**HAS THE AGE OF COVID-19 PROMPTED**

**TECHNOLOGICAL ADAPTATION OR INNOVATION**

**IN THE CORPORATE WORKPLACE?**

By

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Interdisciplinary Honors Thesis

Rutgers University Honors College

April 24, 2023

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ABSTRACT

  The job market is a scary and unpredictable place for a graduating senior, and the past three years of a pandemic only adds to the uncertainty. Factors that come with working in a corporate office environment became more variable. This research intends to bring some clarity for graduating students by evaluating business technology adaptation trends throughout the pandemic, and it asks the question: has the age of COVID-19 prompted technological adaptation or innovation in the corporate workplace? The research begins with exploring broader business information-technology categories under the OECD statistics, running ANOVA (Analysis of Variance) tests to determine the categories that went through significant changes. Then, further, more in-depth tests (fixed-effect linear regression; “xt-reg” command on STATA) are conducted on specific sub-categories, using datasets from the Eurostat database. The datasets represented three industries: “Computer programming, consultancy, and information service activities”, “Publishing, motion picture, video, television program production; sound recording, programming and broadcasting activities”, and “Legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities”. Results shows that while all three industries showed a constant rise in business technology adaptation, computer programming, consultancy, and information service activities are investing in purchasing cloud computing power at an increasing rate. While the impact of the pandemic was not evident across results of all industries, the constant increasing trend over time reflects the digital transformation phenomenon occurring across all industry. The clarity that can be taken away by a graduating student who envision working at a similar corporate environment in the near future is the skillsets in demand due to this trend. Having transferrable skillsets like analytical skills, computer programming, and data gathering better prepares graduate to face a working environment where digitalization and cloud computing power are gaining prominence.

INTRODUCTION

         Since the first breakout of the COVID-19 virus, people’s lives have drastically changed. Disruptions were created in all aspects of life. The official outbreak in the US occurred in January 2020, and statewide lockdowns were implemented thereafter (Centers for Disease Control and Prevention, 2023). People were recommended to stay home and minimize in-person contact to minimize risks of further spread. All parts of life were affected, and work was a major one. During that period, empty offices brought major concerns for small business owners and even corporate tycoons. The COVID-19 climate created a make-or-break situation; whether businesses were determined to push through the hardships by progressing and adapting or to allow disruptions to annihilate operations entirely, there was no option in between. The first year of the pandemic resulted in over 200,000 extra businesses to shut down (Simon 2021); one-third of US small businesses have shut down due to the pandemic.

         From the worker’s perspective, the pandemic has brought the same amount of uncertainty while millions find themselves jobless through COVID-19. In the UK, workers were largely classified as “essential” or “unessential”. This mainly referred to the necessity for the workers to work in person as opposed to working from home (Chao-Fong, 2021). In the corporate and business world, the majority of employees were referred to as the latter. Lower wage jobs were affected differently in that they seldom had the luxury of working from home (Yasenov, 2020). In a completely isolated work environment, how does it impact work efficiency and how does its social impact call for and promote respective technological adaptations or innovations? This is a question this thesis attempts to address. Workplace technology became paramount for businesses that pushed through the hardships, especially for companies that have larger employer populations.

Workplace technologies have been progressing exponentially prior to the pandemic. From hardware to software, technologies of various forms have found their place in the workplace environment (Manyika, 2017). The implementation of technology has promoted communication, efficiency, security, training, and automation. Hence, at the turn of the pandemic, the change and shift truly occurred with the choice of integrating those technologies into their routine work process.

         One of the greatest beneficiaries of the pandemic in terms of revenue and users gained – is Zoom (Bond, 2020). Video conversation naturally became the next best option in the absence of in-person interaction. While Zoom was created long ago, it was only widely adapted after the breakout of COVID-19. One aspect of this was to fill the social void created by the lack of human interaction. However, Zoom’s enabling of immediate virtual face-to-face communication received varying feedback. Opponents claim the sensation of the interaction to be flawed and do not fill the social gaps (Murphy, 2020); proponents argue that it is a more effective way of communication in a corporate setting in that it does not require people to physically be in one location, which offers more flexibility and possibility for work itself (Agustin, 2021).

