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A Metrics Suite of Cloud Computing Adoption Readiness

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A metrics suite of cloud computing adoption readiness

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Abstract Recent research on cloud computing adoption suggests the lack of a deep understanding of its benefits by managers and organizations. We present a firm-level cloud computing readiness metrics suite and assess its applicability for various cloud computing service types. We propose four relevant categories for firm-level adoption readiness, including technology and performance, organization and strategy, economic and valuation, and regulatory and environmental dimensions. We further define sub-categories and measures for each. Our evidence of the appropriateness of the metrics suite is derived based on a series of empirical cases developed from our project work, which encompasses input from field interviews, business press sources, industry white papers, non-governmental organizations, and government agency sources. We also assess how the application of the metrics suite supports organizational users of cloud computing.

Keywords Adoption readiness · Cloud computing · Empirical assessment · Managerial decision-making · Metrics suite · Technology adoption

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"The agility of [the] cloud enables businesses to get products to market faster by joining up the different parts of the development chain. Sectors such as healthcare and financial services can connect customers and influencers … to assess market needs and quickly translate this into new ideas and … new products and services."
Rick Wright, Global Cloud Enablement Program Leader, KPMG, 2013

"It is not sufficient to consider only the potential value of moving to cloud services. Agencies should make risk-based decisions which carefully consider the readiness of commercial or government providers to fulfill their Federal needs. These can be wide-ranging, but likely will include: security requirements, service and marketplace characteristics, application readiness, government readiness, and program's stage …"
Vivek Kundra, past-CIO of the United States, 2011

Introduction

Cloud computing services offer new technological capabilities to support information technology (IT) services users and enterprise clients. They simplify IT services acquisition, support faster implementation, and offer flexibility for the economic consumption of powerful software applications, data management and infrastructure computing resources. The U.S. National Institute of Standards and Technology NIST (2009) defines *cloud computing* as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction."

The concepts, types of services available, and the marketplace for cloud computing have been evolving. (See Table 3 in Appendix A.) Initially, there were mainly three types of cloud services: *infrastructure-as-a-service* (IaaS), *platform-as-a-service* (PaaS), and *software-as-a-service* (SaaS) (Ludwig 2012). As the market developed, more diverse and customized services became available to satisfy increasingly sophisticated clients (Columbus 2015). The new services have included *business process-as-a-service* (BPaaS) (Columbus 2012), *cloud advertising-as-a-service* (CAaaS) (Gartner 2012), *data analytics-as-a-service* (DAaaS) (Johnston 2015), *data storage-as-a-service* (DSaaS) (Seagate 2015) and *cloud management-as-a-service* (CMaaS). Some of these new services have grown fast, all the way to the level of having a top share in the cloud market. This change has led to the re-classification of cloud services. For example, IBM (2015) now bundles IaaS and PaaS together and views both as *cloud platforms.* IBM also bundles BPaaS and SaaS together as *cloud applications.*

Recognizing the discrepant views about the classification of cloud computing services, we adopted the categorization for IBM's Reference Architecture 2.0 and Gartner's (2013) classification, which positions BPaaS on the top of the other three layers of IaaS, PaaS, and SaaS.

In 2012, *InformationWeek* published a commentary, entitled: "How should we measure clouds?" (Croll 2013). The author noted: "[*We*] *need to … look at the business model. From there, we can derive the relevant metrics …*" [1] The approach that we will develop focuses on the issues that arise around adoption decision-making: managers need to assess cloud computing in terms of how it will support their businesses and create business value, while considering the uncertainties and risks associated with its appropriation. This research emphasizes issues that need to be addressed for service type-specific assessment to show if a firm is ready for adoption, and to increase firm-level awareness of value and risk issues.

During the past 3 or 4 years, the Asia Cloud Computing Association (ACCA 2014), a non-govern-mental organization (NGO) representing the interests of stakeholders in the cloud ecosystem in Asia, developed a *country-level cloud readiness index* to assess the national penetration of cloud computing for fourteen countries in the region. It categorized countries as *ever-ready leaders*, *dedicated improvers*, and *steady developers*. It used a survey of organizations in its member countries to identify the things countries need to do to be successful with cloud computing services adoption and business value creation in their economies. Readiness measures like these at the macro level support policy-making by guiding the national development of cloud computing technology. They do not serve this function at the organizational level though. Cloud computing adoption decisions happen at a more micro level – each organization makes the decision for itself, based on all of its own differences and issues. This creates a need for a somewhat more micro-level measurement approach that is managerially useful. This motivates our research, and we have the high-level objective of developing a metrics suite to gauge the extent to which an organization, as opposed to a country, is ready to adopt specific types of cloud computing services. We aim to answer the following two research questions:

(1) During the decision-making process for cloud computing adoption, what risks and uncertainties concern senior managers the most, and what are the drivers and inhibitors of adoption in their view?
(2) Will measures of risk and uncertainty enable an organization's senior management to understand the issues related to value appropriation for four different types of cloud services?

To answer these questions, we developed a metrics suite that covers four different categories to help an organization to assess its cloud adoption readiness. The interpretive discussions that we offer touch on why there should be a metrics-based evaluation process to help senior management to maximize the *business value of cloud computing*. This is the value that can be appropriated by its constituents (Brandenburger and Stuart 1996; Amit and Zott 2001). We emphasize the risks and uncertainties that managers need to understand so value appropriation will occur from the adoption of cloud services.

We identified four categories of factors that seem to matter the most: *technology and performance*; *economics and valuation*; *organization and strategy*; and *regulatory and environment*. We also conducted a field study involving interviews with industry and government practitioners, white papers and consulting reports, the business press and Internet sources, and the academic literature.[2] Our sources characterize the various contexts for different kinds of cloud computing implementation and value creation in practical and academic terms. These categories enable us to assess economic issues,

[1] Discussants of a prior version of this research (Kauffman et al. 2014) presented at the 2014 International Conference on the Economics of Grids, Clouds, Systems and Services (GECON 2014) emphasized the importance of adapting measurement approaches that tie in more closely with the various cloud computing services for data storage, software, infrastructure, data analytics, and so on. These comments encouraged us to develop new results related to the different business models of cloud computing in our own metrics suite work.

[2] To distinguish our research from what is often seen in academic publications, we sought to create a balanced view through the use of non-academic sources, in addition to the interactions and information from our field study interviews. The benefit of working to triangulate a meaningful set of findings that cuts across academic, industry and government sources is that it brings retrospective assessments, current views and prognostications of future outcome all to the present – to create valuable insights into technology-induced firm and industry transformation.

such as cost-benefit or vendor lock-in risks, or organizational issues such as absorptive capacity for cloud computing and senior management support for technology innovation. And they give rise to uncertainty and risk that senior managers perceive may harm the ability of the organization to appropriate business value from cloud adoption.

In practice, the key insights that drive cloud computing adoption decisions will vary across different types of cloud computing services models. Each of them is likely to put the organization in a somewhat different position relative to its *endogenous scope of control and responsibilities* to achieve the desired outcomes. Firms may be able to invest and shift their practices to take advantage of specific aspects of a given cloud computing service, but it is unlikely that they can do this successfully without some intervening time lag. Thus, this will make it hard to dismiss the uncertainties they experience in the short term. In addition, it is likely that the *exogenous maturity of cloud computing* in the market that a firm is considering to buy cloud services from will also play a role. Ongoing development of the niche will depend on vendor investments, market adoption, and keeping up with the "right" technical solutions. Another consideration is to the *extent of an organization's specialized use* of cloud computing services.[3] These considerations motivated us to investigate how the various dimensions and measures in the four different categories of the metrics suite should be weighted differently for the different cloud services, according to their relevance and the essentiality of the capabilities they measure.

The main contributions of this research are as follows.

(1) We offer a new theory-based metrics suite to support senior managers at organizations that are considering whether to adopt different types of cloud computing services. The approach will help them to gain a greater awareness of the key categories and dimensions that will influence their organizations' ability to create business value through the use of new IT services approaches.
(2) Through a field study process to develop the metrics suite, and its application to organizations that have adopted different types of cloud services, we have demonstrated new insights. They include the awareness that management can gain through the use of the metrics suite. We also learned about the shortcomings and limitations of our proposal of how to gauge the risks, uncertainties, and value appropriation from cloud computing. We have noted some areas that can be improved upon.
(3) By obtaining the kinds of insights and experience that we have in the organizational cloud services arena, it becomes possible for managers to consider the potential *limits to the value* of cloud computing in their organizations (Davern and Kauffman 2000).

This article has seven sections. The Background section comes next and gives an overview of the relevant literatures. The Research Methodology section provides the details of our research methodology, emphasizing the theoretical and industry-focused inquiry as the bases for our design of the readiness metrics suite. It gives information on our interview respondents, the instrument that we used to acquire responses in the interviews, and the kinds of documents and evidence we acquired for the cases. We offer sufficient detail on the reader, so our assessment of its strengths and weaknesses will be understood from the academic and industry viewpoints. The Metrics Suite section covers the development of metrics to gauge the *relative importance* of the different dimensions. We offer it as a basis for *supporting strategic decisions in an organization* related to cloud computing adoption, as opposed to a *decision support system that gives* "*yes / no*" *answers* on whether a firm should adopt. Its emphasis is on qualitative assessment, rather than quantitative assessment, and is specifically laid out to support senior management's developing thinking of when their organization will see assurances of payoffs from the cloud that are likely to outweigh the risks to which adopting firms are subjects.

Then, the section on Empirical Evidence presents the cases and the related exploratory empirical results related to them. We illustrate the application of our metrics suite to learn about the issues in four representative case contexts. It also evaluates the validity and usefulness of the metrics suite. In the penultimate section on the Business Value of Cloud Computing, we propose several propositions on how organizations will be able to achieve high firm performance after adoption, by sharing additional information and perspectives from our field study. We close the article with a Concluding Discussion section. It summarizes our findings, considers the decision-makers' use and the limitations of our approach, and suggests some next steps for future research.

Background

We will begin by reviewing related literature on technology and cloud computing adoption, and then present some background on the *metrics suite approach* and the knowledge gained from it in other managerial domains.

[3] When a client's use of cloud computing is *non-essential* because the new technology only supplements existing capabilities, versus when a client relies on the technology to be *essential* for supporting the primary outcomes of its business, the evaluation of the adoption decision is likely to shift dramatically. For these reasons, we will draw on a variety of aspects of different cloud computing services, including contrasts in the architectural models, the current level of maturity of cloud services in the marketplace, and the heterogeneous perceptions of uncertainty and risk with respect to different cloud services of the potential adopting organizations.

Technology and cloud computing adoption

There are multiple main streams of research on cloud computing adoption: *theory-oriented works* by information systems (IS) researchers, and *practice-oriented solution-focused studies* by software management researchers.

Theory The literature suggests some key factors that push forward or hold back adoption. A number of works focus in the *technology category.* These include tech innovations that enable cloud computing (Armbrust et al. 2010), flexibility, infrastructure and standards (IBM 2009), architecture and systems design (Rimal et al. 2011), and information security (Anthens 2010). These features help enterprises assess the advantages over the risks and uncertainties of adoption pertaining to technology advancement (Repschlaeger et al. 2013).

There is the *organizational category*, factors related to technology adoption have been recognized too: the commitment of senior management (Oshri et al. 2010), service quality and partnerships (Grover et al. 1996), the extent to which an organization promotes technological innovations (Hirschheim et al. 2011), the organization's absorptive capacity for new IT projects and new technologies, and its IT governance process (Mani et al. 2006; Carlo et al. 2012). Organizations' awareness of strategic opportunities and their different degrees of absorptive capacity may affect their technology adoption decisions also (Srinivasan et al. 2002), since they load on risk.

