The Impact of Digitalization on Income Inequality in Singapore

Lantian Christina Ma*

United World College of South East Asia (Dover Campus), 139654 Singapore

* Corresponding author. Email: christina201808@hotmail.com

Abstract. Digitalization has become one of the most significant trends experienced by the workforce. However, debates about whether it really benefits the population by offering them with more opportunities, or would exacerbate inequality because of Skill-Biased Technological Change (SBTC) that favours workers with digital literacy, has not yet been settled. This paper serves to investigate the correlation between digitalisation and income inequality (Gini coefficient) in Singapore. Linear regression analysis correlating Gini coefficient (representing income inequality) with percentage of household with internet access (representing individual use of the internet) showed a negative relationship between the two variables, suggesting more individual and household access to the internet helps alleviating income inequality in Singapore. In contrast, linear regression of Gini coefficient and percentage of businesses with broadband subscriptions (representing digitalization of businesses) found that an increase in digitalization within businesses would exacerbate income inequality due to SBTC. A special investigation into the effects on gender pay gap is undertaken, with similar trends obtained when it is correlated with the percentage of household with internet access and the percentage of businesses with broadband subscriptions, but the scales of such correlation are much smaller, possibly because of other social factors that also influence the wages of males and females.

Keywords: Income inequality, Singapore, Internet Access, Digitalization.

1 Introduction

Amongst the key technological advances of mankind, the adoption of computers and the Internet has been a revolutionary factor in reshaping the structure and organisation of workplaces, as well as the nature of occupations demanded. Koch characterises this change as the third wave of the industrial revolution, shifting the focus of production from manufacturing to services in most developed countries [1]. Digitalization, "the adoption or increase in use of digital or computer technology by an organization, industry, country, etc." has become the new normal for most operations today [2]. The International Monetary Fund (IMF) found an average of 6 percent annual increase in

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the rate of digitalization for high income countries [3]. In competitive markets, digitalization enables companies to adapt to rapidly changing market conditions and optimize their processes, operations, and management, for greater efficiency [4]. Digitalization is historically more prevalent among the less contact-intensive sectors and more widely-adopted in larger companies compared to smaller ones. However, during the COVID-19 pandemic, smaller companies caught up, increasing their shares of workers with internet access [3]. With more companies going digital, digital literacy will become a firmer requirement for more occupations.

Seeing how the COVID-19 pandemic accelerated digitalization in workplaces, the Singapore Government realized the importance of equipping its population with digital skills. In 2022, the Infocomm Media Development Authority's (IMDA) of Singapore launched the Digital for Life (DfL) movement with the aim of "bring[ing] together Singaporeans from all ages and walks of life to embrace digital learning as a lifelong pursuit" [5]. The movement is mainly separated in two branches: Digital Technology and Inclusion and Digital Literacy and Wellness. The former part focuses on enabling a wider base of the population to gain access to basic digital services and digital literacy, while the latter one emphasizes the education of cybersecurity and digital well-being [5]. The IMDA also encourages its partner organizations to propose educational projects (can be supported with its Digital for Life Fund if approved), especially targeting vulnerable populations: seniors, youths from disadvantaged backgrounds, low-income or migrant women, as well as people with disability.

With interest in the IMDA's decision promote this project to bridge the digital skill gap among the population, this paper would examine if the impact of digitalization on income inequality in Singapore, in other words, if the DfL project will be an effective way to narrow the income gap. Since the author has volunteered in a Non-Governmental Organization (NGO) that offers education to low-income or migrant women in Singapore, special attention will be devoted to the changes in gender wage gap.

This paper will firstly present a literature review outlining previous research findings on the impact of digitalization and access to information technology infrastructures on households and businesses, as well as their effects of shaping inequality. Then, the paper would present data taken from the Singapore Government's websites on its Gini coefficient (a measure of inequality), percentage of households with access to internet, business broadband coverage, and gender wage gap, over the past 10 years (2013-2022). Correlation analysis and linear regression was deployed to determine the impact of adopting digital technologies in households and businesses on income inequality.

