ultimately hinder collaborative performance and its impact on performance. This has been shown to be the case with organizations that use various forms of IT and cloud computing services that cause problems with interoperability [15]. Future research should incorporate the different uses of cloud computing as well as how services can be combined to effectively manage corporate competitive advantage from a variety of perspectives. Moreover, it is important to note the limitation of using survey analysis. Empirical research is grounded on individual perception. As such, the sample coupled with perception versus reality may impact the generalizability of the data. Future research can incorporate other methods including case study and controlled experiments to provide for triangulation of results. Further, while cloud computing is converging with other IT to transform the IT ecosystem for the better it is also imposing various new complexities with the amount of both structured and unstructured data being shared [17]. As such future research should also incorporate how to efficiently transform and shape data to collaborate in efficient ways. Finally, the practice of combining samples is often unconventional and can present sampling bias [41]. Our study combined two data sets in order to adjust for non-sampling errors as well as ensure adequate generalizability of data through a larger sample size [84]. In order to control for potential bias, we examined each sample using an independent samples t-test. We encourage future research to assess this model using different methods or attempting to elicit a higher response rate.

By examining the link between cloud computing, collaboration, economic and environmental performance our analyses yield three key findings. First, this study provides new insights regarding the role of collaboration for improving economic and environmental performance both directly and indirectly through cloud computing. Contrary to previous studies [i.e., 89, 93, 110] we found collaboration had no significant association with environmental performance and did not mediate the relationship between cloud computing and environmental performance. This finding lends credence to the importance of choosing an IT platform that will not only impact collaboration, but at the same time provide ample support for both economic and environmental performance. From our findings we see that cloud computing can both directly impact economic and environmental performance as well as collaboration. Ultimately, this collaboration may not lead to improvements in environmental performance initiatives. Many organizations that once relied on traditional EDI now are transitioning to cloud services [98].While the energy cost savings cloud computing provides may positively impact environmental performance, organizational use of other less energy efficient IT media may notably impact the relationship between collaboration and environmental performance. This reason may have also played a role in minimizing the positive association between collaboration and economic performance. Evidently, this leads to the realization that it should not be assumed that successful collaboration can balance both economic and environmental performance. Rather, organizations and supply chain researchers should focus efforts on addressing specific tools that can be used to effectively manage environmental performance and ultimately balance it with collaboration and economic performance initiatives.

Secondly, while our results showed a significant positive association between collaboration and economic performance, the strength of this relationship was significantly less than the relationship between cloud computing and economic performance. Moreover, we found only a partial mediation impact of collaboration between cloud computing and economic performance. This finding again relays the importance for supply chain researchers to address specific practices and media that facilitate economic performance. While a myriad of previous research has focused on exploring the link between supplier relationships and performance [i.e., 11, 82], researchers should instead focus efforts on ways to effectively manage collaboration as well as economic performance. This finding also provides practical guidance to supply chain professionals. Supply chain professionals should not assume that effective collaboration between supply chain partners will ultimately lead to enhanced economic performance. Instead professionals should find cost effective means that provide adequate balance to performance initiatives which are important to an organization's stakeholders.

Third, our results showed cloud computing has a similar positive association with both economic and environmental performance. The path coefficient was slightly larger between cloud computing and environmental performance. Currently, there is much debate regarding the environmental benefits of using cloud computing. While some conceptual research has specified the potential energy savings [i.e., 1, 36, 56], news media from Green Peace has speculated that cloud computing may actually increase energy use [58]. Our empirical study provides evidence based on supply chain and IT managerial perceptions that cloud computing has a positive impact on environmental performance when measured through reduction of solid waste, consumption of toxic materials, resource consumption, and environmental reputation. Further, our results provide managerial support for organizations looking toward cloud computing to effectively balance both economic and environmental performance.

A large portion of supplier relationship management research with theoretical foundations, like social capital theory, has primarily focused on the direct association between constructs like "collaboration" on "firm performance" [48]. Based on the plethora of research which confirms this link both theoretically and empirically, we do not argue that there are various benefits involved in maintaining adequate collaboration between supply chain partners with economic and environmental motivations. Yet, it is important to take into account that social capital, like collaboration, may not necessarily impact all dimensions of organizational performance. Researchers should focus on combining different theories to help explain how social capital is brought about to effectively enhance firm performance. Viewed from a

TCE perspective collaboration between supply chain partners, especially when done through inefficient means, can be costly and thus can potentially minimize the direct association between collaboration and economic performance. Further, the lack of energy efficiency in utilizing more than one IT medium for collaboration can reduce environmental performance. Evidently, it is vital for researchers to not only focus on the end result of collaboration, but also on the tools and practices needed to maintain the balancing act between economic and environmental performance.

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Dara Schniederjans is an Assistant Professor of Supply Chain Management at the University of Rhode Island, College of Business Administration. She has published articles in Journals such as Decision Support Systems, Transportation Research Part D, Journal of the Operational Research Society and Business Process Management Journal, etc. She has also co-authored three text books. Dara has served as a guest co-editor for a special issue on “Business ethics in Social Sciences” in the International Journal of Society Systems Science. She has also served as a website coordinator and new faculty development consortium co-coordinator for Decisions Sciences Institute. She currently teaches courses in Supplier Relationship Management and Operations Management.

Professor Hales studies techniques to improve the implementation of Lean, Six Sigma, Mindfulness, and Performance Management improvement programs in industries such as Healthcare, Manufacturing, Government, and Transportation & Logistics. He recently completed a research project on Global Seaport Strategies, interviewing senior port managers and government officials on their competitive strategies in the new millennium. This required visiting the 72 largest container ports in the world, and culminated in an international port conference hosted by the URI Transportation Center in May 2013. Professor Hales is currently working on a project to implement Performance Management in the Rhode Island Department of Transportation and State-wide Planning. His studies are published in top international supply chain journals such as the *European Journal of Operational Research*, *Journal of Business Research*, *International Journal of Operations and Production Management*, among others. As a result of his publications, he is routinely invited to speak at international conferences throughout Asia and Europe.

Highlights

1. Cloud computing is positively associated with collaboration.

2. Cloud computing is positively associated with economic and environmental performance.

3. Collaboration mediates cloud computing and economic performance relationship.