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Exploring the future impact of automation in Brazil

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Abstract

Purpose – Brazil is struggling as the unemployment rate is 12.4% and nearly 13m people are unemployed. The fourth Industrial Revolution is advancing, and the country needs to consider how it will impact the labor market. This work explores the impact of automation on the Brazilian workforce to supply decision-makers with information about the subject.

Design/methodology/approach – The authors converted the probability of computerization from the seminal work of Frey and Osborne to each of the more than 2,500 occupations in Brazil. They then crossed the automation probability with socioeconomic information about workers and companies available in the Brazilian Ministry of Labor Database.

Findings – In total, 60% of employment in Brazil is expected to be highly impacted by automation in the coming decades, with eight out of the ten occupations with the biggest workforce being highly automatable. Automation probability decreases as workers' education level increases, with the most significant difference between workers with higher education and those without it. The results show other inequalities in the impact of automation: the higher the wage, the lower the automation probability of occupations; the bigger the company, the lower the automation index; and workers from 16 to 24 years old have considerably higher chances of being automated.

Originality/value – This work is the first to study, in the context of the fourth Industrial Revolution, the impact of automation in Brazil with a socioeconomic analysis.

Keywords Employment, Automation, Technological change, Future of employment

Paper type Research paper

1. Introduction

The interplay between technology and employment has long been an important subject. The beginning of each new Industrial Revolution brings about new discussions on the topic, as the

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fear of technological unemployment reappears as well as the prospects of technological bonanza are revisited. We are now living one such moment, as increasing discussion about the fourth Industrial Revolution occurs.

Understanding the impact of new technologies applied to production in each industrial revolution might be one of the reasons why the impact of automation has been positive. In terms of job quality, the current wave of automation is expected to increase workers' precision in important areas such as medicine, reduce repetitive tasks as data input and augment workers' capacity to deal with large amounts of information (Action and Research Centre, 2019; Chartered Institute of Personnel and Development and PA Consulting, 2019). In terms of the impact of this new wave of technologies on job quantity, predictions tend to vary widely. However, the current industrial revolution provides opportunities to use automation in a broad range of occupations resurrecting the phantom of mass technological unemployment that has reappeared several times over the past two centuries (Autor, 2015).

One fact that is undisputed is that automation has impacted the world of work in the past, is doing it right now and will do it in the future. The adoption of automation has been accelerated with the COVID-19 pandemic, as it happened with other trends that were expected to take years or decades to happen but are happening in a much shorter time (Blit, 2020; Chernoff and Warman, 2020; Ding and Molina, 2020; McKinsey Global Institute, 2020, p. 8; World Economic Forum, 2020).

In this scenario, companies, governments and workers must prepare themselves faster than ever to deal with the increased pace of automation to bring about positive results once again as it did in the past. Sadly, it does not seem to be the case so far. When it comes to companies' preparedness, a recent survey with over 200 Chief People Officers (CPOs) showed that only 36% consider themselves prepared to respond to the future complexity of business and technology to effectively support their business (SHRM Executive Network and Willis Tower Watson, 2020). In terms of nations' readiness for automation, as (The Economist Intelligence Unit, 2018) shows, even the more advanced economies, such as Germany and East Asian countries, are not prepared to deal with the current wave of automation.

In Brazil, this unpreparedness is even more prominent as no detailed analysis of the impact of automation on the country's diverse workforce has been done. Given this gap in the literature, the objective of this paper is to explore how automation will impact formal employment in Brazil. In order to do so, the remainder of this paper is organized as follows. After this Introduction, Section 2 presents related work about automation and the future of employment. Section 3 describes the methodology of our work. Section 4 is dedicated to the presentation of the results, which are subsequently discussed in Section 5. Finally, Section 6 presents our conclusions.

2. Related work

From the hope of shorter working weeks to the fear of mass unemployment, technology relationship with work has been an important topic for a long time now. In the past few years, with the advancement of AI, Robotics and other technologies, society has been once again looking at the potential that technology represents for impacting work.

The current impact of technology on work can be seen as a myriad of phenomena that can be classified in four groups to facilitate our study of it: automation involves machines executing tasks that were previously done by humans (e.g. self-checkout machines at grocery stores); brokerage is the mediation done by the technology of the relationship between buyers and sellers (e.g. Uber); management is when technology helps to recruit, monitor and organize workers (e.g. scheduling software used by retail); digitization is the use of technology to transform physical goods into digital assets that can be easily shared (e.g. Microsoft Office) (Action and Research Centre, 2017).