         Beyond video conference applications that are more common and mundane, technologies such as artificial intelligence (AI), machine learning, and virtual reality (VR) have all found their way into corporate settings (Cohen, 2023). These are having an equal amount of impact on businesses as communication applications. AI and machine learning have transformed consumer businesses, particularly in customer service (Siegel, 2023). Consumer companies such as clothing brands have adopted AI in replacing or assisting real people (Das et al., 2023). Some chose to use AI in an initial filtering process that replies to customer questions with relevant predetermined written responses, and employers will come into play if the customers need further assistance; others decided to completely replace humans with this system (Streets, 2021). VR has also been adopted by similar businesses largely as a stay-at-home solution for the consumer sector. While premature, VR is able to deliver the sensation of being at a location without actual physical presence (Steed et al., 2016).

         As we gradually walk out of the shadows of the COVID-19 pandemic and evaluate its totality of shifts and effects, we see that large corporations have already announced their blueprints for the future of their working settings. Meta, Twitter, Microsoft, J.P Morgan, and Deloitte are just a few notable firms that have announced their work-from-home plans moving forward that includes either a partial workforce to have the choice to work from home or their entire workforce (O’Loughlin, 2023). Hence, it is apparent that this disruption, in particular, caused by the pandemic will be permanent for the foreseeable future. This suggests that companies have experienced a net positive impact – whether that is an increase in worker efficiency, worker satisfaction, productivity, cost efficiency, etc. – through implementing their remote work system. The system is enabled by structural changes but also technological innovations or adaptations.

What types of office technologies were adopted by companies during the pandemic? Do these decisions change depending on the industry of the company? That will be the conclusion from the data analysis.

METHODOLOGY

Description of Data

         Has the era of COVID-19 prompted technological adaptation in the corporate workplace? And what does the future hold for those technologies after the pandemic? The data used in this analysis is published by the database of the Organization for Economic Co-operation and Development (OECD). OECD is an international organization that overlooks economic development across its 38 member nations, and its database records a wide range of indicators ranging from fields like agriculture to education to healthcare. For the relevance of this analysis, data points were extracted under the category of Information and Communications Technology (ICT) Access and Usage in enterprises under the category of Digital Economy and Society and Science, Technology, and Digital Society.

         The full dataset consists of 49 indicators under 7 general categories that included connectivity, website, information management tools, e-commerce, cloud computing, CT skills, and social media. These indicators were recorded from 25 of the 38 OECD member nations. The data was then further compiled under the 8 categories by taking the numerical average of all indicators under a category for each country. For representation and comparison, the years 2018 and 2020 were chosen as representations for pre and post-pandemic benchmarks.

         Then Anova tests were run on the compiled data sheet. Individual tests were run per category from 2018 to 2020, per country across all categories from 2018 to 2020, and across all categories in each year. To evaluate whether these indicators showed significance in change, the p-value was set at 0.05 to maintain a 95% confidence interval.

RESULTS

ANOVA

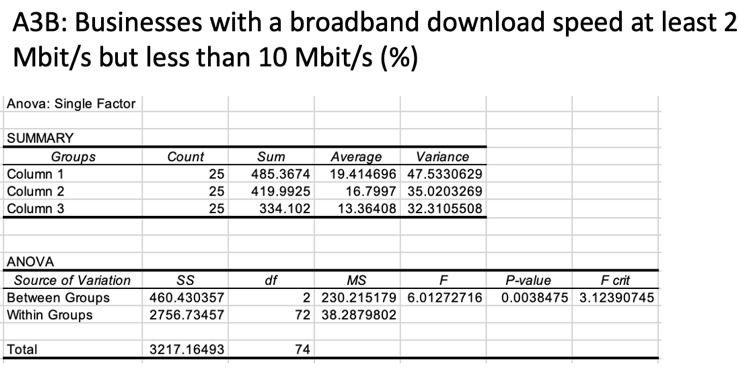
         Notable results were categories of Cloud Computing and Connectivity when evaluating them as individual categories across the two years. Connectivity change demonstrated a p-value of 0.0017<0.05, leading to conclude that the usage and access of connectivity technology showed significant change from 2018 to 2020. Results from Cloud Computing showed a p-value of 0.010<0.05, marking the conclusion that the usage and access of cloud computing technology showed significant change. With a null hypothesis of there is no significant change in Connectivity and Cloud Computing usage from 2018 to 2020, significant change indicated by the p-value (95% confidence) means that we should reject the null hypothesis.