The *economics category* represents another aspect of any explanatory or predictive approach to why firms push forward or hold back adoption. This category includes factors such as network effects and client installed base (Rodriguez 2012), lock-in disadvantage and standards (Marston et al. 2011), investment decision-making under uncertainty (Benaroch et al. 2010), value appropriation and ROI (Alexander and Young 1996), ownership and information sharing (Kim and Moskowitz 2010), and pricing (Ma and Kauffman 2014).

A final category is the *environment.* Theorists in strategic management have long argued that firms adopt technologies because of institutional pressures from constituencies in their environment (Srinivasan et al. 2002). The related factors include industry differences and standards (Qu et al. 2011), data privacy and information security (Breuning and Treacy 2009), vendor and technology competition (Ross and Blumenstein 2013), and perceptions in the financial markets (Oh et al. 2006).

Practice There are two groups of practice-oriented studies. One explores the *practical reasons for cloud adoption*. Through interviews and questionnaire-based surveys, various authors have reported critical areas of business practice that are related to cloud adoption decision-making. These include the study of adoption and governance (Borgman et al. 2013), opportunities and ROI versus the risks (Merrill and Kang 2014), facilitators versus obstacles (Habib et al. 2012), client selection of cloud services and vendors (Koehler et al. 2010), and unexpected market entrants and regulations (*SAP* SAP News 2014). The other group of studies provides *quantitative decision-making tools for managers* related to technology and cloud adoption. They cover areas such as cost-benefit analysis, technology suitability and economic suitability analysis (Khajeh-Hosseini et al. 2012). Other industry papers offer suggestions on architectural and IT governance principles for risk control (Cloud Security Cloud Security Alliance 2010), information security (Wright 2004), and implementation effectiveness (Cisco 2014). These reports are vendor-specific, offer technical details and specifics, and present issues that practitioners face.

Cloud adoption decisions Both theory-based explanations of cloud computing adoption and performance, and actionable suggestions to help with technology use and business operations benefit organizational decision-makers. For example, survey research studies on IT outsourcing (Ang and Straub 1998) and business process outsourcing (Lacity et al. 2011) involve perceptual scales containing limited technical or economic contents; instead, they are intended to aid in the qualitative aspects of decision-making and strategic planning. Practice-oriented studies tend to focus on specific aspects, such as the technological suitability of cloud computing (The Open Group 2014) or migration guidance (Sutherland and Chetty 2014). They reflect aspects of cloud computing that are easily understood by senior IT managers and planners. Thus, measures that capture firm changes in cloud adoption readiness must incorporate the strengths and rigor of theory and relevance of practice.

Characteristics and applications of the metrics suite approach

Characteristics *Individual measures* are useful to provide basic elements to assess performance in processes and systems. When we bring together measures that represent different aspects of performance, we refer to them as a *metrics suite.*[4] Managerial decision-making processes for cloud computing adoption and migration are complicated,

[4] This term, *metrics suite*, is used in engineering, software systems, and business process management contexts. Metrics suites can capture and quantify complex aspects of operational processes, help managers to evaluate business performance, and enable them to make effective adjustments and achieve desirable outcomes. In addition, metrics suites have been used to create measurement approaches to capture quantitative and financial performance, and qualitative and intangible organizational capacities (Kaplan and Norton 1996), measure interdependent aspects of systems design in software development (Chidamber and Kemerer 1994), and simplify financial risks based on a set of numerical measures (Jorion 2000).

and require carefully set targets and effective reviews. Senior managers need information on a range of issues to evaluate the firm's readiness for cloud computing services. Metrics suites based on theory that is relevant for implementation are important. Theory supports understanding how performance outcomes arise.

Applications In *software engineering*, metrics suites have been developed to measure the productivity and quality of application designs based on software objects (Briand et al. 1999). Chidamber and Kemerer (1994) proposed a six-dimension model, including weighted methods per class, depth of inheritance tree, number of children, coupling between object classes, response for a class, and lack of cohesion in methods. The model can be linked to economic outcomes, such as software productivity and re-work effort, which facilitate project planning and control. Empirical evidence has shown that using such metrics in the initial design stage can save 42 % of corrective costs and efforts, and substantially improve final product quality (El Emam et al. 2001).

In *strategic performance management*, researchers and practitioners have designed and developed various metrics to measure process performance and intangible capabilities (Edvinsson and Marlone 1997). These traditionally were ignored by established cost accounting evaluation methods. The Harvard Business School's "Balanced Scorecard" by Kaplan and Norton (1996) is the most successful metrics suite in performance management. It has been widely used to set management objectives or to plan development and decision-making of new strategic systems (Nørreklit 2000), with 60 % of Fortune 1000 firms in the U.S. having experimented with it (Silk 1998). It integrates quantitative financial outcome measures and qualitative non-financial performance drivers. It also assumes there is a causal chain of relationships, starting from measures of organizational learning and growth, to internal business processes, then to the client perspective, and finally to financial performance.

In *financial and accounting risk management*, various metrics such as Stern Stewart's *economic value added* (EVA) and RiskMetrics' *value-at-risk* (VaR) help senior managers to evaluate financial risk and make better investment decisions. EVA is the difference between accounting earnings and the cost of capital used to generate the earnings (Stern et al. 1996). As a metrics suite, it focuses on the measurement of profits that remain after the impacts of debt cost and equity capital on a profit from operations. In financial risk management, VaR represents the worst expected loss over a given time horizon under normal market conditions at a given level of confidence. It assesses exposure for financial firms for multiple financial instruments, which can be aggregated to assess the firm's composite risk (Jorion 2000). Managers use it to forecast losses that may accrue from shocks to their businesses. As a consequence, it is viewed as a forward-looking way to measure financial risk. VaR metrics have received wide recognition due to their impacts on financial practices across industries.

Research methodology

In this section, we will discuss two issues related to the methodology that we applied in this research. We will present an overview of *our exploratory research methods*, including: (1) our research question formulation; (2) our conceptualization of the metrics suite for cloud computing adoption readiness; (3) the manner in which we generated and refined the questionnaire items that we used in our interviewing process to discover the relevant set of adoption-related risk and uncertainty drivers; and (4) the high-level process we used to select and assess the cases in this research. We also will go into greater detail on the process we used to assign *relative importance* levels to the different measures in the cloud computing adoption readiness metrics suite.

Exploratory research methods

We next discuss our exploratory research methods in greater detail.[5] (See Fig. 1.) In this research, we will examine the theoretical basis for cloud computing-related decisions for the firm to adopt, assess some precursors of cloud computing firm-level adoption readiness, and propose three related propositions about how the use of a metrics suite aids the organization to create business value through adoption. We caution the reader that there is no single agreed-upon theory base for cloud computing adoption. The evidence that we share suggests that there are several separate bodies of knowledge in the literature that are relevant though. They include grid computing, general IT adoption, and business process outsourcing, among others. We view our theory work as being *intermediate theory-related research*, positioned between *mature theory-related* and *nascent theory-related research.* Edmondson and McManus (2007) suggested three *archetypes of methodological fit* that go along with such theory work, and different kinds of research methods that are

[5] The idea of using *exploratory research methods* in this work is heavily founded on the use of industry cases, which anchors our research in the central domain of organization IS research scholarship. The exploratory study of cases to learn about relevant issues that bear on theory related to the management of IT in various kinds of settings was pioneered by authors in organizational and management studies (e.g., Eisenhardt and Graebner 2007), information systems (e.g., Benbasat et al. 1987).

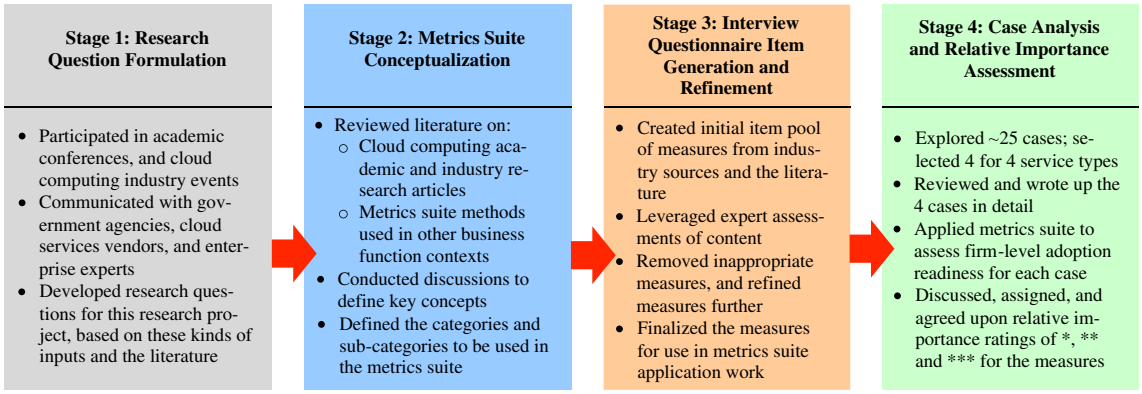

Fig. 1 An overview of the exploratory research methods used in this research

most appropriate to match the different kinds of research inquiry. [6]

Stage one: research question formulation

Informed by government and industry leaders We formulated our research questions around the needs that industry practitioners expressed in business and technology press articles that we read, conferences where we heard them speak, and interviews that we conducted with them. The authors participated in cloud computing workshops and events sponsored by the Asian Cloud Computing Association (ACCA), the International Conference on Cloud Computing Research and Innovation, and the Infocomm Development Authority (iDA) of Singapore, for example, mostly in 2013, 2014 and 2015, with some earlier advance work and continuing engagement. The discussions extended into late-2015. In these meetings and events, we had both formal structured interviews and informal unstructured conversations with government agencies, regulators, cloud service vendors and researchers, and experienced enterprise leaders and managers.

Grounded in practice All of the respondents stressed the necessity to create an approach for the *qualitative empirical assessment* (Markus 1997) of firm readiness for the adoption of cloud computing grounded in practice, reliant on theory, yet not overly academic or difficult to implement in industry. Their emphasis was on the identification of concerns and issues that led to perceptions of uncertainty and risk with respect to the potential for business value from cloud computing that would make their organizations unready to make the major commitment to adopt. This investigation also identified the application of the *metrics suite approach* in other functional areas of management – software engineering, strategic performance management, new product development in marketing, and financial and accounting risk management. This suggested that developing a firm-level metrics suite would be a beneficial and informative activity to build a stronger basis for managerial decision-making for cloud adoption.

Stage two: metrics suite conceptualization

Multi-category model We created a multi-category model of cloud computing adoption readiness based on an extensive review of the literature, backed by input from our field study respondents. The sub-categories and measures in the suite were developed and adapted from previous research studies, with the idea in mind that these things were the *influencers* of senior management's perceptions about firm adoption readiness, especially in terms of the risks and uncertainties that might affect their ability to achieve an appropriate level of ROI with cloud computing. We invited senior IT managers in Singapore who were experienced enterprise cloud users to participate. We also sought the participation of cloud services vendors and government agency analysts. Their combined input enabled us to create an initial design for measures in the metrics suite that would be meaningful to others in industry, while still being able to satisfy university and government lab-based researchers.

Coverage of the literature We conducted an extensive literature review to gain an insightful understanding of cloud computing services, especially in terms of the market for the services and the organizational risk and uncertainty drivers related to their adoption. We searched the Business Source Complete database hosted by EBSCO, the Elsevier and Springer databases for journals and books, as well as the

[6] With this *intermediate theory* perspective, researchers typically work on areas with no mature theories, and only separate bodies of literature, as we have noted. Their purpose is to explore the theoretical basis, test provisional explanations, and propose testable propositions. Prior literature, archival data, industry reports and interviews are the major data sources of data, and the method tend to be qualitative. With this approach, different authors deploy slightly different methods. This description matches our general approach, though we have proposed an artefact for cloud adoption readiness.