Automation itself happens in many forms. Usually, more than one of these occurs when adopting a single technology. Automation can substitute human work when replacing humans in one or more activities; augment it when expanding the former capacity of workers; generate new activities for humans to execute; and transfer activities from workers to customers (Action and Research Centre, 2017). The focus here is on the substitution capacity of automation technologies, but it is essential to note the other possible facets of automation to recognize its impact as a whole.

When looking at the benefits of automation in the current fourth Industrial Revolution, we can highlight its potential for reducing errors, increase productivity, augment human capacity, overcome the challenge of the aging population and improve speed and quality.

Unlike humans, machines do not get tired or have any feelings whatsoever; they can make decisions very fast and based on troves of data. These characteristics give them an advantage over humans in certain types of activities where they can reduce errors and risks such as driving cars and trucks or storing and dispensing medication in pharmacies (McKinsey Global Institute, 2017).

Machines have great potential to augment human capacity in activities where they cannot replace us yet (Autor, 2015). One example is automated diagnostic advice that augments physicians' capacity to deal with a myriad of information from exams such as X-rays and Magnetic Resonance Imaging but does not replace the human capacity of adequately communicating with patients or interpreting their emotions. Another example is augmented human management as used by Uber to allow few human managers to organize the work of thousands of drivers by using algorithms and data analysis (McKinsey Global Institute, 2017).

The (McKinsey Global Institute, 2017) estimates that automation can raise productivity growth globally by 0.8–1.4% annually. This productivity injection brought by the adoption of automation also helps to mitigate the impact that aging populations will have in advanced and some of the emerging economies (including Brazil) that have to deal with this challenge for the labor market (McKinsey Global Institute, 2017). Furthermore, (Steinmueller, 2001) understands that Information and Communication Technologies (ICTs) – which are at the core of the current industrial revolution – are different from previous leading technologies such as steel and chemicals because the conditions of entry and, sometimes, of producing them do not require an expressive amount of investment. According to the author, this difference would allow developing countries to skip some of the processes of accumulation of human resources and investments that advanced economies had to endure, thus "leapfrogging" in terms of economic advancement.

For all the optimistic predictions made about automation, the threat of technological unemployment challenged societies before, and this time there is also no escape from it. At least not from the debate about technological unemployment, which abounds in the recent academic literature and popular discourse even though automation has not reduced employment levels in the past (Arntz *et al.*, 2016; Autor, 2015; Spencer, 2018). Still, this particular adverse effect of automation is back in the research agenda of academics (Ariza and Raymond Bara, 2018; Arntz *et al.*, 2016; Frank *et al.*, 2018; Frey and Osborne, 2017; Mitchell and Brynjolfsson, 2017; Nedelkoska and Quintini, 2018; Spencer, 2018). Moreover, not only the academy is interested in better understanding the future of employment; international agencies, governments and consulting groups are also exploring the theme. The International Labour Organization (ILO) put the future of work at the center of the activities that mark its 100th anniversary in 2019 (International Labour Organization, 2015). The World Economic Forum has been publishing reports on the future of jobs and related themes since it started discussing the fourth Industrial Revolution (World Economic Forum, 2018). Governments such as the United Kingdom and the USA have also been trying to understand the current wave of technology and its impact on employment (UK Commission for Jobs and Skills, 2014; US Government, 2016).

Some papers and reports about the impact of automation have been recently published. The methodologies of these studies can be different because they are concerned with different periods and/or countries. In this section, we will briefly describe some of these studies and highlight their results.

With over 5,000 citations, the paper written by (Frey and Osborne, 2017) is the most cited reference about the impact of automation. The authors focused on estimating the impact of what they call computerization (automation caused by computer-controlled equipment) of the occupations within the US occupation classification. Their methodology involved relating the computerization bottlenecks they identified to work variables listed in the O*NET (an online service providing a detailed description of most US occupations maintained by the US Department of Labor). With the help of a group of machine learning researchers, they evaluated 70 of the 702 occupations in the O*NET in terms of each work variable, and then using statistical methods, they were able to estimate the probability of automation of the full list of occupations that they were working with. The results of their work showed that 47% of US occupations were at high risk (probability higher than 70%) of computerization in the coming decades.

Due to being such a relevant work, these results were applied to other countries. (Deloitte, 2015) applied them to Switzerland and discovered that 48% of current jobs could be automated in the coming years or decades, and (Deloitte, 2014) applied them to the United Kingdom, where the results showed that 35% of jobs were at a high risk of automation. (Brookfield Institute, 2016) did a similar study for Canada and found out that 42% of the country's labor force is at high risk of automation. Other studies (Santos *et al.*, 2015; World Bank Group, 2016) applied the same methodology to developing countries, and the share of the workforce in jobs with a high risk of automation ranged from 55% (Uzbekistan) to 85% (Ethiopia).