This paper found that Gini coefficient is negatively correlated with the percentage of households with internet access but is positively correlated with business broadband coverage. Going digital in households may empower a wider base of the population to gain access to basic services with smart digital software, which boosts the productivity of these workers because they enjoy more efficient and convenient lifestyles. Digitalization of businesses, on the other hand, creates Skill-Biased Technological Change (SBTC) that favours people with digital literacy and skills related to information technology, granting them higher wages. This leads to the exacerbation of the wage gap, which is being addressed with DfL and its partner organizations' educational efforts as well as the support for low-end services to go digital.

2 Literature Review

The mass adoption of digital technology was unprecedented and has often inflicted the debate among scholars regarding its impact – whether digitalization would accelerate or alleviate the problem of income inequality, the uneven distribution of earnings in an economy. Depending on the time, area, and method of study, answers often vary, shining light on different aspects of the problem, revealing the complexity of such correlation.

Some scholars have found that digitalization decreases income inequality and even reduces poverty in many countries, although the magnitude of such impact appears to be stronger for regions with a lower income. Research by Yin and Choi over the period of 2002-2018 in the Group of Twenty (G20) Countries found that in general, income inequality decreased with a wider adoption of digital technology in production [6]. This effect, however, is stronger for middle-income countries compared to high-income countries [6]. Mora-Rivera and García-Mora observed that Internet access helped reduce both extreme and multi-dimensional poverty in Mexico, and this impact is stronger in rural areas in Mexico compared to urban areas [7]. Faizah et al. revealed a strong correlation between an increase in Information and Communication Technology (ICT) infrastructure and decreasing inequality in Indonesia, similarly finding a stronger extent of the change in lower-income regions [8].

On the other hand, many researchers argued the opposite: digitalization would bring about an increase in income inequality due to the uneven rates and needs of adopting digital technology between firms. Qureshi maintains that the benefits of technology are not yet enjoyed by all the firms equally and is in fact, captured mostly by a small number of large firms [9]. The growth in the gap between productivity among the "frontier" firms and "non-frontier" firms would be reflected in the widening gap between income for workers in many economies, especially the OECD countries [9]. Ali et al. concluded that gross ICT affordability is positively associated with income distribution and socio-economic inequality in Australia [10]. Barrantes and Galperin's research in Latin America obtained the finding that the affordability of communication and internet services seems to be a barrier for low-income households to gain greater access to the benefits brought by digitalization, and thus increasing income inequality [11].

The effect of the COVID-19 pandemic cannot be dismissed. The World Bank held the view that the declining global inequality achieved in the two decades has been reversed by the pandemic [12]. Tavares from the International Monetary Fund (IMF) points out the two sides of accelerated digitalization during and after the pandemic: in the long run, economies would benefit from increased productivity; whereas in the short run, labour market inequality between digital and non-digital workers is likely to increase. However, whether there would be a structural change in the employment structure remains unclear, as the less digitalised sectors seemed to rebound more strongly than widely digitalised sectors [13]. As such, the impact of the pandemic may be worth further investigation.

Existing research focused on a variety of contexts, with differing geographical locations and average income levels. Some conclude that digitalization would narrow the income gap by making information technology more accessible while others argue that

digitalization is a barrier for smaller firms or lower-income individuals to compete in the labour market. This inconclusive debate with merits on both sides provides an overview of the correlation between digitalization and income inequality, but the actual scenario in the area of study would depend on the context.

Limited research focuses on how digitalization impacts the Singaporean population. A few glimpses into the conditions can be seen from National University of Singapore's (NUS) report [14], which shows that the internet access rate is significantly lower for residents in public housing (45%) compared to residents in private housing (90%). Such unequal access would expose the low-income households to the physical dangers of the pandemic with a lack of awareness of the virus, as well as impeding their need for home-based learning and working. They have also found participation gaps where people's ability to use technology fully for learning, networking and work further differ between income levels, which are believed to widen social and economic inequality [14]. However, there seems to be a consensus that digitalization accelerated by the COVID-19 pandemic has widened socio-economic inequality.