INFORMS, AIS, IEEE, ACM, and Google Scholar databases. We used a variety of search terms, including "technology adoption," "IT outsourcing," "cloud computing," "software-as-a-service," and "grid computing," among other terms. For industry reports and whitepapers, we also conducted a broad search.[7] Our initial coverage of the literature contained more than 600 academic papers and industry reports. We screened out articles and reports that were duplicates but shared by different entities, had trivial content, or were unrepresentative of the body of content that we obtained.

Model categories and sub-category definitions Many, though obviously not all of the articles and reports that we obtained, are cited in the Reference section of this article. This allows us to share the great breadth of knowledge available from the sources that we tapped into. They come from the multiple disciplines in which cloud computing is of interest. The interdisciplinary perspectives include Strategy, Marketing, Economics, Management and Governance, Computer Science, and Information Systems. These studies together offer a comprehensive view of the cloud market and issues with risk and uncertainty in the organizational adoption of cloud computing. The more technical articles, in contrast, introduce background on the development and operation of cloud services. They also cover the kinds of architectures and infrastructures that make cloud computing services possible, and the principles, standards and approaches to control that enable them to function well. With this knowledge base at hand, we developed the four categories of the firm-level cloud adoption readiness metrics suite. The additional sub-categories were developed on the basis of several rounds of academic review, the presentation of our research in an academic conference, and assistance from industry informants along the way. This process required additional discussion and refinement to reach the form you see here.

Stage three: interview questionnaire item generation and refinement

Interview questionnaire item pool development We sought to develop a set of *interview questionnaire items* to represent information about the measures that our informants believed were most important for populating the different sub-categories. Our initial item pool had around 50 to 80 items for each of the sub-categories that we explored – with 280 in total: far too many to be of practical value. The authors reviewed the item pool and reduced the total by sorting, combining, refining, eliminating and eventually selecting a smaller subset of them. This resulted in 28 items as candidates for measures to include in the sub-categories of the metrics suite.

Senior management review We also sought help from six industry respondents from different organizations with expert knowledge of cloud services to review and assess the measures. Industry reports and practitioner input helped us to scope and select measures that are aligned with various organizational needs (Edvinsson and Marlone 1997), and are closely tied to whether adoption and implementation of cloud services are likely to pay back the organization for its investment. Our respondents were CIOs, CEOs and senior managers who had been in charge of cloud adoption decisions in their respective organizations, understood the external market and growing demand for cloud-based IT services, and had at least 15 years of experience with IT management. During the interviews, the authors took notes on the content of the discussions, and identified some of the major aspects of the information that was shared. We leveraged the knowledge and opinions of these experts to support further refinement of the measures. This process led to the removal of seven of the 28 proposed measures. We further refined the remaining 21 measures, and reached the near-final form of the metrics suite.A smaller, but still effective set of measures with a clearly defined purpose. Through this process, we confirmed that the set of measures provided full enough coverage of the theoretical explanations that academic researchers believe are necessary. And, more importantly, the industry audience came to view them as more carefully tailored so they can be used in organizations, deliver useful information to managers, and support the development of greater awareness about cloud computing's possible impacts. We also became clearer during the refinement process about the purpose of the metrics. As we explained earlier, the purpose is to enable senior managers to calibrate their perceptions of risk and the extent of the uncertainty they face with cloud computing adoption, as a way of gauging their organization's readiness to adopt the new types of IT services.

Stage four: case analysis

Case targeting We chose to emphasize four different types of cloud computing services based on their estimated market shares. They are: CAaaS (48.0 % market share), BPaas (28.0 %), SaaS (14.7 %), and IaaS (5.5 %). They represented an estimated total of 96.2 % of all cloud computing use in organizations in 2012, our benchmark year. (See Table 3 in Appendix A for more information.) Other than these, no other "XaaS" types had more than 1 %

[7] We focused on reports from major consulting firms such as Gartner, McKinsey, and Ernest & Young, and the major cloud services vendors – IBM, HP, Salesforce, Amazon Web Services, Oracle, Fujitsu, Citrix, Insightly, RedHat OpenShift and Heroku – based on a variety of industry sources (e.g., Curtis 2014, Panettieri 2013).

share in the market from 2013 to late 2015, so including them would not have added much information to our research inquiry. For each of these four types of cloud services, we searched for adoption cases from vendors' websites, industry white papers, and various cloud computing blogs. We collected 25 cases that contain sufficient information to support our further analysis. They were our initial case targets.

Selection of cases We then applied the following criteria to select cases in this exploratory research (Graebner and Eisenhardt 2007). The organizations adopting the cloud computing services had to be significant and recognizable players in their industries. There also needed to be some diversity in the industries and activities of the selected firms (Benbasat et al. 1987). But we learned that it was difficult to obtain equivalently informative materials for all of the cases. Some firms had industry reports of high quality, including discussions of the needs of relevant stakeholders and identification of some of the major drivers of organizational risk and uncertainty, and the business value outcomes for the organizations from cloud adoption. Others had a balance of business press and company reports that contributed useful information. Still others offered scant and superficial marketing information, and were inappropriate for our use. We were careful to select cases with reports and business press articles in which senior managers (CIOs, CFOs, CEOs) expressed their views on the business value, risks and uncertainties of the cloud for their firms, especially difficulties that might arise with adoption.[8] This led to the selection of four cases to explore in greater depth, and for which we conducted *document-based analysis* to establish the relative importance of the measures and the overall usefulness and insights the adoption readiness metrics suite was able to produce (Recker 2013).

Evaluating the relative importance of the sub-category measures

We now will explain in greater detail how we assessed the relative importance of the metrics suite's sub-category measures in the selected cases.

(1) Two of the three co-authors independently read the materials that we acquired for the cases. They made initial decisions about how to evaluate the importance of different measures in terms of the risks and uncertainties that they posed to the organization's ability to appropriate value from cloud adoption. This is similar to what managers in an organization would do – by making notes on the evidence that supported their opinions independently – in order to establish the variety of opinions. If the assessments of the two co-authors were similar, then this part of the process stopped.

(2) If there were substantive discrepancies between the two, however, they worked together to share relevant evidence as a basis for reassessment. In some cases, the issues were the lack of a full and common understanding of how the various measures represented risk and uncertainty in the case contexts. In others, it was more a matter of differences in the interpretation of the available evidence. In our view, this process parallels once again how managers in an organization might interact with one another to achieve a "corporate opinion." The third co-author also participated in these discussions, as a way to bring another less biased opinion to the results. This typically resulted in the provision of a corroborating or dissenting assessment, which led to final agreement.[9]

(3) In the rare instances where there was no information available to identify the relative importance for some measure in a specific case, the co-authors examined evidence from the full set of 25 cases, to find cases that were comparable in some respects, and could yield additional insights. This was not a perfect process, of course, but it is similar to what organizations experience; some assessments are made by "the seat of the pants," when empirical observations are absent.

(4) The coding of our evaluations for relative importance was straightforward, and in line with the norms of organizational research methods in IS (Recker 2013). It also was in line with what staff members in a firm might do to assess the risk associated with qualitative aspects of an IT investment or a business process change. Identifying the extent to which some issue is of "relative greater importance" or "average importance," or "relatively lesser importance" was based on the individual author's reading of the publicly-available materials, assessment of

[8] Although it initially made sense to us to use quotations as a way to represent their assessments, we later decided that it was more appropriate to extract the essential elements of their comments only. In too many cases, quoting their words gave an impression that the people who were quoted might be "cherry-picked" to support the marketing of the cloud services vendors they used, which was not appropriate for our narratives. Since the authors had no direct access to the senior managers in the materials that we acquired, and our main emphasis was on the relevance of the measures we identified – to assess whether they were meaningful for the intended purpose. We were somewhat less concerned with their specific values: "less important," of average importance" or "more important." We thank the review team for their guidance on this issue.

[9] An anonymous reviewer suggested to us that it may not be easy to evaluate relative importance especially when the sources, interview partners and documents differ from case to case. We agreed, but wish to note that this is similar to other evaluative methods in different contexts, both qualitative and quantitative. One example is the quantitative method of valuation via net present value (NPV) analysis, where many different assessments, different outcome numbers, and different assumptions are likely to be used by different analysts in different settings. Only in the simplest cases will there be easily agreed upon quantitative outcomes from the analysis.

the type of cloud computing services adopted, and other general knowledge of the firms' business activities and degree of commitment to IT in their strategy.[10]

(5) Finally, all three authors participated in the development of the written case descriptions, and the results and interpretations to portray the main findings.

A firm-level cloud computing adoption readiness metrics suite

Properties of a measurement system for expected performance via new IT adoption

We next present the metrics suite for cloud computing adoption readiness at the firm level. The emphasis of its categories, sub-categories and measures is to enable senior managers to gain an awareness of issues that may create risk and uncertainty in the appropriation of business value for the firm with cloud adoption.

Innovation performance measurement systems should have these following five characteristics, as suggested by Dewangan and Godse (2014): (1) a stakeholder value orientation; (2) an innovation process orientation; (3) cause-and-effect relationships; (4) multi-dimensional assessments; and (5) easy implementation. These considerations apply to the *prospective assessment* the potential business value outcomes of adopting technology innovations, just as it applies to the *retrospective assessment* of implemented innovations.

Stakeholder value In designing measurement systems for assessing how successful technology innovations are likely to be, how to address the needs of multiple stakeholders has always been an essential issue (Jorion 2000; Kaplan and Norton 1996). A *stakeholder* is an agent who initiates changes or is impacted by changes derived from a technological innovation (Bourne et al. 2000). Cloud computing has the potential to generate beneficial impacts by transforming the use of IT services. Identifying its benefits and the obstacles that may block value appropriation for the stakeholders is fundamental for measures suited to readiness evaluation.

Innovation process Cloud computing adoption will be like adopting a technological innovation which may or may not be perceived as being entirely ready. So a meaningful metrics suite in our context must also have the built-in capacity to assess cloud computing in a way that technology innovations are assessed – prior to the time of implementation. Senior management needs to have a keen appreciation of risk and uncertainty, and their ties to the organization's appropriation of business value from adoption.

Cause-and-effect links A metrics suite must contain identifiable *cause-and-effect relationships* between the measures that are used to represent the various sources of risk and uncertainty with adoption relative to the goals of the organization to appropriate business value from IT investment (Kaplan and Norton 1996; Stern et al. 1996). Establishing causality will ensure that strategy, operations, and technical adjustments can be made to improve cloud readiness, so it will serve the organization's goals better and result in higher ROI. A theoretical basis from the literature and for use in interpreting the practitioner interviews helps in identifying relevant causal links.

Multiple measurement categories A metrics suite should represent a balanced view of what is under study: financial and non-financial measures, technical and non-technical issues, and internal and external factors. Multiple categories are meaningful: they establish a base for deep managerial insights. This is consistent with current views of the IT services ecosystem and cloud computing services context.

Implementability An effective metrics suite must be easy for managers to implement in different settings for different types of cloud computing services also. Cloud adoption readiness at the firm level is complex though. Still, it is appropriate to limit the number of sub-category measures, and ensure they have similar granularity.

Categories, sub-categories, and measures of the metrics suite

We now sketch our metrics suite for firm-level adoption readiness, and discuss its contents. (See Fig. 2.)

The metric suite is organized with a *hierarchical structure*. There are four measurement categories in the metrics suite: *technology and performance*; *organization and strategy*; *economics and valuation*; and *regulation and environment*. The *categories* are bold and underlined. In each category, there are multiple *sub-categories* noted with solid bullet points, and in each sub-category, hollow bullet points identify the *measure*s.

