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Cloud adaptiveness within industry sectors – Measurement and observations

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ABSTRACT

Cloud computing combines established computing technologies and outsourcing advantages into a new ICT paradigm that is generally expected to foster productivity and economic growth. However, despite a series of studies on the drivers of cloud adoption, evidence of its economic effects is lacking, possibly because many of the datasets on cloud computing are of insufficient size and often lack a time dimension as well as precise definitions of cloud computing, thus making them unsuitable for rigorous quantitative analysis. To overcome these limitations, we propose a proxy variable for cloud computing usage—*cloud adaptiveness*—based on survey panel data from European firms. Observations based on a descriptive analysis suggest three important aspects for further research. First, cloud studies should be conducted at the industry level as cloud computing adaptiveness differs widely across industry sectors. Second, it is important to know what firms do with cloud computing to understand the economic mechanisms and effects triggered by this innovation. And third, cloud adaptiveness is potentially correlated to a firm's position in the supply chain and thus the type of output it produces as well as the market in which it operates. Our indicator can be employed to further analyze the effects of cloud computing in the context of firm heterogeneity.

1. Introduction

Although mention of "the Cloud," or cloud computing, is now ubiquitous in daily life, our understanding of what it actually is and how it changes private and corporate structures is surprisingly limited. Most people recognize cloud computing as a fairly recent development in information and communication technology (ICT). However, the wide range of opinions of what constitutes cloud computing and how it affects households and enterprises is a partial reflection of the many different uses of cloud computing and the resulting lack of a universally accepted and understood definition of it.

Beginning several decades ago, advances in processor and related technologies and the spread of the personal computer, as well as server structures and communication infrastructure like the Internet, helped automatize production and supply chains and facilitate management and administration. ICT as a whole was expected to have a great influence on the productivity of industries and economies. Indeed, as suggested by Cardona, Kretschmer, and Strobel (2013), ICT has some of the hallmarks of enabling or general purpose technologies that are widely adopted and induce further innovations.

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Various authors identify positive productivity effects from ICT utilization (Brynjolfsson & Hitt, 2003; Bresnahan, Brynjolfsson, Erik, & Hitt, 2002; Jorgenson, 2001, 2005; Jorgenson, Ho, & Stiroh, 2005). These productivity effects coincided with a massive reduction in hardware prices over the last decades, which has spurred investment in IT and communication equipment (Jorgenson, 2001). Jorgenson (2005) finds that despite productivity growth rates being by far the highest in ICT-producing industries, the overall contribution of these industries to economic growth in the United States has been rather limited due to their low share of the economy. As ICT became more widely used, its main growth contribution came from total factor productivity (TFP) growth in ICT-using industries while growth rates in ICT-producing industries plateaued (Jorgenson, 2007). Similar empirical evidence is given by Brynjolfsson and Hitt (1995, 1996, 2003) and Tambe and Hitt (2012) on the effect of computers on firm-level productivity, confirming aggregate findings and painting a more nuanced picture. Cardona et al. (2013) give an overview of research on aggregate and firm-level ICT productivity effects.

"The Cloud" as a logical continuation of ICT-specific services emerged as an architectural innovation (Henderson & Clark, 1990) that was the result of isolated innovative processes and extended data transmission possibilities. Market research estimated the global private and corporate cloud computing market to have reached $56.6 billion (on public cloud services only) in 2014 and it is projected to more than double that by 2018 (IDC, 2014). Eurostat (Giannakouris & Smihily, 2014) reports that 19% of EU enterprises used cloud computing in 2014, mostly for hosting their e-mail systems and storing files in electronic form. The economic benefits of cloud computing adoption in the business segment of Europe's largest economies are estimated to have created 2.3 million net new jobs between 2010 and 2015 (Center for Economics & Business Research, 2010). Hence, major structural changes and productivity-enhancing effects are expected from the usage and diffusion of cloud computing. However, frustratingly for researchers wanting to investigate and quantify the growth impact of cloud computing, data on this phenomenon continue to be scarce.

We aim to advance the understanding of enterprise cloud computing as well as of the firms using it and the potential mechanisms triggered by implementation of this innovation. One of our contributions is that we propose an indirect measure of current or prospective cloud computing adoption that allows researchers to use existing large-scale firm-level panel datasets to analyze cloud diffusion and productivity effects via a reliable and plausible proxy. This is of particular importance as many extant surveys do not employ a precisely defined or even generally accepted measure and longitudinal studies are yet to be conducted. We utilize the widely used Harte Hanks technology database for 13 European countries and the years 2000 through 2007 to develop our cloud indicator and then merge this technology data with balance sheet information from the ORBIS database. Applying our indicator to the data, we make six observations on firm-level cloud computing regarding possible correlates of adoption and the correlation between firm productivity and cloud computing in the context of structural differences in industry sectors. These observations show how the economic effects of cloud computing could be analyzed using our indicator so as to provide initial insight into empirical cloud computing economics and shape an agenda for further research on cloud computing. We derive the following three suggestions for further research:

1. As adaptiveness of cloud computing differs widely across industry sectors, studies on cloud computing should be conducted at the industry level. For example, in our sample, services exhibit especially high adoption rates.
2. We need to understand why firms implement cloud solutions and what they actually do with the Cloud. Do they intend to increase productivity or flexibility, or both?
3. Cloud adaptiveness is potentially correlated to a firm's position in the supply chain and thus suggests a linkage of cloud adaptiveness and the type of output the firm produces as well as the market in which it operates.

We first outline the concept and market of cloud computing (Section 2). In Section 3, compile existing first steps toward a theory of cloud computing economics and review the empirical literature on the topic. Section 4 introduces the data and our measure of cloud adaptiveness; Section 5 presents six observations from descriptive analyses of this dataset. Section 6 concludes.

2. A primer in cloud computing

2.1. From shared infrastructure to cloud

These days, the commercial world is characterized by a trend toward sharing, for example, sharing companies, crowdsourcing, and open design platforms (Gansky, 2010). Interestingly, information technology sharing has a long tradition. The history of computing and IT begins in the late 1950s with the arrival of the first mainframe computers. These were mostly found in universities and governmental organizations, where one machine filled a large room and served all the researchers or employees of an institution, who therefore shared the infrastructure. IBM was the most important producer and developer of this kind of computing architecture (Bresnahan & Greenstein, 1996; Pallis, 2010). Mainframes had high upfront costs for hardware and software and were therefore optimized for efficiency. The newly founded insurance company CompuServe, started renting out idle computing capacity to other companies around 1970, introducing capacity sharing across organizations. This was the first step toward a network of computers. However, hardware advances favored decentralization. Personal computers, such as the Commodore PET (introduced in 1977) and the Amiga 1000 (1985), were