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A 2020 perspective on "Client risk informedness in brokered cloud services: An experimental pricing study"

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Abstract: Cloud computing and the cloud services market have advanced in the past ten years. Cloud services now include most information technology (IT) services from fundamental computing services to more cutting- edge artificial intelligence (AI) services. Accordingly, opportunities have emerged for research on the design of new market features to improve the cloud services market to benefit providers and users. Based on our observation of the recent development of cloud services, in this short research commentary, we share our agenda for future studies of this important sector of IT services.

Keywords: Cloud computing, Digital intermediation, IT services, Market design, Pricing

When we first started a research project on the cloud computing services market in 2012, cloud computing was still in its peak of inflated expectations stage, as suggested by Gartner. The consultancy predicted that cloud computing would become mainstream adoption in two to five years (LeHong and Fenn, 2012). Over the past decade, cloud computing has advanced quickly, and public cloud adoption recently reached 94%, according to a survey conducted by Flexera (2019). The landscape of cloud computing services has also expanded from its original focus on IaaS (infrastructure), PaaS (platform), and SaaS (software) to numerous "X-as-a-service" offerings that include everything from the Internet of Things to machine learning, artificial intelligence (AI) and analytical services on the cloud.

Though the cloud computing services market is still dominated by the big players – Amazon, Microsoft, Google, and Alibaba – areas such as AI have opened up opportunities for other providers to create new services and compete with the big players. As a result, the strategies and business models observed in the market remain in a state of flux.

In our article published in ECRA (Shang et al., 2020), we discussed and illustrated the importance of intermediation and pricing mechanism designs to the cloud services market. In this research commentary, we share our research agenda related to market design issues for cloud computing services, based on our observation of their recent development.

1. Marketplace design for cloud computing services

One of the recent trends in cloud computing services is the adoption of multi-cloud services, a practice in which enterprises use multiple cloud providers for different application workloads to meet different technical or business requirements (Flexera, 2019).1 One of the drivers of multi-cloud services adoption is to avoid becoming locked into a particular cloud provider's services, in addition to improving the performance and resilience of such services.

Today, cloud applications based on containers and microservices are technically ready to be portable between different clouds. As a result, there is a growing, but only recently recognized need to design and develop new marketplaces for cloud computing services, in ways that are similar to energy markets. This form of market exchange via trading of cloud resources as commodities will help to increase the liquidity of cloud computing services, creating fuller utilization and greater market-generated welfare. This also will provide the desired flexibility on the user side to be able to convert unutilized resources into money.

This is a fruitful research direction because it is necessary to develop and test different market designs, business models, and pricing strategies, to see what will work the best in the emerging markets. There are also opportunities to conduct research to understand the distribution of prices across cloud providers that offer similar services. The operation of a relatively efficient financial market for cloud services should serve to rationalize prices and make it easier for clients to optimize their cloud spending. In addition, new instruments, similar to financial instruments in financial markets, can be created to support the transfer of cloud services resources from one client to another, a broker to another broker, and so on, by embedding the appropriate options in tradable contracts.

2. Platform design for cloud computing services

Cloud computing services providers create IT services ecosystems by building platforms that consists of cloud computing services providers, cloud applications vendors, services brokers, and services clients. Amazon, Microsoft, and Google all have cloud platforms to provide customers with services that range from computation and storage to machine learning and AI. The latter, AI, is an area of growth for these providers as they work toward establishing machine learning platforms. According to a recent Gartner white paper (Smith and Burke, 2019), AI PaaS is now in its peak of inflated expectations stage and still has five to ten years to achieve mainstream adoption. Users wishing to benefit from these high-growth areas are choosing cloud computing services as a means for creating a basis for and developing their AI and machine learning efforts.

To foster the AI services available on their platforms, these cloud providers have been opening up their platforms to software vendors and developers. Many have also been active in promoting open source development, as is evident in Microsoft's acquisition of Revolution R (Smith, 2015), IBM's acquisition of Red Hat (Lardinois, 2019), and Google's acquisition of Kaggle (Linley, 2017).

These platforms can play an important role in fostering innovation and AI services development by promoting more flexible licensing and pricing models. Related opportunities are available to researchers to investigate what licensing and monetization models can promote the creation or co-creation of AI services and optimize the value created by the ecosystem in order to maximize growth. For example, software vendors offer pre-configured software solutions in Amazon Machine Image (AMI) as well as SaaS formats, all hosted on AWS (2020). Clients can customize cloud applications and build business solutions on top of the AWS platform, with flexible pricing options and simplified software licensing arrangements. A blend of license, subscription and usage models is needed by software vendors on the platforms.

3. Algorithms for cloud management

While cloud services users rely on "X-as-a-service" functionality for data storage to analytics, cloud management still is a big challenge for them. There are variations in how services are provided and consumed in the market, and thus there is a need for cloud management console that can free clients from uncertainty about adoption, use, workload management, and demand-and-supply conditions in their day-to-day operations.

As we wrote in our article, cloud brokers are natural intermediaries that mitigate the risks of exchange and support improvements in the quality of markets for IT services. Many brokered services vendors, such as Data Dog (datadoghq.com) with its cloud service monitoring and data analytics, and SpotInst (www.spotinst.com) with its cloud infrastructure automation to improve performance, reduce complexity and optimize costs, have

designed and built management consoles to enable customers to manage multiple systems, services and providers. They apply various resource management techniques to provide more streamlined and reliable services to clients.

Related opportunities are available to researchers to port ideas from statistical analysis, risk management, and machine learning into cloud computing services management practice to make cloud computing more refined and potentially frictionless. For example, risk management is one of the major performance parameters of cloud management. It is possible for cloud services users to hedge against the consequences of potential service outages or interruptions by purchasing insurance policies to transfer the risks to insurers (Mastroeni and Naldi, 2017). New algorithms can be developed for the forecasting and evaluation of financial risks associated with cloud failure. In addition, predictive analytics and machine learning can be applied to design insurance policies and gauge the risk that cloud services users file claims against the insurers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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