[10] We also want to indicate that the weighting scheme that we used (*, **, ***) is worthwhile to examine carefully for biases. They include: (1) possible *data source biases* since we conducted an "arm's length" analysis; (2) potential *author-introduced biases* based on the coding process; and (3) *information availability biases* due to variation from case to case. These biases will all be mimicked when senior managers use our approach though: so there is no complete escape from this kind of problem. But senior managers will not be at "arm's length" from their organizations: they will be them. The consistency of coding by senior managers may be subject to differences in their organizational experience, technical knowledge, and risk management experience. Nevertheless, we proffer that these issues will be less of a problem when managers in organizations are driving and participating in the metrics suite-based evaluative process. For more information on coding, see Recker (2013).

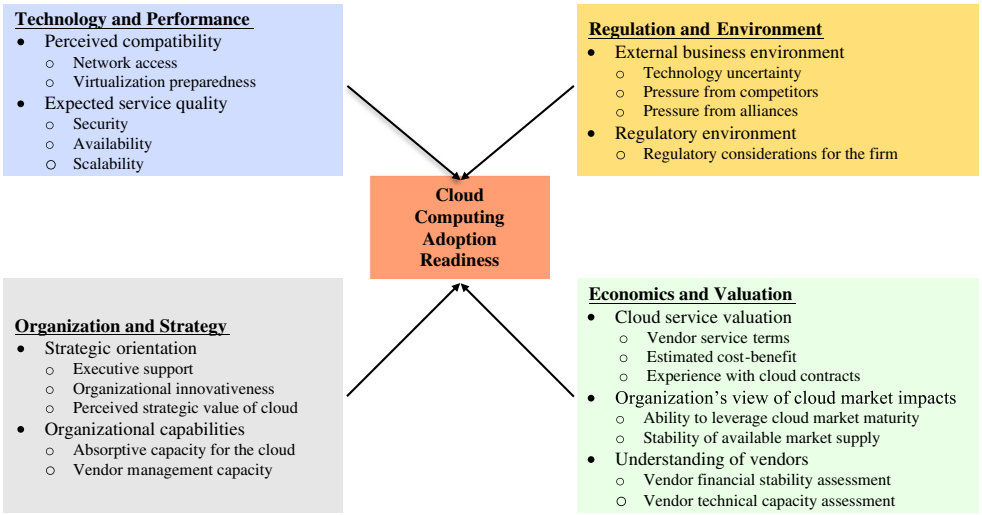

Fig. 2 The firm-level cloud computing adoption readiness metrics suite. Note: The representation of the metrics suite shown above is intended to emphasize how se*nior management's perceptions about potential business value* that can be appropriated from cloud computing services adoption may be affected by *technology and performance*, *organization and strategy*, *regulation and environment*, and *economics and valuation* issues. In each category and sub-category, and for all of the individual measures, the key thing to keep in mind is that the perceptions of an organization's senior management are the essential drivers of whether the organization will exhibit adoption readiness for cloud computing. Their perceptions are driven by: internal and external influencers; their past experience; their sensitivity to risk; and *rational expectations* of what is likely to happen in the future (Au and Kauffman 2003)

We use appropriate theoretical background to characterize, to the greatest extent possible, what are the most distinct and independent explanatory components to use.[11] As a result, we employ different technological, organizational, economic and regulatory variables to map out the full space of potential explanations in a meaningful way, without being too complex or overwhelming for managers. (See Table 5 in Appendix C for more details.)

The metrics suite consists of 21 measures within the four categories. We chose measures to reinforce the information that the category produces as a whole. Also, when they are brought together, there may be *countervailing or offsetting effects*. This seems true within a category based on the values of the different measures, as well as across different categories. For example, senor managers may not wish to commit to cloud adoption, because they are risk-averse in the face of new technology, despite the fact that the organization is profitable and the rational expectations expressed in the market suggests that it will produce high ROI from adoption. There may also be *reinforcing and amplifying effects*. For example, the estimated cost savings from moving to the cloud have been recognized and technology performance related to the specific service types may be especially valuable, influencing senior managers' views that the organization is ready to adopt.

We next will discuss each component in the metrics suite: its categories, sub-categories and measures.

Technology and performance

The first category of measures involves *technology and performance*. It assesses whether the cloud computing solutions fit the firm's existing IT and systems so that the production of business value will not be held up. There are two subcategories: assessments of *expected compatibility* and *expected service quality*. Managerial decision-makers have to assess the technology's suitability and understand the expected level of IT service quality. This will enable them to gauge whether the cloud is right for their organizations or too risky (Armbrust et al. 2010). This requires fit and compatibility assessment (Low et al. 2011; Repschlaeger et al. 2013), and information, system and service quality levels that are consistent with the firm's business and IT practices (DeLone and McLean 1992; Tornatzky and Klein 1982; Espadanal and Oliveira 2012). To assess expected compatibility, we use *network access* and *virtualization preparedness*. Cloud computing requires high-quality network access and virtualization and minimal latency (Vouk 2008). Experience with virtualization will also reduce the expected costs and uncertainties associated with cloud migration (Jamshidi et al. 2013).

[11] Models that explain or characterize processes will work best when they have *orthogonal or maximally distinct components*. An example is econometric regression models; they have greater explanatory power for a given number of variables when the independent variables are correlated with the dependent variable, but are uncorrelated with one another. Also, frameworks that aim to provide explanatory capability are considered to be *robust* when they employ relatively independent elements and components that sustain their relevance over time, in different settings, and for different purposes of use. Our choices of categories in the metric suite follow the same logic, and the categories have the least overlap among one another.

Expected service quality is critical for boosting senior management's view of firm-level IS success (Pitt et al. 1995). Prior research has addressed the benefits and risks from an IT perspective (Venters and Whitley 2012). In the expected service quality sub-category, we include three critical quality measures of: *security*, *availability* and *scalability* (Benlian and Hess 2011; CSMIC 2012). The indicators of security risks include contractual loopholes, confidentiality, information security, and service outages. Clients expect high availability, based on the percentage of time they can access the services (Garg et al. 2013). And scalability measures clients' needs for services that scale to the organization's demand for them (Venters and Whitley 2012).

Organization and strategy

The second category is *organization and strategy*, which assesses two sub-categories pertaining to whether cloud computing solutions match the firm's *strategic orientation* and *organizational capabilities* to produce business value and ROI. Companies with well-established organizational capabilities and a strategic orientation are more ready to benefit from cloud computing (Buyya et al. 2010; Carlo et al. 2012). Decision-makers need to recognize the potential impacts of cloud computing use, and prepare for different kinds of obstacles (e.g., leadership, political, technical capabilities) within the organization (Garrison et al. 2012).

In our interviews, some IT executives emphasized that, when moving to the cloud, organizations have to adjust their IT governance policies and operating models, according to the criticality and sensitivity of their tasks and data. An organization with accumulated experience and managerial capacity will adjust more smoothly (Hsu et al. 2014). The organizational capabilities that are critical for cloud adoption success include *absorptive capacity for the cloud* and *vendor management capability* (Aral and Weill 2007; El-Gazzar 2014). These are complementary assets for the firm, which positively affect the technology adoption process (Tripsas 1998; Srinivasan et al. 2002). We assessed external and internal knowledge acquisition and dissemination for organizational absorptive capacity (Liao et al. 2003), and contractual and relational governance for vendor management capacity (Poppo and Zenger 2002), as a basis for determining whether value appropriate might be problematic.

Strategy-focused organizations have an easier time to identify the prospective business value of cloud computing, and match its innovative characteristics with their own internal business needs. To represent the strategic orientation of heterogeneous organizations, our metrics suite includes three measures: *executive support*, *organizational innovativeness*, and *perceived strategic value* (Messerschmidt and Hinz 2013; Espadanal and Oliveira 2012). *Executive support* is critical for creating a supportive climate, with adequate resources and opportunities for cloud adoption (Low et al. 2011). *Organizational innovativeness* affects a firm's intention to adopt new ITs (Barczak et al. 2007), and *perceptions of strategic value* and competitive advantage matter too (Hsu et al. 2014).

Economics and valuation

The third category is *economics and valuation*, which assesses the risks and uncertainties associated with the economic suitability and appropriation of business value from cloud computing. The sub-categories include: *cloud service valuation,* the *organization's view of cloud market impacts,* and the *organization's understanding of vendors*. For *cloud service valuation*, we employ a set of measures on the *vendor's service terms,* the *estimated cost-benefit,* and the organization's *experience with cloud contracts* (Truong and Dustdar 2010; Misra and Mondal 2011). For example, cost-benefit estimation in cloud computing is likely to be complicated. When vendors decompose their services into small configurable units, users need to gauge their aggregate execution costs carefully. In the total cost-benefit calculation for cloud services, operational and hidden costs for IT interoperability need be considered, as do tangible and intangible benefits. On the other hand, an organization's experience with cloud contracts, especially how to achieve contract flexibility, will allow clients to balance the trade-offs among cost, benefit, time, perceived risk, and resource requirements (Koehler et al. 2010; Li 2011).

For the *organization's view of cloud market impacts*, we apply measures for the organization's ability to *leverage cloud market maturity*, and *stability of available market supply.* Standards, transparency, and reliability for vendor performance are basic market stabilizers (Hauff et al. 2014; ISACA 2012; Bhat 2013). They help to reduce firm-level uncertainty. A healthy cloud market will have a sufficient number of alternative services and vendors (ISACA 2012; Teo et al. 2003), so that clients will tend to reach a higher perceived readiness level. In addition, vendor stability, scale, and reputation are critical for estimating the risk involved in adoption (Pauley 2010). We use two vendor-related measures of firm-level perceptions: *vendor financial stability assessment*, and *vendor technical capacity assessment.* Related factors are process maturity, security breaches and outage news.

Regulation and environment

The final category describes the external business and regulatory environment constraints that an enterprise faces. The *external business environment* creates pressure, support or obstacles for adopting IT innovations. It can shape the strategic responses of firms that are affected by it (Miles and Snow 1978). According to Walker et al. (2003), the business

environment can be viewed in terms of several different things. They include: the stage of the relevant product life cycle; the extent of market segmentation, competition, and industry concentration; and the level of technological maturity and structure. Desarbo et al. (2005) suggested three environmental uncertainties: market, competitive and technology. Cloud computing services vendors deliver shared IT resources and capabilities with strong network effects for their clients. Past experience with one vendor's cloud services can generate imitative and conformance pressures on the client's beliefs about adoption (Messerschmidt and Hinz 2013; Espadanal and Oliveira 2012; Teo et al. 2003). Thus, we include three descriptors in the external business environment sub-category: *technology uncertainty, pressure from competitors,* and *pressure from alliance*s.

The *regulatory environment* constitutes the other important environmental sub-category, with the measure *regulatory considerations for the firm*. Different countries have different legal rules regarding data privacy, data sovereignty and local laws for data governance (Harris and Alter 2010). Many have laws requiring cloud providers to keep client data and copyrighted material within national boundaries (Armbrust et al. 2010). Such constraints are a bind in multinational business (Bhat 2013). We use new measures that recognize the relevance of regulatory constraints and data sovereignty issues based on ISACA (2012) and Armbrust et al. (2010). These may also influence senior managers' uncertainties about the readiness of the organization to move to the cloud.

Evidence from applying the cloud computing adoption metrics suite

All of these aspects of the metrics suite required multiple sources and kinds of background knowledge.[12] Both our field study in Singapore and feedback that we obtained suggest the value of considering the different types of cloud services, as well as the heterogeneous nature of the adopting organizations, when assessing the applicability of our metrics suite. We next provide descriptive overviews of the four cases that we will evaluate, and share the findings through the applications of the adoption readiness metrics suite.

