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### Cloud Computing and Productivity of the UK Economy

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This paper focuses on the impact of cloud technologies on the productivity of enterprises in the UK. The central belief is that cloud computing gives a boost to company productivity thanks to automation, intangibles and financial channel (Acemoglu and Restrepo, 2018, Bloom and Pierrri, 2018, Ewens et al. 2018). However, traditional IT technologies were blamed for having no significant impact on productivity (Doms, Dunne and Troske 1997, Morrison 1996). This problem is known as a productivity paradox (Brynjolffson 1993, Solow 1987). As cloud technologies are the next development step of previous IT technologies, this poses the question of whether modern cloud technologies have a positive and economically significant impact on the productivity of enterprises.

The paper utilizes the data of cloud usage statistics in the UK from financial reports of enterprises. The dataset contains more than 800 thousand companies and includes the major part of enterprises throughout the UK. It has been used to find empirical evidence about the positive impact of cloud computing technologies on the productivity of firms. This large scale study proves that the benefit of the usage of cloud technologies is increasing throughout time and is more prominent for small UK companies because of the nature of cloud computing technologies (Jin et al., 2017). This recent tendency is opposite to what was happening with traditional IT investments where, due to high upfront costs, larger companies could afford to invest more in traditional IT infrastructure (Bugamelli, Pagano 2004).

In order to answer the main question about the influence of cloud technologies on the productivity of UK enterprises, the authors used a register of companies that had website addresses. We collected financial indicators of companies` performance, such as income and profit indicators, financial ratios, number of employees, statistics about foreign and own investments. Financial statistics were used in order to assess the performance of the given enterprise.

The second part of the data gathering process was to combine financial statistics collected with cloud usage statistics. Unfortunately, statistics about cloud usage and companies` expenses have been insufficiently collected and studied in the UK. Therefore, this part of the data gathering process required web scraping techniques and some analysis of the Internet infrastructure. Using

metadata that companies leave in the Internet records, it is possible to grasp whether the given company uses cloud-related technologies.

Every website that the company owns has DNS metadata left as a publicly available footprint. Domain name service (DNS) is a register of companies websites along with physical addresses of actual servers (Internet Protocol addresses or IPs of the server) that is used to host the website. DNS record will contain the name of a vendor who hosts a company website. In general, every company decides the way they want their website to be hosted.

Companies can build their web site using their servers, employ vendors to host a website for them (hosting providers) or use cloud-related infrastructures. Therefore, a name mentioned in the DNS record can be a name of the company itself, traditional web hosting vendor, or cloud technologies vendor. An assumption is that if a company is spotted in using cloud vendor to host their website, there is a certain probability that it also uses other cloud-related technologies. The primary rationale beyond this assumption is that it is suboptimal for a company to use cloud deployment for a website without using any other cloud-related technologies.

In order to build cloud usage indicators, the authors use a history of DNS records generously provided by SecurityTrails. We get the data for all companies listed in the financial dataset (FAME) from 2008 till 2018. We classify web hosting providers as cloud and non-cloud ones. In such a way, we build the indicator of cloud usage by assigning one (1) to companies that employ cloud-related vendors for their website hosting, and zero (0) otherwise.

We also add other useful information about the usage of modern technologies by utilizing additional website metadata. Available information discloses additional services that the company uses, such as Gmail, Outlook, Salesforce, SharePoint and many other technologies. We use an output per worker as an outcome indicator of the company's productivity.

As the first stage of analysis, we perform a statistical analysis of the data gathered. The data tells us that cloud adopters have a persistently more substantial return on capital employed than non-cloud firms. Moreover, non-cloud enterprises have lower operating profit. The interesting fact is that companies that did not use cloud before 2016 have had higher fixed assets and substantially lower fixed assets since 2016. Also, non-cloud adopters had higher operating profits before 2016 cloud adoption and lower operating profit after 2016 cloud adoption. These two facts may suggest that patterns that were true before 2016 (big companies had a higher tendency to incorporate new technologies) were reversed. After 2016, smaller companies tend to adopt technologies more eagerly. Cloud adopters have a higher turnover in all consecutive years after 2016. The final observation is that companies using cloud services pay fewer dividends. The observation validates work of Brynjolfsson and Yang (1997), showing that ICT investments positively influence the value of the firm.

As a final step, we built regression and propensity score matching models in order to relate the usage of the cloud to the differences between companies in terms of financial indicators. Both

models show consistent and positive, economically and statistically significant impact of cloud technologies on the productivity of the company. According to the models, cloud usage in 2018 gives an additional 5 per cent to the sales per employee ratio, and 7,5 per cent for cloud usage in 2017. Companies that started to use the cloud in 2010 have an additional 15 per cent to sales per employee ratio in 2018. These observations confirm the general rule of all ICT investments telling that their impact rises through time (Brynjolfsson and Hitt, 2000). Additional analysis will be carried out by size of firms etc.