The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

THE IMPLICATIONS OF AUTOMATION IN A SELECTED AUTOMOTIVE ASSEMBLY ORGANISATION IN SOUTH AFRICA

ROBERT WALTER DUMISANI ZONDO

Associate Professor, Durban University of Technology (DUT), Faculty of Management Sciences, Department of Entrepreneurial Studies and Management, Durban. E-mail: dumsaniz@dut.ac.za,
Orcid: http://orcid.org/0000-0003-0214-860X

Abstract

Improving productivity in the manufacturing system is the core objective of all manufacturing companies as it determines how well the company utilises its resources compared to requirements. Emanating from a continued demand for efficiency and productivity, automation becomes the key driver in such an achievement. Thus, automated flow line manufacturing systems are becoming more relevant in the automotive sector. This study examines the influence of automation for productivity improvement in a selected automotive assembly organisation in South Africa, automation being the creation and application of technology to monitor and control the production and delivery of products and services. The study was quantitative in design and examined the production of an automotive assembly organisation that has adopted an automation system for productivity improvement in its automobile Deck Tailgate process in its weld plant. This company operates in the eThekwini Municipality in KwaZulu-Natal province of South Africa. The study was conducted by collecting pre- and post-quarterly data for labour productivity and process efficiency. The results established that labour productivity and process efficiency improve as a result of the application of automation. However, automation will lead to the reduction of human participation in the production systems. This may result in uncertainties amongst employees that must be properly communicated and managed. The original value of this study is its approach in uncovering strengths and weaknesses of automation for productivity improvement in South Africa.

Keywords: Automation, Automotive Assembly Organisation, Deck Tailgate, Downtime, Labour Productivity, Process Efficiency, South Africa

INTRODUCTION

There is an upsurge in the use of automated flow line manufacturing systems, especially in the food and beverage as well as the automotive sectors. For instance, improving the efficiency of automated flow line manufacturing systems for automotive assembly is the core objective of companies that are measured by the overall equipment effectiveness (OEE) index (Rahman & Hoque, 2014). Automated manufacturing systems are now being profoundly influenced by the changes in market requests. Increasing variety and differentiation due to factors such as more customisation, shorter product lifecycles and uncertainty in demand need to go hand-in-hand with increased effectiveness in order to be competitive (Mourtzis, Doukas. & Psarommatis, 2012).

For automation to be part of the manufacturing system, it has to comply with the overall production strategy. According to Manyika (2017), automation designed for the improvement of lean manufacturing does not reduce the flexibility and robustness of the system. Lean automation uses robust, reliable components and minimises overly complicated solutions (Daso, 2017). In order to fit lean principles and practices, there is a need for the development

The Seybold REPORT
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

of robotised working cells with solutions giving increased availability, the reduction of set-up times, the improvement of the ability to easily reconfigure, and the existence of information design to clearly present visual information and options to the operators. Automation involves the entire process, including bringing material to and from the mechanised equipment. It normally involves integrating several operations and ensuring that the different pieces of equipment 'talk' to one another to ensure smooth operation.

It has been established that automation affects competitive advantage if it plays a significant role in determining the relative cost position or differentiation. Since automation is embodied in every value activity and is involved in achieving linkages among activities, it can have a powerful effect on both cost and differentiation. Using highly automated manufacturing systems is a way for companies with high labour costs to compete (IVA, 2005). Traditionally, high-tech automation has been used by companies that are not considered lean (Muffatto, 1999), while companies such as Toyota have developed so-called low-cost automation (McCarthy & Rich, 2004). Hence, this study assesses the implication of automation on productivity in an automotive assembly organisation in South Africa.

The interplay between automation and employment has long been an important subject, with the beginning of each new Industrial Revolution bringing about new discussions on the topic as the fear of technological unemployment reappears, and as the prospect of technological bonanza is revisited (Webb, 2019). That moment has arrived with an increase in discussions about the fourth Industrial Revolution. 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 such as data input and augment workers' capacity to deal with large amounts of information (Action and Research Centre, 2017). It is estimated that by 2030, 75 to 375 million workers (3–14% of the global workforce) will need to change their occupations as in many current occupations up to 30% of activities will be automated by smart machines with the aid of artificial intelligence and robotic process automation (RPA) (MarketWatch, 2017). In addition, the adoption of automation has been accelerated with the COVID-19 pandemic, as has happened with other trends that were expected to take years or decades to occur but are happening in a much shorter time (McKinsey Global Institute, 2017). It has thus been observed that global industries have not only faced technological changes that have led to opportunities of automation such as greater flexibility but have also presented diverse challenges such as rapid technological changes, increased complexity and changing customer preferences and legal requirements (Syverson, 2017). This has led to challenging situations in a corporate context including the perception of manifold new technological opportunities. However, people are uncertain as to how to use and implement them simultaneously for productivity improvement (Smith, 2018). Consequently, this study examines the implication of automation on productivity in an automotive assembly organisation in South Africa.

ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

PROBLEM STATEMENT

Low-level productivity in the manufacturing sector in South Africa

South Africa's productivity level, in the manufacturing sector, continues to be low despite numerous attempts to improve it (The Conference Board, 2015). The manufacturing industry achieved only 36% of the USA's productivity level in 2014. It also showed low labour productivity when compared with its BRICS counterpart countries like Russia, India and China (CEIC, 2020). The South African manufacturing industry achieved only -0.65 per cent as compared with 1.79 per cent for Russia, 3.64 per cent for India and 6.27 per cent for China in 2019 (CEIC, 2020). South Africa needs to deal with the competitive challenges involved in promoting automation in relation to the improvement of productivity (Doherty & Kiley, 2019).

The rest of the study discusses the literature review, the methodology employed, study results, as well as the discussion of results. In addition, it deliberates on the implications of results for policy and practice, study limitations, conclusion, as well as future research required.

LITERATURE REVIEW

This section discusses automation as an advanced manufacturing system, and its effect on labour during the automation change process. The influence of automation on efficiency concludes this section.

Background and overview of automation

Historically, technological development has led to profound social conflicts (Mokyr, Vickers Ziebarth, 2015). During the first industrial revolution organised groups of workers destroyed the factories where machines were contained as the new technology was viewed as destroying jobs (MacLeod, 2007). Mechanisation, or the socio-historical process that had led to the replacement of workers with machines and an exponential growth in labour productivity, was the object of a profound socio-economic debate in the 19th and 20th centuries (Webster, 2002). On one side were the followers of Karl Marx, who regarded machines as increasing the exploitation of workers, and on the other side were most classical and neo-classical economists who regarded technology as the main variable of modern economic development. The debate on the economic effects of automation survived into the 20th century (Bix, 2000; Woirol, 1996; Neisser, 1942). From the 1920s in the USA, the spread of new methods of analysis of productivity allowed researchers to observe how it was continually and rapidly growing. Until the end of the seventeenth century, the debate about the theme of technological unemployment was completely theoretical. The scientific division of work and the production chain as presented in Henry Ford's factories allowed a great increase in work productivity. According to the US Bureau of Labour Statistics between 1918 and 1927, work productivity grew in all economic sectors (in particular in the mineral extraction) in values between 20 and 50 per cent, whereas in railway transportation and in manufacturing, there was a decrease of work force. Economists such as John Maynard Keynes and Wassily Leontief predicted an evolution of the economic system, in which human labour would become increasingly residual. Keynes praised the benefits of new-found free time, almost considering technology as a means of freeing man

The Seybold REPORT
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

from the toil of work (Milliken, 1987); Leontief, more pessimistically, compared the process of replacement of humans with machines, predicted to take place during the 21st century, to that which led to the replacement of the horse with the car during the 20th (Leontief, 1983). Ricardian pessimism, for which the introduction of machines in factories would mark the advent of an enduring period of technological unemployment, reappears in the writings of 20th century authors (Aronowitz and Di Fazio, 1994). While Keynes was aware of the acceleration of technological progress due to the modernisation of work and the assembly line (Fordism), Leontief was a keen observer of the economic effects of the digital revolution of the 1980s. They both knew that future technology would be infinitely more powerful and less expensive than its predecessors. It seemed very unlikely that such technological advances, maintaining this pace, would not impact the labour market over time.

It can thus be pointed out that manufacturing systems are often considered to be complex systems (Deshmukh, Talavage & Barash 1998; Kuzgunkaya & ElMaraghy 2006). Typical areas where the concept of automation has been investigated, experimented with, and refined are in the studies of situation awareness and the handling or the understanding of data (Syverson, 2017). This concept is interesting in systems with multiple system goals, multiple tasks competing for an operator's attention, and high-task demands under limited time resources. Results from the studies of such systems (Schwab, 2015; Syverson, 2017; Webb, 2019) are to some extent transferrable between different researches areas (Doherty & Kiley, 2019). In one of the organisations in Sweden, work with continuous improvement was done primarily outside of the robot stations (Almandeel, 2014). This was because the robot stations were considered 'black boxes' that did not provide enough support for the production engineers and operators to institute improvements and optimisation in the automated stations. When organisations build their own automation solutions, the process can easily be maintained by the production engineers themselves (Arbuckle, 2013). One of the typical problems when dealing with complex automated systems is that the user has to navigate through a large set of information in order to find out what information is required at any particular point in time (Fernandez & Aman, 2018). This becomes increasingly difficult when the information is distributed over several entities and interfacing points in the work station. Designing a user interface that sorts the information in the automated system and only displays that information that is relevant at any point in time is a critical task in making the system easier to use.