3 Method and Data

Variables including Gini coefficient (after taxes), percentage (%) of population with internet access, number/percentage of businesses with broadband subscriptions, and average earnings by gender were chosen as representations of the rates of digitalization as well as the effects manifested on income inequality. They were all taken from credible databases from official websites, such as the Department of Statistics Singapore, IMDA, Ministry of Manpower Singapore, and World Bank. Correlation analysis and linear regression were employed to find the correlation between the variables mentioned above. Table 1 summarizes raw and processed data for these variables. The variables that are used in the "Results and Discussion" section (section 4) was bolded. The row, "% Business with broadband subscriptions" is calculated by dividing the values of "Number of businesses with broadband subscriptions" by the values of "Total number of businesses". The row "Gender pay gap" is calculated by subtracting the average month earnings for female workers from that of the male workers.

Table 1. Raw and processed data table [15-19].

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gini coefficient	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.35	0.36	0.36
% Population with internet access	81	82	83	84	84	88	89	92	91	92
Number of businesses with broadband subscriptions (thousands)	96.15	103.03	110.95	116.4	123.75	129.03	122.08	124.58	128.33	130.95
Total number of businesses (thousands)	222.1	244.2	247.6	249	255.7	264.1	273.8	282.3	292.4	299.8
% Businesses with broadband subscriptions	43.29	42.19	44.81	46.75	48.40	48.85	44.59	44.13	43.89	43.68
Average monthly earnings for male workers (SGD)	5,291	5,412	5,584	5,774	5,935	6,118	6,266	6,308	6,473	6,957
Average monthly earnings for female workers (SGD)	3,909	4,006	4,172	4,353	4,509	4,693	4,827	4,972	5,137	5,497
Gender pay gap	1,382	1,406	1,412	1,421	1,426	1,425	1,439	1,366	1,336	1,460

4 Results and Discussion

4.1 Gini Coefficient vs Percentage of Population with Internet Access

The Gini coefficient of income inequality is calculated by plotting a curve relating the cumulative percentages of the population against the cumulative proportions of income and finding the difference of the areas between the perfect equality line and the curve obtained with the distribution of income in the population. With a range from 0 to 1, the higher the number is, the more unequal the income is distributed. According to table 1, both the Gini coefficient and percentage of population with internet access showed a consistent decrease or increase from 2013 to 2020. The disruption of the pattern was likely to be a result of the pandemic in 2021, which pushed back against the normal rate of progress in the Singaporean economy. The correlation of the two variables is plotted in the scatterplot of Figure 1 with a least-square regression line.

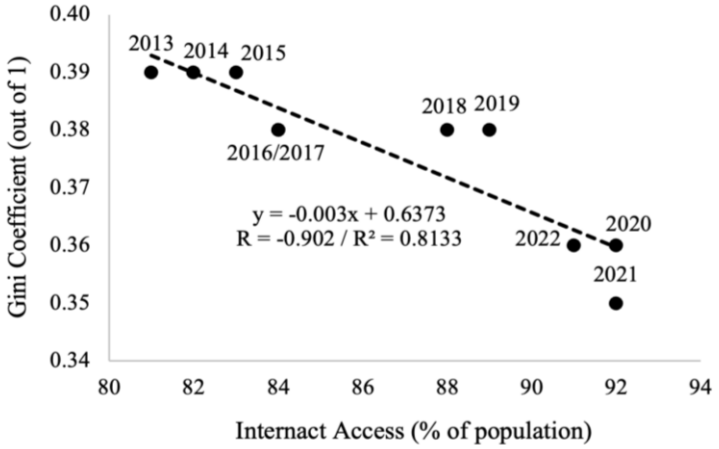

Fig. 1. Gini coefficient vs percentage of population with internet access in Singapore (2013-2022) [15,16].