Then, to take a more detailed look at sub-categories under Connectivity and Cloud Computing, I conducted individual ANOVAs on categories under Connectivity: Businesses with a wired or fixed wired broadband connection (%), Businesses with a mobile broadband connection (%), Businesses with a broadband download speed at least 2 Mbit/s but less than 10 Mbit/s (%), and Businesses with a broadband download speed at least 100 Mbit/s (%).

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Results show that sub-categories A3B (over 3 years) and A3E (over 5 years), which are indicators that measure the proportion of companies that have a slow or high-speed internet connection, reflect the statistical significance of p<0.05. Furthermore, while the proportion of businesses with a slow-speed internet connection is gradually falling through the years, the proportion of businesses with a higher download speed is increasing at an accelerating rate. This would suggest a number of firms decided to upgrade to a faster internet connection to accommodate the capacity of operations that is online. This observation of the results leaves little room for more nuanced and in-depth research. However, in conjunction with Cloud Computing statistics, these results provided a fundamental explanation for the increased adoption of cloud technologies.

Categories under Cloud Computing include (1) Businesses purchasing cloud computing services (%), (2) Businesses having performed big data analysis (%), (3) Businesses using the Internet of Things (IoT) (%), and (4) Businesses using Artificial Intelligence (AI) (%). Internet of things is defined as “the network of physical objects - “things” - that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet” (Oracle).

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Categories G3 and G13 showed significance in change throughout the years. Over the five years, there was a significant rise in the proportion of businesses that purchased cloud computing services, which would partially explain more businesses turning to faster internet connections. Although the same trend was present in the proportion of businesses using IoT (G13), the result is less significant and applicable because of the lack of data points across a significant number of years. Hence, category G13 was then identified to require more in-depth speculation for change in the businesses’ usage of cloud computing services.

Segregated Data Description

NACE Rev.2 activities pertaining to cloud computing services constitute a subsidiary dataset housed within the Euostat database. This comprehensive database contains panel data of businesses across various industries such as manufacturing, wholesale, and consulting, operating within European Union (EU) countries. The dataset also includes various concentrations of cloud computing services adopted by businesses: cloud computing services, security software, customer relationship management (CRM) services, office software, etc.

To better answer the prompt related to business technology use in corporate workplaces and conclude with more nuance, three specific cloud computing categories were chosen across three representative industries. “Buy office software”, “Buy Customer Relationship Management (CRM) software”, and “Buy computing power to run the enterprise's own software” were chosen in industries of “Computer programming, consultancy, and information service activities”, “Publishing, motion picture, video, television program production; sound recording, programming and broadcasting activities”, and “Legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities”. The categories were chosen to ensure a sufficient amount of data across a significant number of countries and years while maintaining relevance to answering the prompt. The methodology used here is the “xt-reg” - fixed-effects and population-averaged linear models - command in STATA to reach a more precise result. Since data was selected for three industries across three types of cloud computing services, preparation of data was required for each of the nine panel-datasets.

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Table . Example for Eurostat Datasheet

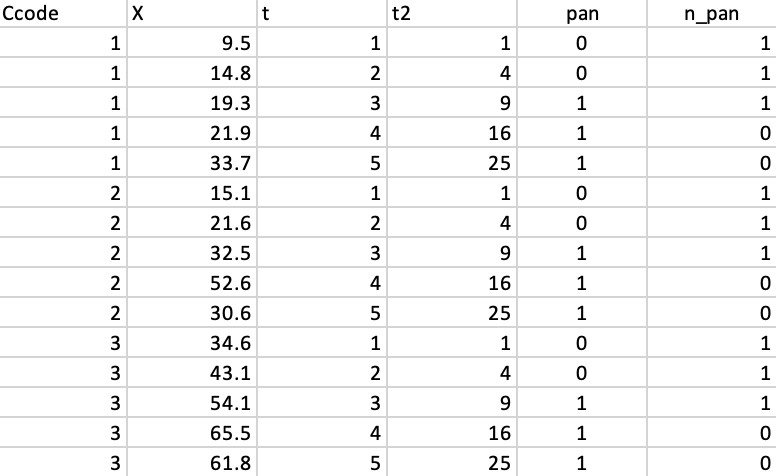
The first step involved cleaning the data of missing (when a country is missing multiple years of data points) or irrelevant (aggregated data across the European Union) datapoints to ensure consistency. Each dataset was able to retain up to 75% of its original data points. For the data to fit STATA formatting, the original panel data required to be traversed and stacked so all countries across all years are under a collective column with each country assigned an arbitrary country code.