Cases: descriptive overviews

Case 1. Cloud advertising-as-a-service (CAaaS): JetBlue and Salesforce JetBlue Airways (www.jetblue.com) adopted Salesforce.com's Buddy Media cloud advertising service with the intention to transform its social advertising campaigns in 2013 (Salesforce.com 2013). Its senior management's primary expectation was to achieve high productivity and enhanced flexibility for the launches of its ad campaigns with somewhat different designs. Buddy Media allowed JetBlue to focus its agency investment on strategic activities, to ensuring that ad targeting was improved and that more new customers and increased purchases where achieved. It simultaneously sought to de-emphasize the development of other more routine ad campaign development. Overall, JetBlue hope to save ad campaign execution expenses. JetBlue reported a number of specific goals for moving to cloud-based social advertising: (1) better productivity through easier advertisement and promotion tracking and scheduling, and greater impact with its promotions; (2) more visibility through extended reach to consumers, with higher campaign volume and improved alignment with audience demographics and psychographics; and (3) quick activation of social media promotions to target audiences around specific events. After the implementation of BuddyMedia social media-based advertising supported by the cloud, JetBlue reported a 140 % ROI, with 8 months to payback of its investment. It also reported an annual saving of US$72,916 in advertising production cost by extending its activities through CAaaS into the social media acquisition channel.

Case 2. Business process-as-a-service (BPaaS): global payments Global Payments provides e-transaction processing services for merchants, independent sales organizations, financial institutions, government agencies and multi-national corporations. It offers processing solutions for credit and debit cards, business-to-business purchasing cards, gift cards, e-check conversions and check guarantees, and verification and recovery services. Its Brazilian unit faced mounting pressures to reduce operating costs and to enhance quality control. The management opted for BPaaS services in order to enhance its financial and account service processes. The firm selected the Indian software and cloud services provider, Wipro (2014). This provides a scalable cloud-based ERP solution on the NetSuite platform to address Global Payment's

[12] The information sources for our analysis work in this section are as follows. (1) Industry reports and relevant cloud computing websites and forums provide information on vendor and technology performance. They help firms to get an idea about the technological maturity of a specific type of cloud computing service at the aggregate level. In addition, some vendors provide free trials of their services on their websites, which offers firms an opportunity to get a sense about vendor-specific technology information. (2) When considering the firm's own organizational factors, senior managers such as the CIO and the CEO will mainly rely on internal support from their staff to acquire relevant information. The firm also needs to have an appropriate understanding and self-evaluation of its overall strategy, organizational culture and capability, as well as a longer-term orientation and targets. (3) Cloud vendors' websites typically provide pricing information, which assists users to estimate the economic value of using cloud services. In addition, for a cloud computing services vendor, company reports are typically publicly available, so that firms can gauge their financial status and stability. And (4), to get a good understanding about regulatory constraints, firms need to pay attention to announcements on cloud-related government regulations and laws. For example, a government's requirements about security in terms of the boundaries of data storage are a key concern.

needs, and also lower complexity in the processing of billions of payment card, check and e-commerce transactions.

Case 3. Software-as-a-Service (SaaS): Dixons store group international and Citrix online In 2007 and 2008, Dixons Store Group International, the United Kingdom-based owner of the magazine *PC World*, launched an SaaS application called "TechFriend" for its TechGuys unit (Twentyone 2008). This was to provide users with 24 × 7 technical support beyond what typical PC sellers will offer. This was viewed by Dixons as a necessary step for the provision of customer service in a highly competitive after-purchase service market. TechFriend was successful and growing, but it generated many calls, and the service staff had to handle different problems at different levels of complexity. The SaaS solution by Citrix Online was called "GoToAssist." It provided the functionality for TechGuys to remotely take control of a user's PC in order to fix it.

Case 4. Infrastructure-as-a-Service (IaaS): ASOS Fashion and NaviSite ASOS.com, a rapidly expanding United Kingdom online fashion store, sought a flexible computing infrastructure solution in 2012 and 2013. It selected NaviSite's NaviCloud enterprise IaaS (Navisite 2014). NaviCloud made it easier for ASOS to set up new software development environments. This enabled the company to keep pace with application development to match its 30 % annual growth. Its first two cloud applications were the ASOS Fashion Finder and ASOS Marketplace. These represented interactive search and exchange environments, helping the organization to generate new revenues. Senior management viewed this services delivery software as a strategic, market-differentiating part of its business. An effective IaaS was thought to be a necessity to maintain a competitive edge for ASOS. Following the implementation of cloud services at ASOS in 2013, in January 2014, the firm reported a 38 % gain in global sales revenues for the prior year. This nearly matched the 37 % increase that occurred in its 2013 U.S. sales. In the fourth quarter of 2013, ASOS achieved £335.7 million in sales and two million shipped orders. NaviCloud-based developers were able to do new application tests in a day, instead of 2 weeks in-house. Also, the time for testing to production fell from 4 months to 2 days, and multiple software releases in a day became possible. ASOS gained agility in its new software deployment capabilities and greater financial control.

Applicability of metrics suite to the business cases

We next will assess some of the key considerations that managers are likely to take into when they contemplate adoption of the cloud computing services. Our analysis of the cloud services is organized by type: CAaaS, BPaaS, SaaS, and IaaS. We provide general remarks about the appropriation of business value for each service type, followed by supporting case evidence. Recall that the four cases span air travel advertising, financial services business process redesign, remote PC service consultation software, and online fashion sales order-taking. For each of the service types, we will comment on the extent that the various categories, sub-categories and measures are important. Although the exploratory case analysis we conduct here does not tell the whole story, it still gives useful information about the applicability of the different elements of the metrics suite to gauge firm-level adoption readiness in the eyes of senior management.

Cloud advertising-as-a-service (CAaaS) Our sources broadly suggest that the adoption of cloud advertising is chiefly driven by some key strategies of senior managers. The Internet and social media-based ad campaigns need to be created in fast response to changing business conditions. This has driven higher advertisement spending, greater ROI and lower costs. This strategy must be implementable in a manner that reflects an organization's innovativeness in its marketplace (Fujitsu 2014; Nucleus Research 2013; Salesforce.com 2013). The capabilities of firms that pursue social media marketing campaigns seem to vary a lot though. They go from relatively low to league-leading capabilities with marketing via this channel. So firm-level capabilities for absorbing new cloud computing projects and managing vendor relationships (Aral and Weill 2007; Hsu et al. 2014) were not much discussed for cloud advertising projects. Part of the reason may be that these are typically small in scale compared to other cloud projects, and so may show up "on the radar" a little less.

By the same token, social media advertising is not very much regulated (other than for information privacy, customer "opt in" and "opt out," and so on). So there are few concerns related to regulatory issues. On the other hand, external business environment factors, such as the speed of technology change, pressure from competitors and pressures in alliances all seem to be issues that create risk and uncertainty for senior management. As a result, they cannot be ignored in adoption (Messerschmidt and Hinz 2013). In addition, the consideration of how much a client will save or earn seems to be more important than the contract flexibility in this area, likely again due to the smaller-scale, shorter-term nature of cloud advertising projects (Miller 2014).

Analysis of Case 1: JetBlue and Salesforce The budget airline JetBlue Airways, as we noted earlier, became involved in social media advertising via the cloud with the involvement of Salesforce.com. JetBlue required sophisticated cloud infrastructure and application support for its social media ad-serving activities. So it was natural that the firm's senior management was highly concerned about uncertainty arising around network access to the Internet. Virtualization preparedness, in contrast, was not an issue for JetBlue. The evidence

we reviewed for JetBlue and Saleforce also suggested that the quality of cloud computing services mattered, especially whether adoption would involve additional uncertainty about security, availability and scalability. These things were standard "must haves" and were expected from capable vendors. This helped limit senior management's uncertainty about these issues. This was similar as uncertainty about vendor technical capacity assessment and vendor financial stability assessment, which constituted "due diligence" checks for all the different cloud computing services that we considered.

The JetBlue implementation of cloud advertising required the social media ad services intermediary, Social.com, in addition to the application builder, Salesforce. So it is clear in these and other cloud advertising services contexts that the solution had to suit the needs of multiple alliance partners and not just JetBlue itself (Armbrust et al. 2010).

Business process-as-a-service (BPaaS) The BPaaS model is a coupling of traditional business process outsourcing and SaaS that results in a new service delivery model. It enables standardized, yet highly-configurable and quickly-deployed processes. For example, human resources management business processes is one of many that BPaaS has transformed (Callewaert and Deckers 2011). With capabilities that are supported, such as *value-capture acceleration* and *consumption-based pricing*, BPaaS has earned a share of the large markets for outsourcing services involving finance and accounting, and procurement also, though not every business process is a sure "win" for their adopting organizations (Roy 2014). Relying on cloud services to support mission-critical business processes is a major undertaking for most organizations. The issues associated with the outsourcing of business processes are widely known (Lacity et al. 2011; Mani et al. 2006). *Network access* and *virtualization preparedness* are of typical importance, along with: *executive support; organizational innovativeness; vendor pricing, reputation and stability; the maturity of the cloud market; and technology change*. In addition, *contract flexibility* in large-scale IT services outsourcing projects is known to be of critical importance, as well as how much cost savings and higher revenues can be appropriated from adoption (Benaroch et al. 2010).

Analysis of case 2: global payments A leading provider of e-transaction processing services, Global Payments, sought to control operational costs while improving quality (Wipro 2014), as we noted earlier. The desire to attain a competitive edge by cost-effectively streamlining business processes has led to market demand for moving to BPaaS solutions. In this case, pressure from competitors and expected cost savings were two key drivers of adoption. Senior management at Global Payments had high expectations with respect to improved regulatory compliance and accelerating time to the market. These were some of the promised benefits of adopting the BPaaS model that were envisioned in the firm's relationship with Wipro.

Also, it is typical that firms that undertake large-scale outsourcing and cloud services projects, like Global Payments in this case, require high quality services. These include outstanding levels of information security, high up-time and availability, and effective scalability for business growth. The BPaaS services were aimed at automating the whole business processes involving finance and accounting at Global Payments. The intended outcome was to achieve a transformation of the firm in a comprehensive way. This would require exceptionally strong organizational capabilities to handle the resulting process changes to support the value appropriation. Taking business processes to the cloud are large bets on the strategic, economic, operational and customer service aspects. So it was natural that a greater span of considerations needed to be made to support Global Payments' adoption. For example, organizations must assume greater responsibilities for understanding the downsides of risk and uncertainty on payback from non-standard solutions. In BPaaS adoption, clients and vendors typically need to find ways to share these responsibilities.

Software-as-a-service (SaaS) SaaS is the most well-known by industry observers (Huang et al. 2014). The typical economic rationale for moving business applications to SaaS is to reduce cost and improve quality. Other goals are to make business start-ups activities faster, and avoid commitment to specific software development. This is especially true for projects with short lifecycle, or where the development trajectory may be uncertain and performance can only be tested once implementation occurs.

Organizations often choose SaaS to take advantage of compatibility for *network access* and v*irtualization*, and emphasize the importance of *security, availability and scalability* – all of which the vendor needs to do better than the client itself. So we typically expect to see the importance of these measures when the organization considers moving to SaaS. Also, because the kinds of applications that are moved to SaaS are not core business activities – these include accounts receivable and payment, pricing updates, and human resources, often the use of SaaS is not associated with organizational innovativeness or a big push from senior management. For SaaS, because adopting organizations can exert only limited control over the operations and maintenance of cloud resources, their concerns about IT governance and operations will also be relatively low.

Analysis of case 3: Dixons store group international This case shows an example of a medium-size firm in the U.K., Dixons Store Group International, which provides home computing technical support. The main emphases of the case

include the need for 24 × 7 operations, speed to set up the service, remote control of a customer's computer, flexibility to scale the size of the operations as the company's subscription based grew, and being able to re-focus on its customers' experience (Twentyone 2008). In hosted cloud applications like this, the emphasis is typically on expected cost-benefit and the available market supply of services, as opposed to unique organizational and strategy concerns, executive support, absorptive capacity, or organizational innovativeness. There also are no serious regulatory concerns. In this case, many SaaS vendors and applications are available, and most employ the standard subscription-based pricing. Thus, issues such as the depth of available services and the pricing mechanism used were not key considerations in Dixons' adoption decision.