Differently from (Frey and Osborne, 2017), the research done by (Arntz *et al.*, 2016; McKinsey Global Institute, 2017; Nedelkoska and Quintini, 2018; Pricewaterhouse Coopers, 2018) focused on skills rather than tasks. (Arntz *et al.*, 2016) studied 21 OECD nations and found that, on average, 9% of jobs have a high risk of being automated. The level ranges from 12% in countries such as Germany and Spain to 6% in Korea and Estonia. Building on this work, (Nedelkoska and Quintini, 2018) broadened the study to 32 OECD countries. They estimated that 14% of jobs in these countries are highly automatable (probability of automation higher than 70%), ranging from 6% in Norway to 33% in Slovakia.

(Pricewaterhouse Coopers, 2018) also worked with the methodology of (Arntz *et al.*, 2016), calculating the potential job automation across industries and found that Transportation and Storage and Manufacturing are the ones with most workers at risk in the long run (up until 2030), with 51 and 45%, respectively. Still, in the short run (early 2020), (Pricewaterhouse Coopers, 2018) believe that the areas at most risk (around 8% of the workforce) are Finance and Insurance, Service Professionals, Scientific and Technical and Information and Communication.

The (McKinsey Global Institute, 2017) estimated that less than 5% of occupations of the 46 countries studied are subject to full automation, considering the adaptation of currently available technology. They also estimated that about half of the activities that people are paid to execute could potentially be automated.

As can be seen, there is a growing body of research about automation, but a study focused on the impact of automation on Brazil's workforce was not done so far. This study represents one of the first efforts of estimating the impact of automation on Brazil in the context of the fourth Industrial Revolution.

This effort becomes even more urgent as the current COVID-19 pandemic is set to accelerate automation worldwide (Blit, 2020; Chernoff and Warman, 2020; Ding and Molina, 2020; McKinsey Global Institute, 2020, p. 8; World Economic Forum, 2020). A recent global survey done by the (World Economic Forum, 2020) shows that 50% of employers are planning on accelerating the automation of tasks as a response to COVID-19 with the number reaching 68% in Brazil. Another survey, this one done by the (McKinsey Global Institute, 2020) with 800 executives, shows that 67% of companies have significantly (20%) or somewhat (47%) accelerated automation and artificial intelligence adoption since the start of the COVID-19 outbreak.

The effects are already being perceived, mainly by in-person service workers with a higher risk of viral transmission replaced by automation so that companies do not stop providing their services (Chernoff and Warman, 2020). Regionally, the effect of automation during the pandemic is being felt as shown by a recent analysis done by the Federal Reserve Bank of Philadelphia (USA) where the workers in automatable occupations were more displaced during the pandemic than those that have a lower risk of automation (Ding and Molina, 2020).

3. Data and methods

In this study, the Brazilian Occupations Classification (*Classificação Brasileira de Ocupações* – CBO) was used. The latest version of the CBO has 2,614 occupations, which are updated from time to time by selected institutions supervised by the Ministry of Labor (Ministry of Labor, 2018). Another important source of information was the Annual Report of Social Information (*Relação Anual de Informações Sociais* – RAIS). RAIS is a yearly data collection instrument of the Brazilian government through which companies with more than ten employees must inform about its employees itself.

Our study converts the computerization probability calculated by (Frey and Osborne, 2017) to the USA to the Brazilian occupations. To do so, we adapted the crosswalk between the CBO and the O*NET occupations created by (Maciente, 2014).

In order to explore the future impact of automation on employment in Brazil, we crossed the probability of automation of occupations with socioeconomic data, using the following formula that was created by (Frank *et al.*, 2018) to analyze the impact of automation on American cities.

$$I_a = \sum_{j \epsilon \text{Jobs}} p_{\text{auto}}(j) \cdot \text{share}_g\ (j),$$

In which:

$p_{\text{auto}}(j)$ denotes the automation probability of occupation j, and $\text{share}_m(j)$ is the number of people employed in occupation j in a given group g, divided by the total number of people employed in the same group.

The Automation Index (I_a) can be interpreted as the expected percentage of total employment in a given group subject to automation (Frank *et al.*, 2018). The formula was used in the present paper to compare the impact of automation in different groups according to workers' education level, age and sex and companies' economic sector and size.