Table 2. Example for 3 Countries Over 5 Years

Table 3. Example Country Code List

Additional variables were added to complete the dataset. Variable “X” denoted all the corresponding proportions of businesses for each country each year; “t” and “t2” represent the constant time variable and an exponential time-squared variable; and “pan” and “n\_pan” represent the years considered under the influence of COVID-19 and otherwise.

Before preforming the “xt-reg” command, STATA requires the panel data/variable to be declared; in this case, “Ccode” is the declared panel variable. The following regressions are all run with four variables unless specified otherwise.

Results by Industries

* Computer programming, consultancy, and information service activities

The industry’s investment on CRM software has grown as indicated by the significant, positive coefficient of the t variable. The p-value on the t-squared variable is just above the 0.05 threshold, and the pan variable shows no statistical significance. Investment on office software had a significant 16.5 coefficient for the t variable and a significant t-squared variable with p-value 0.018. The pan value yielded a 0.245 p-value (>0,05). Investment on computing power increased. This is indicated by the positive t variable coefficient with a 0.033 p-value. There was no statistical significance from variables t-squared or pan.

* Publishing, programming and broadcasting activities

The industry showed a positive increase over time investing in business office software with a 9.44 coefficient and 0.01 p-value. The t-squared variable and pan variable showed no significance with p-values greater than 0.05. The time trend is paired with a moderate R-squared of 0.53. The insignificant results held for the industry’s investment on CRM software. The t-variable’s significance level was marginally close to 0.05. The industry showed a significant increase in the purchase of business computing power: the t variable had a 6.49 coefficient with a 0.031 p-value (<0.05). The other three variables showed no significance.

* Legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities

The industry showed an insignificant decreasing trend with a negative 2.37 t coefficient; t-squared was positive and significant; and the pan variable was also insignificant. However, when the regression only included the x, t, and pan variables, the t variable indicated a positive significant change over time. All variables for the industry’s investment in CRM software showed no significance; the t coefficient was positive and significant when regressing x with t only. The industry’s investment in business computing power showed marginal insignificant change with a 0.07 t coefficient with a 0.961 p-value. T-squared was significant (0.012 p-value) with a 0.54 coefficient. The pan variable was negative and insignificant.

DUSCUSSION

The general upward trend of businesses investing in cloud computing services was reflected by the overall significance in change of the category through the years. While more than one category showed statistical significance, Businesses Purchasing Cloud Computing Services (%) was the only category that included a sufficient number of years and countries along with a significant p-value. This sufficiency in data allow the trend indicated by its results to be robust enough for further research.

From the STATA regression test results, the industry of computer programming, consultancy, and information service activities showed the most increase investment on the three types of business technologies. This was strongly indicated by the significance of multiple t-squared variables, indicating an increase in the rate of change. The industry of Legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities showed the least amount of change throughout the years. Nevertheless, across all three industry types, most results indicated at least a linear change was evident as indicated by the significant and positive t coefficients, suggesting that there has been a positive trend of businesses investing in cloud computing business technologies over the years. In some cases, there was a rise in the rate of the increase. Cloud computing business technologies are gaining prominence in the corporate office environment.

It is important to note the low r-squared values in most of the regression results. The statistic (also known as the Coefficient of Determination) measures the proportion of data in the dependent variable explained by the independent variable. All the tests had a moderate to low r-squared value, suggesting that the independent variable does not account for much of the dependent variable. This also means that datapoints provided for the regression does not uniformly fit a specific linear trend over time. The low the r-squared value, the more scattered the datapoints are. However, a low r-squared value does not inhibit the results from concluding a general trend as this research intends.

LIMITATION

A major limitation to this research was the limited amount of available data. It was difficult to find a sufficient amount of data available to the public that is relevant to answering the question. The Eurostat data set adopted in this research process could only answer so much, which affects the accuracy and credibility of the conclusion. The statistics merely provide descriptive data of the proportion of businesses in a single country that adopt a type of action regarding office technology. Even in this data, there entails many uncertainties. It is unknown whether the list of businesses surveyed every year is fixed, which means that there could be more to disclose, good or bad, behind the proportions. Additionally, while the database offers a plethora of datasets across a wide variety of topics, many of the datasets are partially incomplete. Part of the research and testing process was to find data sets on topics that were relevant and included enough data for the results to be relevant and representative. The process also included cleaning datasets such as deleting countries and years with missing data. The effect of this is that not all OECD nations were included in the regression testing, which renders less robust results.