The effects of labour during the application of automation

Automation requires less manual intervention and may result in a reduced requirement of employees as well as the adoption of newer ways of working (Lingmont & Alexiou, 2020). For those employees who understand the business reason and implications of an automation-driven change and are unable to reskill or re-align current competencies to future demands of jobs, there is a possibility that any uncertainty in the change process itself might induce job loss.

This increased appreciation of the discipline and knowledge of the inevitability of automation is likely to promote insecurity. Organisational change can increase demands of time and skills, create fissures within team structures and cause insecurity (Wiesenfeld *et al*., 2001).

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

Uncertainty refers to the psychological state of doubt about the results of a situation (DiFonzo and Bordia, 1998). This state of doubt is experienced by individuals at three levels (Milliken, 1987) when it comes to organisational changes and related decision-making: state, effect and response uncertainty. State uncertainty represents the lack of foresight into how the parts of the organisational environment are changing. Uncertainty of change increases when the process of change is poorly communicated, or when leaders fail to engage employees in the change discourse, leading to perceived marginalisation (Riolli and Savicki, 2006). While job insecurity can be precipitated by organisational change (Baillien and De Witte, 2009; Ferrie 2001; Ferrie et al., 2002), it is also a subjective assessment of involuntary job loss exacerbated by a perceived lack of control over the resulting circumstances.

In its 2017 survey, McKinsey found that 83% of the surveyed firms in India reported willingness to automate their work. Robots featured as an important technological adoption, ranging from humanoid robots (27%) to stationary ones (39%). Furthermore, jobs involving repetitive tasks have a very high potential for automation. In this situation one would find organisations start preparing their employees through workshops and training sessions (Fernandez & Aman, 2018), helping them understand the process, benefits, technical implementation details and use of automation. Employees may also realise that their existing skills may be deficient or unsuitable in the new situation, resulting in a sense of despair, further leading to job insecurity and a potential intention to quit. Recent research by Lingmont and Alexiou (2020) has shown a positive correlation between awareness of automation technologies and job insecurity. Employees could experience uncertainty at a personal circumstantial level in spite of their high-skill level and the realisation of the benefits of automation to the organisation. The individual could have questions about relevance of existing job functions, span of control and outsourcing strategies. There could be doubts about how this impacts his or her existing employment in the short and medium term. The employee may have options to respond to these uncertainties, such as upskilling, moving laterally within the organisation or seeking other employment. However, the impact of these responses may still be unclear. It could also be argued that even those employees who do not have the relevant skills may still display commitment to change, namely, the intention to support change due to acknowledgement of benefits as rational beings. Thus, it is likely that this commitment to change, believing in the inevitability of the change, will aggravate the likelihood of job loss in such individuals (Webb, 2019).

When looking at the benefits of automation in the current fourth Industrial Revolution, one can highlight its potential for reducing errors, increasing productivity, augmenting human capacity, overcoming the challenge of the ageing population and improving speed and quality (Bejakovi & Mrnjavac, 2020). Unlike humans, machines do not get tired or have any feelings; they can make decisions very fast, based on an abundance 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 labour (Autor, 2015). Hence, this study assesses the influence of automation on labour productivity.

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

Significant of automation on process efficiency

Automation, in the manufacturing sector, is influenced by the changes in market requests (Webb, 2019). As personalisation of products, mix variability, requirement of short time to market and risk of product obsolescence all increase, the need of continuous flow and JIT solutions force industry to make constant improvements in terms of product quality, operation efficiency and production capacity utilisation (Battini, Manzini, Persona & Regattieri, 2006). The food and beverage sector is characterised by automated flow line manufacturing systems. This means that there are several machines working in sequence, connected through various transport systems. Automation, in general, leads to the reduction of human participation in the production systems, the introduction of machines for repetitive and/or complex actions as well as the transformation of production to make it as continuous as possible (Autor, 2015). With this kind of production system, few operators are required. Nevertheless, downtimes remain as a relevant cause of inefficiency and require focused analysis. As a result, this study examines whether automation has the ability to improve organisational productivity in the selected automotive assembly organisation in South Africa. It explores the suitability of automation as an appropriate manufacturing system for productivity improvement.