It is important to note the limitations of our methodology. The RAIS database used on this work covers 46m workers, while, according to (IBGE, 2020), there are 91.2m people in Brazil's workforce. The main reason for this gap is the number of self-employed people and those working off the books, which accounts for 34.1m (37.4% of the total) workers (IBGE, 2020). Another group that is not reported in the RAIS is domestic workers, representing 6.2m (6.8% of the total) workers. Finally, filling in the RAIS form is only mandatory for companies with more than ten employees, which also accounts for part of the gap. Nevertheless, another limitation of the RAIS database is that 1,561,885 workers (3.4% of the total) were registered as nonclassified and were left out of our study because we could not calculate the probability of automation for their occupations.

The methodology can be criticized for applying the automation probability calculated by (Frey and Osborne, 2017) to the Brazilian reality. Technology adoption occurs differently from country to country and even more so from developed countries (e.g. USA) to developing nations (e.g. Brazil), as it usually takes more time for innovations to be adopted in the latter group. (Comin and Hobijn, 2010) analyzed the diffusion of 15 technologies in 166 countries over two centuries, and they found that, on average, it takes 45 years for countries to adopt a technology. However, this value varies significantly between technologies and from country to country. However, more recent technologies have been taking much less time to spread worldwide (Comin and Hobijn, 2010; Steinmueller, 2001). For example, the Internet took, on average, eight years to diffuse, while steam and motor ships took 123 years (Comin and Hobijn, 2010). Taking this into consideration, we believe that the gap of five years between the Oxford research – which was first published online in 2013 – and our own and the fact that the predictions that resulted from it do not have a specific time frame for coming to fruition (they talk about “some unspecified number of years, perhaps a decade or two”) will help mitigate this limitation.

4. Results

4.1 Automation in Brazil

The impact of automation in Brazil is analyzed here in terms of the most impacted occupations, the impact of automation in the workforce and the historical evolution of the workforce.

Table 1 shows the ten occupations with the highest number of workers in Brazil, representing over 26% of the total number of workers in the latest RAIS from 2016. As the table shows, eight of those occupations have a probability of automation higher than 70%, and in four of them, the probability is higher than 92%.

The distribution of the total Brazilian employment against the probability of automation is presented in Figure 1.

The probability of automation ranges from the occupation least susceptible to automation (Music Therapist – 0.0028) to the most susceptible (Telemarketing Operator – 0.99). The graph shows that 60% of Brazilian workers are at a high risk of automation (probability of

CBO occupation name	*P*(Auto)	Ranking *P* (Auto)	Number of workers	CBO code	SOC code
Administrative Assistant	0.96	4	2,081,939	411010	439061
Office Clerk	0.96	4	2,036,571	411005	439061
Retailer Salesclerk	0.92	8	2,007,042	521110	412031
Janitor	0.66	34	1,344,939	514320	372011
Truck Driver (Regional and International Routes)	0.79	20	877,081	782510	533032
Production Line Feeder	0.93	7	860,740	784205	537063
Cashier	0.97	3	823,476	421125	412011
Middle-Level Teacher in Fundamental Teaching	0.56	42	749,667	331205	259041
Security Guard	0.84	16	630,387	517330	339032
Construction Helper	0.88	12	571,663	717020	473019
Total			11,983,505		

Table 1. List of the ten occupations with the most workers in Brazil

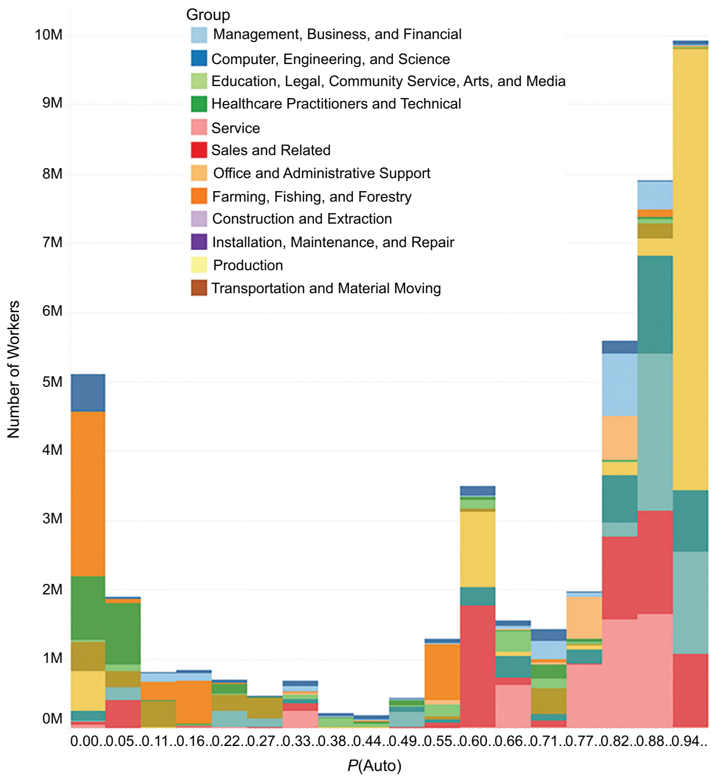

Figure 1.
Brazilian workforce distributed by *P*(Auto)

automation higher than 70%), 18% are at medium risk (30% < probability ≤ 70%) and 22% are at low risk of automation (probability ≤ 30%).