Nevertheless, Dixons' management – as is the case with other SaaS users – certainly would have been duly diligent in checking out the capabilities of its vendor, Citrix Online, to ensure there was no unduly high risk that might arise from a lack of financially stability or technical capabilities. They also would have explored the extent to which Citrix offered contract flexibility, and could create acceptable ROI. There is no evidence in this case, or in Dixons' marketplace in general, that pressure from competitors or alliance partners, or the speed of technology change played any major roles. So this turns out to be a useful case in general terms: it shows some differences because SaaS involves a different cloud type, and Dixons is an adopter with unique and heterogeneous needs.

Infrastructure-as-a-service (IaaS) Some years ago, Huber (1993) reported on Continental Illinois Bank's decision to sign a 10-year contract to have IBM to take over its IT operations – the first money center bank in the U.S. to do so. In the past 5 years from 2011 to 2015, IaaS has become an alternative that is not so drastic a move as what Continental Illinois did, but decisions to outsource some aspects of IT infrastructure to the cloud still represent a bold maneuver for most organizations.

Our assessment of the various measures in the metrics suite for IaaS is that somewhat more of them will be critically important than the other cloud service types we have reviewed, especially in terms of organizational perceptions of risk and uncertainty. This also was suggested by (IBM 2009) and Rimal et al. (2011). Examples include: both the *compatibility* and *service quality* sub-categories will be important, as will *strategic orientation* and *organizational capabilities*. For IaaS clients, since they are taking their computing infrastructures to the cloud, they have to try to exert a high amount of control over the resources and so their organizational capabilities must be sophisticated enough for them to understand how to handle such resources. In contrast, it is likely to be the case that *economic and valuation* considerations will be only of a typical importance to IaaS clients (Alexander and Young 1996; Marston et al. 2011). In addition, the organization must work hard to ensure the *performance of the vendor* and *maturity* of IaaS services in the market (Hauff et al. 2014), but there are likely to be no more than typical pressures from competitors and alliance partners, unless the market niche is special.

Analysis of case 4: ASOS fashion ASOS.com, which operates in the online fashion apparel market in the U.K., experienced 30 % growth per annum of its online business. Its existing in-house infrastructure was not able to keep pace with such fast growth, putting the company at risk of missing market demand. It contracted with NaviSite for IaaS capabilities that emphasized infrastructure flexibility, easy-to-set up software development environments, and scalable and robust cloud computing services (Navisite 2014). Thus, the vendor's technology performance, such as services robustness and security, scalability, and network access, was among the top concerns.

ASOS approached the adoption decision by laying out goals for reducing the amount of time needed for application testing to production, as well as greater agility and financial control. It viewed NaviSite as a long-term and reliable business partner able to support its on-going business goals, instead of a pure technology provider. Convinced by the NaviCloud platform's performance, ASOS soon outsourced two of its most important and mission-critical production systems to the cloud. The senior management also recognized that, with the use of cloud services, there was a need to reshape and redefine the company's culture and customer relationships accordingly.

Relative importance of the adoption measures across cases

The analyses of these cases suggest some dimensions of the proposed adoption metrics suite have relatively higher importance than other dimensions in different cases (See Table 1).

Across the top in Table 1 are column headings for each case. Arrayed down the left-hand side of the table are the categories, sub-categories and measures in our proposed metrics suite that are of potential interest to organizations when they are considering adopting certain cloud computing services. The entries in the table are intended to identify the relative importance of these categories, sub-categories and measures for each of the four cloud service cases. We use a different number of asterisks to represent the relative importance of a measure. This is consistent with empirical research, which uses them to show the significance of a parameter in an estimated model. We use *** to mean of "relatively greater importance," ** to mean of "average importance," and * to mean of "relatively less importance."

We determine the relative importance of a measure based on the in-depth case analysis, our reading of industry articles and academic papers, what we learned from interviews with senior managers who have experience in cloud adoption and

Table 1 The relative importance of the adoption measures across four cloud computing services types

Categories (Sub-Categories)	JetBlue (CAaaS)	Global payments (BPaaS)	Dixons (SaaS)	ASOS (IaaS)
Technology and performance category				
• Perceived compatibility				
○ Network access	***	**	**	***
○ Virtualization preparedness	*	**	**	***
• Expected services quality				
○ Security	**	***	***	***
○ Availability	**	***	***	***
○ Scalability	**	***	***	***
Organization and strategy category				
• Strategic orientation				
○ Executive support	***	**	*	***
○ Organizational innovativeness	***	**	*	***
○ Perceived strategic value of the cloud	***	***	*	***
• Organizational capabilities				
○ Absorptive capacity for the cloud	*	***	*	***
○ Vendor management capacity	*	***	**	***
Economic and valuation category				
• Cloud service valuation				
○ Vendor's service terms	*	**	**	**
○ Estimated cost-benefit	***	***	**	**
○ Experience with cloud contracts	*	***	**	**
• Organization's view of cloud market impacts				
○ Ability to leverage cloud market maturity	**	**	*	**
○ Stability of available market supply	**	**	*	**
• Understanding of vendors				
○ Vendor financial stability assessment	**	**	**	**
○ Vendor technical capacity assessment	**	**	**	**
Regulation and environment category				
• External business environment				
○ Technology uncertainty	**	**	*	**
○ Pressure from competitors	**	***	*	*
Pressure from alliances	***	**	*	*
• Regulatory environment				
Regulatory considerations for the firm	*	**	*	**

The relative importance results presented here are intended only for the specific case analysis in each service type, and should not be taken as being generally true for others. In the metrics suite application, it indeed may yield different results, depending on the organizations

use, and multiple rounds of discussions among the authors.[13] The detailed process of evaluating relative importance of measures has been provided in the earlier Exploratory Research Methods section. For example, in the cases on CAaaS adoption, JetBlue, there was evidence that the potentially huge economic gains from moving to the cloud played a significant role, making the measure for estimated cost-benefit relatively important in comparison to the others. Also, the fact that a CAaaS solution relies on collaboration among multiple partners including the social media and services intermediary suggests that the organization's assessment of the pressure from alliances, just like network access and the risk and uncertainty that arise around it, is a key consideration for whether the firm can appropriate business value from CAaaS. Hence, we assigned three asterisks to both measures.

On the other hand, the outsourcing of social media advertising activities usually does not involve sensitive data being

[13] It is worthwhile to note that, rather than interpret these entries as being definitive, the reader should view them as broadly representative of relevant considerations for a specific type of cloud computing service, and more narrowly representative of our application of the metrics to the cases.

pushed across the boundary of the firm, nor does it require adjustments in organizational governance policy or mode of operation. This also was observed in the JetBlue case, which did not require fundamental transformations of its business processes to cope with the risks of information security. As a result, issues such as regulatory considerations, absorptive capacity for the cloud and vendor management capability are less important: the related risks were not viewed as being quite so large. We marked them with one asterisk.

Some additional discussion of the relative importance of measures seems appropriate. First, the measures in the metrics suite provide a generally good coverage of the issues that are likely to arise with the cloud adoption decision-making. Among them, the least important dimension turns out to be regulatory considerations in the regulatory environment subcategory. In mid-2014 in Singapore, the government instituted sweeping reforms and regulations via the Personal Data Protection Act (PDPA) of 2012 (Personal Data Protection Commission 2012), which charges organizations that handle private personal data to be much more cautious than even before. Such changes in regulations have occurred in many other countries in Asia, the Americas and Europe, and so it seems to be increasingly taken for granted that these issues will be handled carefully by cloud services vendors, in spite of the high concerns expressed in the past decade (Aron et al. 2005).

Second, most of the measures in the economic and valuation category appear to be relatively standard considerations in cloud adoption, as both our literature review and knowledge from market practice indicated. When cloud computing services initially entered the market, the emphasis was on providing affordable, cheap, and hassle-free IT resources and services, in contrast to the traditional in-house IT solutions. The market has embraced this idea. As a result, most adopters of cloud computing probably are already keenly aware that business value is a due diligence issue, and no cloud computing projects can go forward without essential economic value. In the seven entries for each of the four cloud computing services types, there were only 3 out of the 28 entries in the economic and valuation category for which relative importance was above average.

Third, adoption decisions in the four cloud services cases we have discussed will likely be marked by relatively common perceptions of market maturity. This may be less the case for some new services though, for example, for cloud management, platform and data analytics-as-a-service (DAaaS). In a mature market, cloud users will have more alternatives to choose (which may be confusing but beneficial nevertheless), and the value that organizations put on price and contract flexibility will affect their adoption decisions to a somewhat greater extent, until the market settles down and vendors standardize their pricing approaches. Less mature product and service markets typically have fewer vendors serving them. Clients thus have limited choices, which will tend to make their adoption decisions in a way that relies more on the track record of the individual vendor.

Implications for the business value of cloud computing adoption

Cloud computing will lead to fundamental changes in how enterprises conduct their IT-related activities. Bringing cloud solutions into a firm makes it necessary to mitigate business risk, and understand the potential for strategic advantage and improved profitability (Iyer and Henderson 2012). To achieve success, the firm need to adjust its business model, strategic goals, risk management, and IT governance policy. But this is hard: changes and adjustments all need to be made simultaneously. The metrics suite is helpful, since it offers a balanced view of adoption readiness across technology, economic, organizational, and external factors. With this in mind, we offer three propositions drawn from our empirical findings on the applicability of the firm-level adoption readiness metrics suite, recognizing its importance related to the different cloud services.

First, we state that the business value of cloud computing services to an adopting organization will be larger when it is able to make adjustments to pave the way for successful implementation. The metrics suite supports managerial efforts to identifying the issues that need to be addressed to diminish the adoption risk. They can develop from understanding the issues that arise from the external environment, organizational capabilities and readiness, as well as the technical and performance aspects and maturity of a specific type of cloud computing service in the market. Less experienced vendors, less market maturity, less standard technical capabilities, and less understanding of the economic and valuation outcomes are likely to affect any cloud adoption project negatively, and meanwhile the risks will be greater when less mature service types are involved. We assert:

- **Proposition 1 (The Business Value Versus Organizational Risk Proposition).** *A metrics suite for adoption readiness will help an organization to shift its focus from the expected level of business value through adoption to balancing business value* versus *risk in the adoption process. Recognizing the differences among the different cloud services will further support adopters to more fully articulate the value propositions* versus *the risks and uncertainties of adoption, and make better decisions.*

  Even experienced senior managers indicate that they are still learning about the impacts and consequences of cloud computing adoption. For example, many recognize that not all of the information they need regarding the fit costs of the services functionality will be known at the start (Ma and Kauffman 2014). This is likely to be a

learning-by-doing process, so the hidden costs and frictions of externally-provided IT services will be revealed only when the organization experiences them first hand. In addition, the impacts on existing IT staff and business policies related to changes in how computing resources are used within the organization will give rise to other risks that also cannot be fully understood before the cloud migration begins.