Results show that there is a very strong correlation between the two variables, with the correlation coefficient of – 0.902, which is higher than both the .05 (0.632) and .01 (0.765) levels of significance at 10 – 8 = 2 degrees of freedom [17]. This shows that there is enough statistical evidence that having access to the internet for individuals and households in a population helps reduce income inequality. The change in the figures from 2019 and 2020 is a powerful illustration of this pattern. The percentage of population with internet access increased by 3% (from 89% to 92%) and was followed by a 0.03 decrease in the Gini coefficient (0.38 to 0.35). Both changes were the greatest during the 10-year period of sampling, supporting the fact that an increase in internet access among individuals and in households help reduce income inequality.

The trend is not hardly explained. Websites and applications that made the citizens lives more convenient and efficient all required basic access to the internet and digital devices. Online shopping websites like Shopee and Lazada largely decreased the time

spent fiddling through the shops and supermarkets, and the time saved could be spent elsewhere. Additionally, software applications like the Trace Together app that indicates the risk of contracting COVID-19 in specific areas (by showing the number of cases nearby and where they went) required Bluetooth and internet connection to work. With basic access to these services, the productivity of these workers would increase as they are more likely to spend their time on more meaningful tasks and taken precautions against sicknesses or injuries.

With remote learning and work-from-home during the pandemic, the need for internet and technology became even more apparent. A good access to the internet ensures working adults a smooth working experience with all the tasks and meetings being moved online. Especially for the less stable or secure jobs that are likely to be lower-paid, keeping a consistent performance during the pandemic decreases the chances of losing one's job or being demoted. The rebound in Gini coefficient in 2022, however, may be a delayed reflection of some workers from this group losing their jobs or were cut down on their wages.

4.2 Gini Coefficient vs Percentage of Businesses with Broadband Subscriptions

Surprisingly, the opposite trend holds true regarding the relationship between the percentage of businesses with broadband subscriptions (an indicator that they are connected to the Internet) and the Gini coefficient. Figure 2 presents a very weak (not significant at 8 degrees of freedom) but positive relationship between the two variables with the correlation coefficient of 0.105.

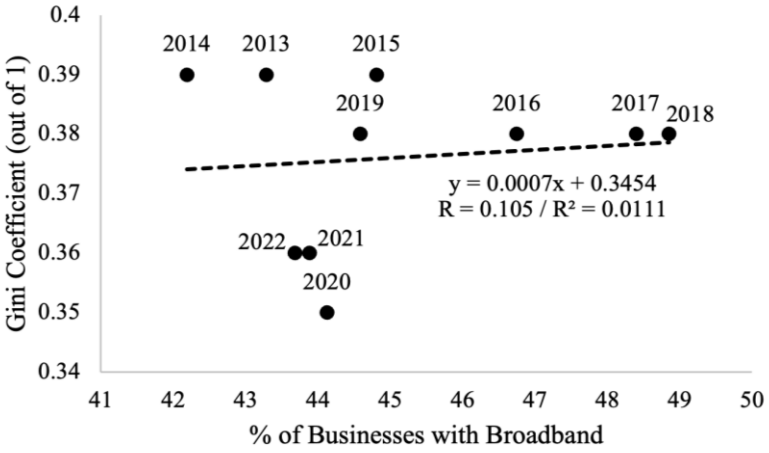

Fig. 2. Gini coefficient vs percentage of business with broadband subscriptions in Singapore (2013-2022) [15,18,19].

The trend may be a result of SBTC that favors the industries or types of jobs with higher exposure to digitalization. As summarized in Table 2, the highest paid-occupations have at least "Some" levels of digitalization while the lowest-paid occupations have "None" or "Limited" levels of digitalization.

Table 2. Occupations arranged by median gross monthly income and categorized by the levels of digitalization ("None", "Limited", "Some", or "High") as of March 2023 [20].

Highest-paid industries	Level of Digitalization	Lowest-paid industries	Level of Digitalization
Managers & Administrations	High	Cleaners, Labourers & Related Workers	None
Professionals	Some	Plant & Machine Operations	Limited
Associate Professionals	Some	Craftsman Related Trades	Limited
Clerical Support Workers	Some	Service & Sales Workers	Some

4.3 Case Study: Effects on The Gender Pay Gap

With the general trends of digitalization explored in the previous two sections, the trend for gender pay gap serves as a case study to illustrate the impact of digitalization on income inequality.