The analysis of the change in occupations in the past in terms of their probability of automation shows that, in every group, the change in employment from 2003 to 2016 was positive, which means that employment rose in all groups. Figure 2 shows a graph with these results where the occupations were divided into ten groups, according to their probability of automation, with the first group composed of occupations that had a probability smaller than 10% and so on.

The group with the most significant increase in employment was the tenth, with an increase of over 6m jobs, distributed mainly between Office and Management Support, Construction and Extraction and Services. The second most significant change in employment came from the other side of the automation probability spectrum: the first group had an increase of more than 2.5m jobs, distributed mainly between Education, Legal, Community Service, Arts and Media and Healthcare Practitioners and Technicians.

4.2 Automation and workers' characteristics

The impact of automation was analyzed according to three workers' characteristics: education level, age and wage. In order to understand the impact of automation on the different education levels in Brazil, we produced the graph in Figure 3. As shown in the graph, the Automation Index is higher when the education level is lower, and there is a considerable

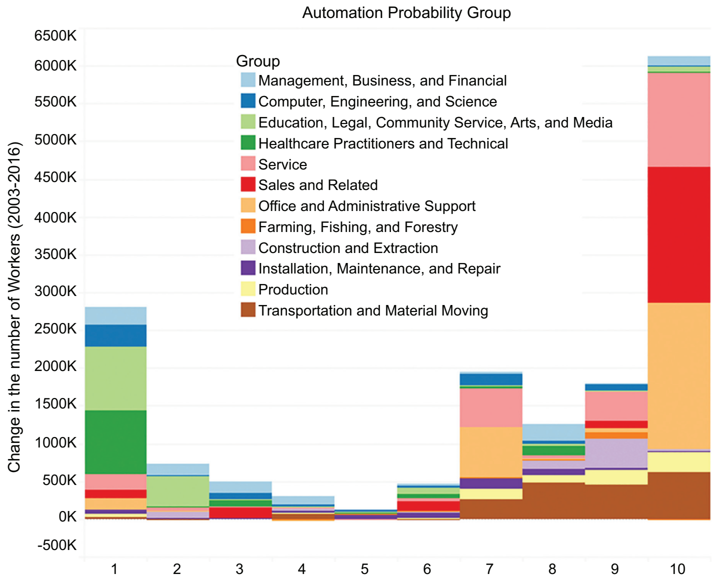

Figure 2.
Change in the number of workers, from 2003 to 2016, for each automation group

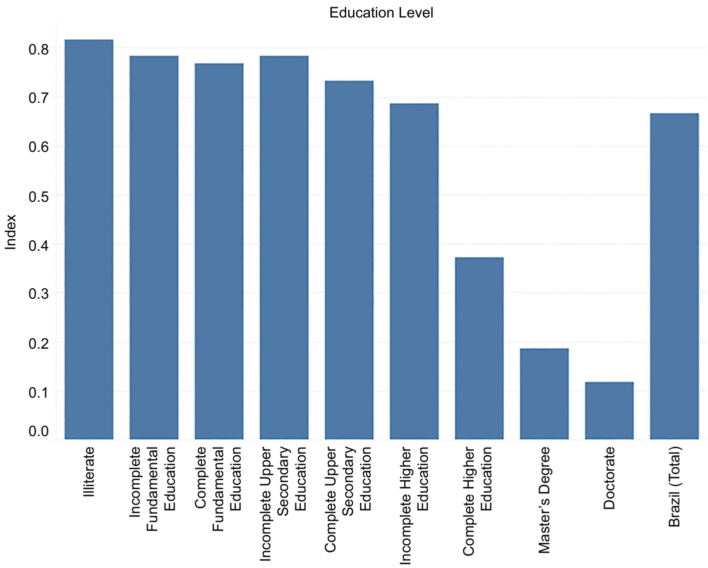

Figure 3.
Automation index for each education level

drop in the index's value between the incomplete higher education and complete higher education levels from 68% to 37%.

Another worker characteristic that we analyzed was age. The results show that for workers in the 16–24 years old age group, the index is 79%, and for those in the 25–29 years old group, the index drops to 70%. After that, the index stabilizes at around 63–64% for the other age groups.