Although the evidence that we obtained from our empirical assessment of the metrics suite did not yield much insight into firm-level absorptive capacity, we nevertheless expect that there will be path dependence with respect to learning when organizations deal with new innovations (Cohen and Levinthal 1990). The experience acquired by managing the cloud adoption decision-making process through the metrics use will help organizations build cumulative knowledge for handling disruptive innovations. Since not everything can be planned in advance, especially with the newer forms of cloud computing services that have emerged in the market recently, decision-makers need to find ways to learn about cloud computing in the process of its use. We suggest:

- **Proposition 2 (The Organizational Learning Proposition).** *A metrics suite will aid decision-makers to view adoption as a learning process, so they can identify possible risks, uncertainties and costs prior to adoption, while making ongoing adjustments to support value production. They will need to be aware of the need to calibrate their learning efforts to deal with the riskier types of cloud services, such as BPaaS and IaaS, and the newer types, such as DAaaS.*

The design of an organization's structure, process, governance and transaction contents create value through the exploitation of business opportunities (Amit and Zott 2001). The paradigm shift that has occurred with cloud computing allows managerial decision-makers to refine or redesign their transaction-making processes to achieve business model innovation (Chesbrough 2010). To make such improvements and innovations, organizations need reliable and informative metrics to continuously monitor and create baselines for improved application, systems, process and infrastructure performance. Thus, we suggest:

- **Proposition 3 (The Continuous Performance Monitoring Proposition)N** *A metrics suite for firm-level cloud computing adoption readiness will encourage an organization to implement continuous performance monitoring, which will need to be tailored for the different kinds of impacts that various cloud services create. The services with less commoditized and less well understood impacts will need to be monitored the most closely to ensure that an appropriate level of ROI is obtained, and the organization's concerns about risk and uncertainty are effectively addressed.*

Concluding discussion

We conclude with a set of concise statements related to the research questions raised in the beginning of this article, the answers that we have obtained, and the basis for support and comments on our findings. (See Table 2.)

Practical contributions of this research

In this research, we developed a firm-level cloud computing adoption readiness metrics suite. We assessed the applicability of the metrics suite with four case studies that cover the four cloud services with the largest global share. We sought to integrate knowledge from industry and university research to reflect the strengths of practice and theory. The adoption readiness metrics suite is the result of this process, based on the definitions we developed for the categories and sub-categories of measures. It aims to help decision-makers to assess the value of adoption, the sources of risks and uncertainties in the process, and the overall readiness level of the firm. Thus, it serves as a useful measurement approach to support enterprise users' decision-making process for the move to cloud computing. To the best of our knowledge, this is the first research attempt in this direction.

Typically, decision-makers in organizations involve C-suite-level leaders – the CIOs, CEOs, senior managers who are in charge of external relations with vendors, and those who handle IT performance assessment. They can use the proposed metrics suite essentially to gauge the potential value as well as the associated risks that cloud adoption may bring to their organizations. Our case analyses in this research will provide a benchmark. An organization's senior management needs to take a similar approach, look at both external and internal factors their firm is facing – just like what we did for the four cases – and compare the nature of their situations with these successful adoption cases to assess their adoption timeline, strategy, and readiness preparation. Also, this evaluation process needs to be repeated, instead of being only a one-shot action – managers should do it before and during the adoption process to observe the changes, which will enable them to adjust their organizational strategies to support better value appropriation and risk control. Specifically, they can use the metrics suite in three ways, by:

(1) *Enumerating an organization's limits to the potential value of cloud adoption*. The procedure begins with an assessment of whether cloud adoption will permit the organization to create business value by gauging the categories, sub-categories and measures for which risks and uncertainties are present.
(2) *Evaluating the sources of the limits to value, both within and outside the organization*. The next

Table 2 Research questions, findings, support and comment

Research questions	Findings	Support and comment
During a cloud adoption decision-making process, what risks and uncertainties concern senior managers the most and what are the drivers and inhibitors of adoption in their view?	• Four categories of risk and uncertainty-generating issues were identified. • These affect senior management's perceptions of organizational readiness or lack of readiness for cloud computing adoption due to how they view the likelihood for appropriating business value. • The four categories included in the metrics suite are: ○ Technology, performance ○ Organization, strategy ○ Economics, valuation ○ Regulatory, environment • Multiple sub-categories were added, with specific measures that enable senior management to characterize the core risk issues. • Sub-categories were assessed prior to the case analysis, as well as after it, as a basis for evaluating robustness.	• Multidisciplinary literature, press, white papers. • Technical, managerial sides covered to create a full picture. • Adjusted to match our government, industry and academic informants' input on recognizing how the four categories, sub-categories and measures affect senior managerial perceptions. • Informants gave guidance on: categories, sub-category appropriateness; critical vs. non-critical measures; and reducing / adjusting the measures. • Pre-case assessment yielded useful information for adjusting the sub-categories. • Post-case analysis, input from peer reviewers pointed out the need to emphasize "perceptions" of risk and uncertainty, resulting in minor changes to the measures and sub-categories.
Will measures of risk and uncertainty enable an organization's senior management to understand the issues related to value appropriation for four different types of cloud services?	• The small exploratory sample of cases and interviews did not permit a generalizable assessment of the differences in the assessment of risk and uncertainty among the different types of cloud services. • Nevertheless, we did obtain a reading on the differences in relative importance for measures based on these cases. • We learned that evaluation differences occurred across all the four types of cloud services.	• The issue in the present work was not so much about generalizability; instead it was more about applicability and implementability. Support for these aspects was developed from the four cases. • We expect to see different opinions presented via the application of the metrics suite in terms of the degrees of importance of the measures. • The cases that we analyzed demonstrated the range of differences that might be observed.

important step for senior managers is to identify how to remove any roadblocks to the creation of business value. Leveraging the metrics suite and checking technological, organizational, economic and regulatory factors, management should better understand how to make the organization more ready internally, and work toward mitigating risks from the outside during adoption.

(3) *Examining the organization's evolution in its readiness over time.* Organizational readiness and ability to appropriate value from cloud computing change over time. The metrics suite offers a straightforward way to support continuous monitoring of how organizational cloud adoption readiness is evolving as time passes, technology changes, and the external environment and industry practices shift.

As management scientists who understand organizational behavior, we have to emphasize that adoption decision-making is much more complex. The application of the metrics suite is generally helpful to provide a structure to guide managers to understand various issues in adoption. Senior managers need to rely on multiple types and sources of data, including cloud industry reports and white papers, information on the vendors' websites, cloud computing adoption case studies, the organization's own internal reports, and government regulation-related announcements. In fact, many factors need to be considered, and the four categories proposed in the metrics suite may be only a subset of them.

There is always a trade-off between comprehensiveness and usability, as we learned from the interviews and field study work we have done, however. The senior managers from industry, government agency analysts and policy-makers that we interviewed offered useful ideas on how to improve the contents of the metrics suite without growing the number of its components. Their central concern was *usability*. They cautioned us to recognize the effort required to instantiate the knowledge that our metrics suite requires, and suggested that we could further reduce our metrics suite to about twelve to fourteen measures.

Theoretical contributions of this research

The main theoretical contributions involve our new arguments in the following aspects of this research. (1) We developed the

metrics suite categories, sub-categories and measures as a comprehensive representation of the theories that can be brought to bear on the problem of cloud computing readiness. (2) Our interpretation is that a firm's readiness is not an entirely internal organizational matter, but also something that influences senior management's perceptions of the risks and uncertainties associated with cloud adoption, so that it is necessary to consider external issues such as economic and regulatory factors. And (3) the kind of approach that we put forward in this research is supported by other theoretical perspectives, especially the theory of rational expectations from economics. The latter theory is important in our context because new technology adoption decision-making requires so much knowledge that IT managers may not have. This view enabled us to argue that the opinions of many probably track the ground truth of cloud computing services-led business value in the market-at-large, which is very helpful for organizational decision-makers.

Finally, we need to point out that the use of the adoption readiness metrics suite may not lead directly to an eventual adoption decision. When the organization does not exhibit readiness, adoption probably will not be recommended. The evaluation process actually will shed light on how the organization to identify what more it needs to do to reach adoption readiness. When an organization does show readiness, it still may be the case that adoption should not be undertaken immediately. There need to be financial resources available, and also a willingness on the part of management to undertake the risks that cloud computing services present. So, the proposed metrics suite is intended to act as a self-assessment tool for organizations, and not a 'go / no go' decision tool.

We recognize that there is a trade-off between the extraction of appropriate knowledge from the metrics suite use and the cost of its acquisition. There are too many measures identified by academic literature that may have influenced the success and readiness of cloud adoption, while our field interviews revealed that many of them are difficult to apply in organizations. The theory-practice gap is wide in this area. What we did was to winnow the list of possible measures, and identify those that were meaningful for senior managers to form a metrics suite that is practical for them to use. We have done our best so that the contents of the metrics suite do not require users to have detailed historical information about an organization, or even detailed knowledge about specific types of cloud computing. It's also not really necessary for users to respond with standard research scale-type responses. Instead, the most important thing that should come out of the use of the metrics suite is an appreciation of the extent to which cloud adoption will give the organization a sufficient understanding of future flows of business value in the presence of reasonably well-identified risks.

Factors beyond the metrics suite

We need to note that although our metrics suite represents the strongest factors related to the managers' perceptions of risks and uncertainties in the cloud adoption evaluation process, there are other influencing factors. That is what we learned from the field study and interviews, and it is a highly beneficial aspect of the qualitative empirical research work that we have accomplished.

During our interactions with senior managers at small and medium-size enterprises (SME) that are cloud computing adopters in Singapore, we realized that they understood the benefits of cloud computing pretty well. Many SMEs do not have established IT departments, so they often take advantage of the economic benefits of IT outsourcing. When they consider external factors such as the maturity of the cloud market, the available of reliable vendors, and the extent of competitor and alliance pressures, SME senior managers move to cloud computing because of the potential benefits it offers.

Large enterprises' decisions to adopt cloud computing are more complex though. They often have their own IT departments, so their managers will assess the risks and benefits of cloud computing more carefully. They will be suspicious about whether cloud technologies are sufficiently mature, especially in terms of their security and interoperability. Some adopted the different types of cloud services from different vendors, and expected high interoperability across them. Those enterprises that were especially concerned with information and network security often opt for in-house data centres or they chose to build their own private cloud computing capabilities.

We also found that an organization's age seems less relevant to cloud adoption decision-making in comparison to its management's strategic vision of the global orientation of its brands and operations, and its innovativeness in research and development. Nevertheless, start-ups and established businesses are likely to be equally cautious with respect to the key features of cloud computing, such as security, availability, and scalability. In addition, the features of the underlying industry sectors may affect the way an organization assesses its cloud adoption readiness. Firms in different sectors will have different business requirements for IT services, since their business processes and operations are likely to be quite different. The vendors have catered to specific industries over the years, especially those that were early adopters, and as a result, their service capabilities may not be very easily fit to other industries that were later to adopt. This may lead to a mismatch in the different levels of maturities or sophistication of cloud computing services, resulting in industry-specific perceptions of business value.