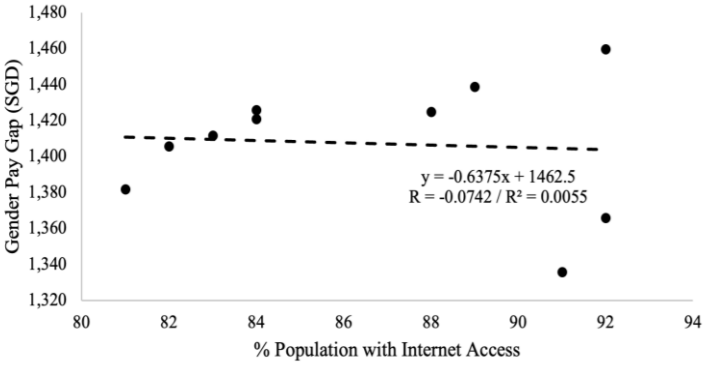

Fig. 3. Gender pay gap vs percentage of population with internet access (2013-2022) [16,21].

Figure 3 presents a slight negative correlation (not significant) between the gender pay gap and internet access rate among the population. This shows that while an increase in internet access among the population does have a considerable impact on income inequality, it does not affect the gender inequality of wages as much. This is because other complex reasons may be involved, for example, society's perception of women's roles (whether they should take up high-paid jobs or be housewives [22]), and the wages of women is not solely related to if women have access to the basic services provided by the internet. Education on digital literacy does help the women at the bottom 10% of the socioeconomic ladder to find better jobs, but the effect does not penetrate to the income levels above [23].

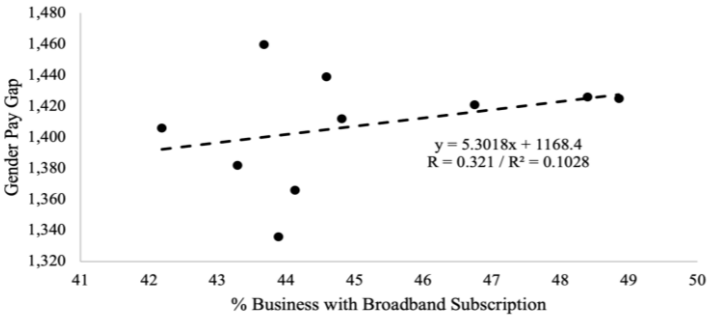

Fig. 4. Gender pay gap vs percentage of businesses with broadband subscription [18,21].

Figure 4 presents a somewhat strong positive relationship between gender pay gap and the percentage of businesses with broadband subscription. The nature of women's jobs plays a role in this pattern. For example, 16% of women work in the clerical support sector [19], who disproportionately constitute 77% of the industry, which ranks the 4th in the salary ranking [24].

5 Conclusion

This paper found that while individual and household access to the internet helps alleviating income inequality in Singapore, as shown by the negative slope of the least-square regression line, an increase in digitalization within businesses would exacerbate income inequality due to SBTC. This holds true for both the general pattern relating the two percentages with the Gini coefficient, and for the specific case of gender pay gap, although the significance level for the latter is considerably smaller due to the influence of sociological factors. With a significant correlation between the percentage of population with internet access and the Gini coefficient, it can be concluded that a widespread use of technology benefits the citizen's lives and careers. The digitalization in businesses cannot be stalled, but education to the workforce can be done to equip more workers with adequate digital knowledge and literacy. The DfL movement, therefore, is a targeted way to bring about more digital inclusion to a wider base of the population, which will in turn, decrease income inequality. The research highlights the trends and possibilities in Singapore with secondary data from various sources. Due to the different perspectives observed around the world in the literature review section, and some of the insignificant correlations obtained with data from different databases, further research involving primary data is needed to uncover the full picture of digitalization and income inequality in Singapore. Primary researches into countries with inadequate literature, similar to the conditions of Singapore, are also essential in revealing the patters in these countries. With sufficient research, policy recommendations can follow suit.

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