The scatter plot in Figure 4 shows the Automation Index and the mean monthly wage of each occupation. The model is significant (p-value < 0.0001), but the relationship between the two variables is not as strong as the value of the determination coefficient was low (0.16).

Finally, the comparison of the impact that automation has on the different sexes showed that women are relatively more vulnerable than men. The Automation Index was 69.7% for men and 62.5% for women. Further exploring the relationship between automation and sex, the percentage of male workers in every occupation was calculated. The scatter graph in Figure 5 shows that the higher the percentage of men in an occupation, the higher the automation probability. Despite being a significant model (p-value < 0.0001), the value of the determination coefficient is low (0.11), which indicates that the relationship between the two variables is weak.

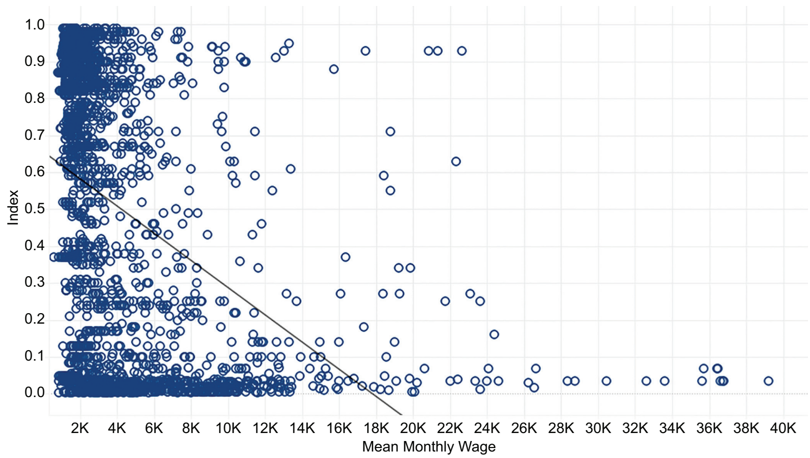

Figure 4. Scatter graph of occupations distributed according to the Automation Index and the percentage of the mean monthly wage for each occupation

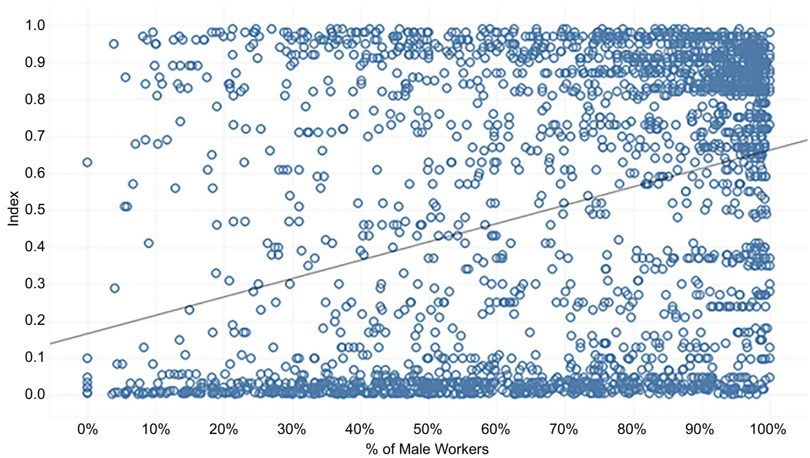

Figure 5. Scatter graph of occupations distributed according to the P(Auto) and the percentage of male workers of each occupation

4.3 Automation and company sector and size

The analysis of the index of automation for the companies' sector shows that the three most affected sectors and their Automation Index are as follows: Agriculture, Forestry, Fishing and Hunting (79%), Commerce (75%) and Manufacturing (74%). The three least affected sectors are Public Administration (48%), Services (64%) and Public Utility Services (67%).

Company size is another characteristic that we were able to analyze. Here, the companies are classified according to the number of employees: micro (1–19), small (20–99), medium (100–499) and large (>500). The results show that, as company size increases, automation impact decreases as the Automation Index of microcompanies is 75%, small companies is 69%, medium companies is 65% and large companies is 57%.

5. Discussion

Automation in Brazil is set to have a considerable impact, as 60% of the workforce or 26.9m workers are expected to experience a high impact (automation probability higher than 70%), as Figure 1 shows. Also, among the ten occupations with the most workers, eight are in this high-risk group comprising nearly 10m people, as the results presented in Table 1 show.As such, even considering the size of the informal workforce in Brazil that was not part of the analysis, as discussed in Section 3, the impact of automation is expected to be high in the coming decades for at least 30% of the whole Brazilian workforce.