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Appendix A. Cloud computing services types, by market share of services

Table 3 Cloud computing services types with relative market shares in 2012

Model	Share	Description	Firms
Cloud advertising-as-a-service (CAaaS)	48.0 %	CAaaS. Processes to support the selection, transaction, and delivery of advertising and ad-related data, where content and price are determined at the time of end-user access, by an auction mechanism that matches bidders with impressions as they become available (Darrow 2013).	• HP • IBM • Oracle • Salesforce
Business process-as-a-service (BPaaS)	28.0 %	BPaasS. Business process outsourcing services that are sourced from the cloud and constructed for multi-tenancy. Services are often automated, and where human process actors are required, there is no dedicated labor pool per client. The pricing models are consumption-based or subscription-based commercial terms, and accessed via Internet-based technologies (Gartner 2014).	• Appian • Fujitsu • Oracle • Pegasystems • Salesforce
Software-as-a-service (SaaS)	14.7 %	SaaS. A software distribution model in which applications are hosted by a vendor or service provider and made available to clients over a network, typically the Internet. Offers hosted application management and software-on-demand, which makes it similar to application services providers (ASPs) in the 2000s (Callewaert et al. 2009; Rouse 2014a).	• Citrix Online • Google Apps • Oracle Fusion • NetSuite • Salesforce
Infrastructure-as-a-service (IaaS)	5.5 %	IaaS. Processing, storage, networks, and other fundamental computing resources, where the consumer is able to deploy and run any software (OS, apps, etc.). Consumers of IaaS are system developers and administrators, and IT managers interested in creating, installing, managing and monitoring services for IT infrastructure operations IaaS revenue represents the second largest share of the cloud market (Rouse 2014b).	• Amazon • Citrix Online • Eucalyptus • Oracle • RightScale • Salesforce
Cloud management-as-a-service (CMaaS)	2.8 %	CMaaS. Enable cloud services providers to monitor performance, continuity and efficiency in virtualized, on-demand environments. Services give access to tools that track networks, systems and application performance, as a way of gauging service delivery with restricted capacity, and assuring high-performance (DeCarlo 2014).	• HP • IBM • Joyent • Oracle • Terremark
Platform-as-a-service (PaaS)	~1 %	PaaS. Provides platform layer resources, including operating system support and software development frameworks. Enterprise users of PaaS are typically in the development or testing areas of software engineering industry. By itself, PaaS is a small niche market in an early stage (Rouse 2014c), but is viewed as directly connected with IaaS.	• Amazon • Caspio • Google • Heroku • Microsoft
Data analytics-as-a-service (DAaaS)	<1 %	DAaaS. Provides an analytics platform using a cloud-based delivery model, where various tools for data analytics are available and can be configured by the user to efficiently process and analyze huge quantities of heterogeneous data. Clients feed enterprise data into the platform, and get back concrete and useful analytic insights. These insights are generated by analytics apps, which orchestrate data analysis workflows (Güemes 2013).	• Amazon • IBM • Microsoft • Oracle • SAP • SAS

(1) Gartner (2013) recently laid out a detailed view of how cloud services should be classified. Some, however, consider CAaaS, BPaaS, and DAaaS to be instances of SaaS. This is because they primarily involve the use of software to deliver different types of services. And CMaaS is one type of PaaS. If we apply this traditional view of the most frequently adopted classes of cloud computing services, their market shares were: SaaS (~91.7 %), IaaS (5.5 %), and PaaS (~3.8 %)

(2) There are a number of other cloud computing services, including: application platform (APaaS), backup (BaaS), communications (CaaS), desktop or database (DaaS), disaster recovery (DRaaS), hardware (HaaS), integrated platform (IPaas), and storage (STaaS) (Güemes 2013). These only have tiny service shares overall, and are not included in this table

Appendix B. Estimated economic impacts of cloud computing services

(Table 4).

Table 4 University, industry and government assessments: works published from 2009–2014

Authors	Publication, method	Comments
• University-based estimates		
Etro (2009)	Review of Business and Economics; dynamic stochastic general equilibrium model with endogenous market structures from macroecon.	Viewed cloud computing as general purpose technology. Assessed effects on business value creation, employment and output in Europe; noted the broad-based diminution in the fixed costs of IT capital for cloud firm market entry. Estimated growth of workforces in different European Community countries due to cloud computing innovations.
Han et al. (2011)	Information Systems Research; microeconomic production function analysis, with panel data for 60 NAICS industries (1998–2006), and 92 SIC manufacturing industries (1987–1999)	Reported that the average annual growth rate of IT capital for two IT service industries in the United States over the period from 1998 to 2006 was 23 %. Noted that this was two times the rate of growth for IT capital at 11.5 % in the rest of the American economy. And showed that different performance levels were observed for industries with low-intensity versus high-intensity IT capital investments.
Iansiti and Richards (2012)	Technology Policy and Management	Developed a model and forecasted that investment in cloud computing would increase the gross domestic product (GDP) of the U.S. by 8.64 % to 10.37 % in the years from 2010 to 2020, about 0.83 to 0.99 % per year. Also estimated that this would result in increases of IT capital stock of 63 % for developed and 72 % for developing countries from 2010 to 2020.
• Industry and government-based estimates		
Centre for Economics and Business Research (2010, 2011)	Two-part study of Europe, Middle East and Africa (EMEA). One studied Italy, France, Germany, Spain and the UK; the other studied im-pact on EMEA region impact	Projected €763 billion in economic benefits between 2010 and 2015 in EMEA, with 24.1 % of the gains occurring in the banking, financial and business services sectors, and 30.6 % flowing into the distribution, retail and hospitality sectors. Benefits across the region for direct and indirect employment gains expected at 2.4 million new jobs.
European Commission (2014)	White paper, developed under the 'Digital Agenda for Europe' and the 'Europe 2020 Initiative'	Did not report economic impacts based on macroeconomic or microeconomic theory and analytics methods, but called for new metrics studies on cloud computing impacts to make this kind of knowledge available in Europe.
Fujitsu (2014)	Report: The Impact of Cloud, in association with the Economist Intelligence Unit	Projected that the key economic impacts will result in the reshaping of business markets and firm operations. Noted cost flexibility as the primary driver for firm-level adoption. Predicted that cloud computing will cause firms to shift to network organizational forms, away from current hierarchical organizational forms.
KPMG (2011)	White paper, in cooperation with: Department of Broadband, Communication and Digital Economy, Australian Government, SalesForce. Microsoft, Google, Fujitsu, Hitachi and others.	Forecasted between impacts of market adoption of public cloud computing services in Australia on its annual GDP at the 50 % and 75 % uptake levels. Economic impacts expected to be in the range of A$1.01 to A$1.44 billion in IT capital, and A$1.15 to A$1.87 billion per year in operational capital, for a total of between A$2.15 to A$3.32 billion per year additional capital investment and expense.
Manyika et al. (2013)	McKinsey Global Institute	US$1.7 to US$6.2 trillion annually by 2025 in economic impact from cloud computing, with US$3 trillion in expected enterprise IT spending, and 80 % adoption by firms in the North American region.

We caution *Electronic Markets* readers that the qualitative observations we have included, and the financial and employment effects impacts in this table may be subject to debate. They should not be viewed as estimates, not *ground truth*. They may be biased and subject to various kinds of errors. We view them as indicators of the future state of the world that many industry observers have recognized is likely. The Carnegie Mellon University economist John Muth, who is widely recognized as the "father" of *rational expectations economics*, offered a useful interpretation of forecasting in a seminal article published in *Econometrica*. Muth (1961, p. 316) averred: "Averages of expectations in an industry are more accurate than naive models and as accurate as elaborate equation systems, although there are considerable cross-sectional differences of opinion." He further noted that "reported expectations generally underestimate the extent of changes that actually take place." If we consider Muth's views, then the ground truth of future impacts from the cloud may not be far away from what industry, government and academic researchers have reported. We thank an anonymous reviewer for offering helpful suggestions

Appendix C. Details of the cloud adoption readiness metrics suite

Table 5 Categories, sub-categories, measures, supporting literature and related disciplines

Categories	Sub-categories, measures and proxies	Measures	Supporting literature	Related disciplines
Technology and performance. Assesses whether the characteristics of cloud computing solutionscreate uncertainty with respect to the fit with existing IT and systems.	Perceived compatibility. Risk with degree that cloud technology fits with potential adopter's organizational values, practices and needs. Expected service quality. Risk that service quality that a client expects meets its aspiration for achieving appropriate ROI.	*Network access*: Uncertainty with current and future network size and availability. *Virtualization preparedness*: Client's experience and capability to create and use a virtual version of IT resources. *Security*: Contract loopholes, data privacy, information security, and service outages. *Availability*: Uncertainty about percentage of time a client will have access to services. *Scalability*: Uncertainty that services can be scaled over time to match client's demand.	Armbrust et al. (2010) Grover et al. (1996) Pitt et al. (1995) Vouk (2008) Garg et al. (2013) Jamshidi et al. (2013)	Software engineering Service science Cloud computing
Organization and strategy. Assesses to what extent cloud computing matches with firm's strategic orientation and organizational capacities.	Strategic orientation. Extent and stability of leadership support for technology innovations in the organizations that have the capacity to change its business processes and profitability performance profile. Organizational capabilities. Capability to adjust governance policy, strategy, and operations to support appropriation of business value and achievement of ROI.	*Executive support*: Decision-makers' commitment and support for cloud adoption in the organization. *Organizational innovativeness*: Perceived risk with organization's intention to adopt cloud services as an IT innovation, and then to stay the course with stable commitment. *Perceived strategic value:* Clarity of senior management's understanding of the strategic and competitive advantages associated with cloud computing in the organization. *Absorptive capacity for the cloud:* Firm's capability to acquire external and internal knowledge so it will be able to implement it in a way that promotes value appropriation. *Vendor management capacity*: Risk with managing cloud services relationships that require contractual governance.	Aral and Weill (2007) Barczak et al. (2007) Buyya et al. (2010) Liao et al. (2003) Low et al. (2011) Messerschmidt and Hinz (2013) Poppo and Zenger (2002)	Cloud computing Strategic management Technology adoption Outsourcing Grid computing
Economics and valuation. Evaluates the risk and uncertainty with the economic suitability and appropriability of business value of cloud computing.	Cloud service valuation. Risks and uncertainties that arise from the organization's knowledge of and ability to forecast the business value of cloud computing in terms of actual and expected costs and benefits.	*Vendor service terms*: Organization's risk and uncertainty with whether the vendor will offer flexibility (usage-based fees, subscription fees, and hybrid pricing). *Estimated cost-benefit*: Uncertainty about total cost of cloud services, including contract costs, expenses of operational processes and systems adjustment, and hidden costs for IT interoperability to support benefits. *Experience with cloud contracts*: Especially uncertainty on whether organization has	Hauff et al. (2014) ISACA (2012) Koehler et al. (2010) Li (2011) Pauley (2010) Truong and Dustdar (2010)	Cloud computing IS economics Information and cyber-security

Table 5 (continued)

Categories	Sub-categories, measures and proxies	Measures	Supporting literature	Related disciplines
		option to exit a cloud contract with no harmful or unexpected costs.		
	Organization's view of cloud market impacts. Economic supply-and-demand relationship in cloud market, which creates uncertainty when there is instability and lack of sufficient service supply.	*Ability to leverage cloud market maturity*: Whether risk arises for the organization with the lack of maturity and stability with vendors in the cloud services market.		
		Stability of available market supply: Uncertainty of senior management about whether alternative cloud vendors are available.		
	Understanding of vendors. Managers' perceptions of risk with vendor stability, scale, and reputation pertaining to process maturity.	*Vendor financial stability assessment*: Whether the vendor is known to be financially stable, so that no major risks have to be borne by firm with cloud adoption.		
		Vendor technical capacity assessment: Whether there is uncertainty associated with the vendor's technical sophistication to deliver effective and reliable cloud services.		
Regulation and environment. Assesses the potential impact of organization's perceptions of impact of external issues that may affect the viability and value of its cloud computing services adoption.	Regulatory environment. Management's perceptions of risks with data, privacy practices and the law.	*Regulatory considerations for the firm*: Create risk and uncertainty for the organization related to how vendors must handle and protect client data, and whether they are in compliance with related legal restrictions.	Miles and Snow (1978) Desarbo et al. (2005) Walker et al. (2003) Messerschmidt and Hinz (2013)	Strategic management Grid computing Public policy
	External business environment. The degree to which external business environment issues create uncertainties that affect the organization's perceived ability to achieve high ROI through the decision to adopt cloud computing practices.	*Technology uncertainty*: Tech standards, new technologies, and other issues related to interoperability affect organizational perceptions of whether ROI can be achieved.		
		Pressure from competitors: Actions of competing firms and their cloud strategies create uncertainties for whether firm is adoption-ready and can handle market pressures.		
		Pressure from alliances: Other uncertainties arise when organization become involved in multi-firm alliances that require co-adoption of new cloud computing practices.		

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