To answer the question of whether the period of COVID-19 prompted technological innovation or adaptation in the corporate workplace with more comprehensiveness would require improvements on setting clearer boundaries about the prompt enabled by the plentifulness of data. To begin with, the “period of COVID-19” itself requires more definition. The first COVID case was detected in December 2019, but its global effects did not happen until April 2020. Furthermore, companies would have felt the need for technological adjustments in their operations much later than that. The problem then is when that boundary of time can be properly defined to answer the question. Types of technologies should also be better defined. The technology in this research covers several general and broad categories of technologies, and the result would be more explanatory if the datasets could be more specific in which technologies specifically are included.

However, more definition in the research prompt cannot be achieved without the luxury of relevant and sufficient data. The prompt of this research is formed around the information provided by the Eurostat database. For example, the year 2020 was used as the year of the beginning of COVID-19. Surely, it would be better to exact the time to quarters or months, but the data itself closed off that possibility which led to the generalization. The general categories provided by the database made it difficult for the research to conducted on a particular type of office technology.

The nature of the data serves as another major limitation. The data was presented in a panel form, which leaves little room for further analysis with the only variables being the year and the corresponding proportion for each country. The only plausible statistical method that could be applied to the datasets were fixed-effect regressions with the assistance of dummy variables.

The usage of two different databases to reach one conclusion hurts its credibility. Although the ANOVAs and regression tests were run across near identical nations (mostly European countries), the specific businesses surveyed that constitutes the X variable could be drastically different.

FUTURE IMPROVEMENTS

High p-values for the pan variable held true for across all nine regressions. On the surface, this suggests that, over the period of the pandemic, there was no significant increase in the business’ adoption of the three types of office technologies, which deviated from the speculation. Though there was no other method to prove or disprove these results with the data available. Regardless of whether there, in reality, was a change in the rate of investments during the pandemic, the pan variable itself does require further polishing enabled by larger and more detailed datasets. In most datasets, the years of available/complete data ends in 2021, which means the pan variable can only take the value “1” for two years. As a result, the regression testing results are merely from comparing one year against another. An immediate fix to this issue would be to categorize 2019 as a pandemic year, but this change will not yield accurate, relevant results even if statistically significant. The better approach would be to gather more datapoints for each year, whether to involve more countries or to have more statistics from each country (having country data in time unit of month rather than year). This will allow the regression test to have more information to process and more datapoints to compare. Another approach, which is the most reasonable and effective, is to wait and incorporate statistics from 2022. By elongating the time period for the pan variable, the regression test will be more nuanced and achieve a more realistic reflection of the real world. 2022 is also important in that it marks the year that many countries announced plans of moving past the shadows of the pandemic and easing COVID-19 regulations. To have datapoints from 2022 would allow the effects of the pandemic to be reflected completely.

To have a more precise conclusion, the results would require a higher r-squared value, suggesting that the independent variable has a substantial effect on the dependent variable. This would mean that, graphically, the datapoints will be tighter surrounding a regression line over the years, yielding more confidence in stating a more precise result rather than a general trend.

CONCLUSION

Has the age of COVID-19 prompted technological adaptation or innovation in the corporate workplace? While the test results of this research do not answer the specific questions asked prior to the research process regarding whether future working environments and colleague interactions in corporate offices will be in-person, hybrid, or virtual, this research shows a clear direction from business investment trends in office technologies throughout the pandemic. This research uses the OECD Database and Eurostat Statistics to determine the overall increasingly adapted business technology over years before and during the pandemic. Then, it takes a deeper look into the cloud computing services category to conclude that Cloud Computing Services have seen the most gain in prominence in corporate workplaces in European countries. Furthermore, the research looks at the change in adaptation in three types of cloud computing service technologies across three industries. The industries of computer programming, consultancy, and information service activities take lead in investments in cloud computing business technologies.

This research topic stemmed from providing some clarity to graduating undergraduate seniors who wishes to enter the job market and get a job in a similar corporate environment. The test results indicate and validify the strong wave of digitization storming all industries and working environments that goes beyond working relationships on the front end. Digitalization refers to businesses integrating digital technologies or software computing power to their traditional business models to enable greater business agility and efficiency, better suited for the future. As students, the main takeaway from this trend is the skillsets that are rising in demand by employers. To better fit businesses of the future, students should adapt towards transferrable skillsets like data analytics, software engineering, and computer programming. These are skillsets demanded by job positions across all fields of work.

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