These numbers alone would be enough to create a worrisome scenario, but when we consider how poorly the country is prepared for automation, the problem seems even worse. The Automation Readiness Index – calculated by (The Economist Intelligence Unit, 2018) – considers the innovation environment, education policies and labor market policies of 25 countries and gives Brazil a score of 46.4 (average is 62.1), putting the country in 19th position. Brazil is in the last place for the category of innovation environment, 17th on education policies and 13th regarding labor market policies.

When we look at the past, over 9m jobs were created in Brazil between 2003 and 2016, in occupations that are highly susceptible to automation, as Figure 2 shows. Deloitte (2014, 2015) made the same analysis for Switzerland and the United Kingdom, showing that both countries – differently from Brazil – are shifting toward a less automatable workforce by reducing the number of people occupied in highly automatable occupations and increasing the number of workers in occupations less likely to be automated. This transition depends partly on the education of those workers entering the workforce; if this is not changed, companies will not be able to invest in adopting new technologies as the country lacks the workforce to deal with them.

Even if the scenario is complicated for Brazil, when compared with other developing countries, the country fares well. In comparison with other 42 nations, Brazil occupies the eighth position as the least impacted country. Considering that the workforce at risk for the OECD nations is 57%, only three points lower than the one for Brazil, we can see that Brazil is closer to the average of the more advanced economies than to the average (67%) of the developing countries. When comparing with other Latin American countries such as Ecuador (69%), Argentina (65%) and Uruguay (63%), Brazil has a lower share of its workforce at risk of automation (World Bank Group, 2016).

Still, when compared with the impact of automation in one of the most advanced economies of the world, the result of 60% for Brazil is distant from the 47% value estimated by (Frey and Osborne, 2017) for the USA. One factor that can explain this difference is the occupation structures of both countries, as presented in Figure 6. As (Maia and Sakamoto, 2015) show, the Brazilian structure, in 2011, had a larger share of workers in highly automatable activities than the USA; for example, Farming (10.6 vs 1.3%), Private Household (7.5 vs 0.5%) and Blue Collar

(29.5 vs 19.7%). These differences can be partially explained by the opportunities of using automation still untapped by the sectors that have some of the highest automation indexes according to our results: Agriculture with 79% and Manufacturing with 75%. In the future, we can expect that these sectors, along with Commerce, which has an automation index of 75%, increase their usage of automation, consequently reducing the workforce employed that could migrate to less affected sectors such as Public Administration and Services.

Besides the different occupational structures, as (Oxford Martin School and Citi GPS, 2016) highlighted, developing countries are also more susceptible to automation because cheap labor is abundant. Despite a recent reduction in real wage growth in Brazil (International Labour Organization, 2016), the cost of labor is relatively high when compared to other developing countries due to taxes – the total cost of an employee is around 2.5 times their gross wage (Souza *et al.*, 2012). This high cost of maintaining an employee in Brazil might be greater than the capital investment required to make automation happen (Piketty, 2015), thus accelerating automation impact.

The (McKinsey Global Institute, 2017) sees in automation an opportunity for Brazil. According to the institute, if used with other productivity-enhancing strategies such as process transformations, automation could help countries such as Brazil, Russia, China and Argentina increase current GDP, given that there is an expected decline in the growth of the working population of these countries. (Steinmueller, 2001) supports this view by defending that ICTs could help developing countries in "leapfrogging" – reducing the productivity gap between advanced economies and developing ones by bypassing some of the steps to accumulate human capabilities and fixed investment. In order to do so, the countries must satisfy three prerequisites: have absorptive capacities to produce or use ICTs; have access to equipment and know-how necessary to make productive use of later stages in technological development, without developing technological precursors; and have access to technological capabilities that are complementary to the use of ICTs (Steinmueller, 2001).

Even though the adoption of automation can be used to increased productivity and GDP, the distribution of these positive results must also be a matter of concern. In the last decades, developed economies have been facing this distributive issue as they increased their GDP, but workers did not experience an expected increase in their wages as well (Brynjolfsson and McAfee, 2011; Lewis and Bell, 2019).

In this sense, one of the most pressing issues that Brazil will have to tackle in the future of employment is the increasing impact that automation will have on the social groups that have the most trouble in transitioning to new jobs. This problem has been highlighted by previous studies on the subject (Arntz *et al.*, 2016; Frey and Osborne, 2017; Nedelkoska and Quintini, 2018; Pricewaterhouse Coopers, 2018) and confirmed by our results to the Brazilian scenario. Less-educated workers, most prominently those without complete higher education, have an Automation Index of 68% while the value for those that completed their higher education is only 37%. Young workers tend to be more impacted than their older counterparts as the Automation Index goes from 79% for workers in the 16–24 years old group to 63–64% for those over 30 years old. Our results also show a tendency for workers with lower wages to be more impacted than those with higher wages. Finally, it is also shown that male workers are more susceptible to automation than their female counterparts. A different type of inequality

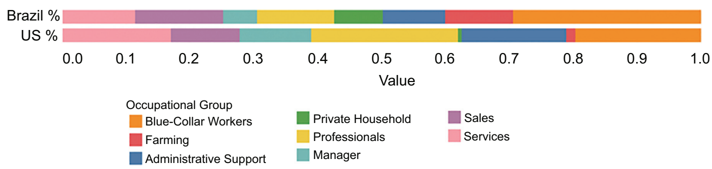

Figure 6.
Brazil and US occupational structures (2011).
Based on: Maia and Sakamoto, 2015

in the impact of automation that was not shown by previous studies but is demonstrated by our results is that microcompanies, with an Automation Index of 75%, tend to be more affected than large companies with an index of 57%.

Aggravating this situation is the COVID-19 pandemic that, coupled with the accelerated pace of automation, has been causing a dual impact on jobs that disproportionately affects more vulnerable groups such as women, less-educated and younger workers with the risk of increasing inequality (Chernoff and Warman, 2020; Ding and Molina, 2020; McKinsey Global Institute, 2020; World Economic Forum, 2020).

Given this scenario, companies and the government will have to find ways to deal with a possible increase in unemployment and the need to retrain these vulnerable workers by aggravating that a significant portion of them will be working at microcompanies that have fewer resources to retrain workers. As such, education should be a priority issue in the fourth Industrial Revolution since it influences not only the retraining of displaced workers but also the new jobs that are going to be created. Initiatives such as those in the studies of (Nesta *et al.*, 2018; Partnership for 21st Century Learning, 2018) aimed at understanding the future demand for skills are a good indication for helping the Brazilian companies to prepare its employees for a more automated work and also for the government to update its educational system. In general, the skills that will be demanded from the workers of the future are those that are recognized as bottlenecks for present computing technology, namely creativity, social intelligence and fine motor skills (Autor, 2015; Frey and Osborne, 2017). As automation will not only replace jobs but, in many cases, augment them, digital literacy will become an even more important determinant of employability than it already is (Bejaković and Mrnjavac, 2020). In a country such as Brazil, where 11.3m people still are illiterate, let alone digitally illiterate, the danger of excluding part of the workforce from jobs that require digital skills or slowing down the adoption of new technologies is considerable.

6. Conclusions

This study is an essential step in understanding and estimating the impact of automation in Brazil, which is essential for companies, government and individual decision-making. Our results show a preoccupying scenario for the future of employment in Brazil because of the high impact that automation is expected to have in the following decades. Making this situation even worse, those in the most vulnerable social groups – low income, lower education level and young workers – are the ones who are expected to suffer the most from automation in the coming decades.

The present labor situation in Brazil is already poor – the unemployment rate from February to April 2020 was 12.6%, 6.1m workers would like to work more hours but do not have the opportunity, and 5m people have given up looking for a job, a 7% growth from the previous trimester (IBGE, 2020). Thus, the country is left not only with the challenge of creating new jobs that are not going to be automated in the coming decades but also of providing more job opportunities in the short term. The COVID-19 pandemic is a new factor that has been accelerating automation and will demand an even faster and incisive response from those involved. Tackling these challenges will require a combined effort of several social actors such as government, companies and unions that might allow the country to tap into the benefits that automation presents to the economic advancement as a possible driver of GDP increase.

In order to take the necessary measures to adopt automation in the most favorable way for society, decision-makers themselves need to learn about digital transformation and to keep themselves updated with the latest information about the technological possibilities available. As a recent survey with over 500 executive shows, only 35% of them believe that future CPOs are getting the development they need (SHRM Executive Network and Willis Tower Watson, 2020). This is a critical issue that has to be addressed if employers are to take their role as drivers of this technological revolution and to be capable of making decisions that steer technology adoption toward positive outcomes while avoiding the many challenges ahead (Chartered Institute of Personnel and Development and PA Consulting, 2019).

Society's failure in preparing itself for automation is likely to cause problems such as the concentration of the benefits of automation in the hands of a few, high unemployment rates and reduced GDP growth. On the other hand, being prepared for the automation wave that is set to last some decades means that companies can increase their output, jobs can become more meaningful and less dangerous and society as a whole can reap the benefits of automation. In the end, it is a matter of understanding technology as a tool that can be used for better or worse.

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