RESEARCH DESIGN AND APPROACH

This study was quantitative in nature. It examines the relationship of company productivity as a dependent variable to labour productivity and process efficiency. Bryman and Bell (2007) describe the quantitative design as an approach involving the use of statistical procedures to analyse the data collected. Consequently, after the measurements of the relevant variables, the scores were transformed using statistical methods. For this study to achieve its objectives, the pre- and post-automation data were collected over time from one large automotive assembly organisation. The organisation is situated within the eThekwini Municipality in the province of KwaZulu-Natal in South Africa. Data were analysed using the descriptive and conclusive designs. Conclusive studies are meant to provide information that is useful in decision-making (Yin, 2008).

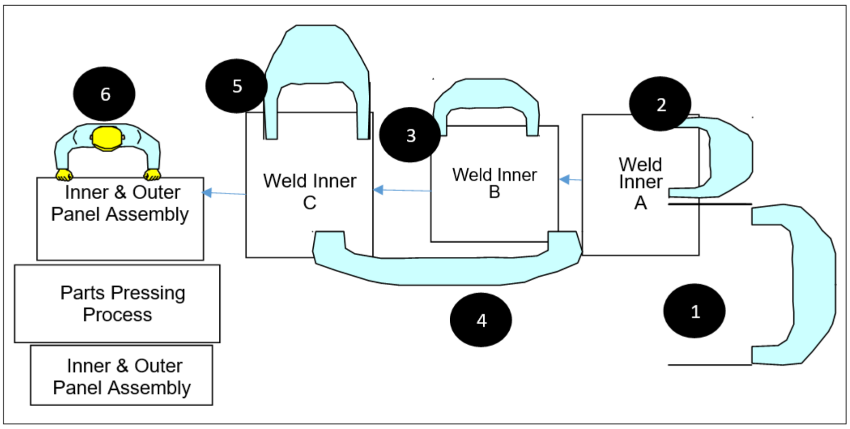
Company Position Pre-Automation

The company that agreed to participate had adopted automation in its Deck Tailgate process in the weld plant. Prior to automation, it was unable to achieve the set production target of 87 Takt time. Takt time is the rate at which the product is completed in order to meet customer demand (Lebednik, 2012). It therefore implemented automation in process in order to improve plant productivity through standard time improvement. This resulted in the development of a human resource capacity to handle automated systems for both the internal staff and suppliers. The automated system was directed towards the company’s blue-collar employees whose jobs require manual labour. The following Figure 1 presents the layout of the Deck Tailgate process prior to its implementation of automation.

ISSN 1533-9211

DOI 10.17605/OSF.IO/57GZ2

Figure 1: Pre-Automation Deck Tailgate



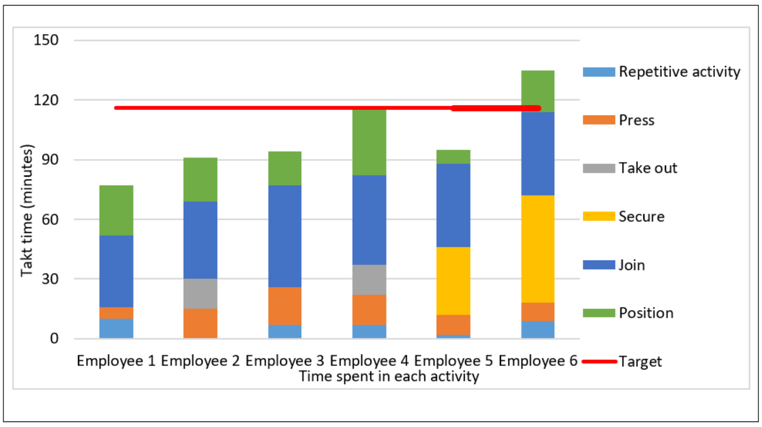
Source: company's quality records (2022)

The Deck Tailgate was assembled through six processes by six blue-collar employees. Employee numbering on Figure 1 explains the flow of the Deck Tailgate assembly process from employee 1 to 6. The process is complete once the Deck Tailgate panels are assembled into a single unit (employee 6).

Pre-automation performance implications

The Deck Tailgate assembly had six activities. These included the repetitive activities, namely press, take out from press machine, secure, join and position. Workloads for all six employees were unbalanced. Their activities were completed by each at different cycle times, thus affecting labour productivity and process efficiency. For instance, employee 6 took longer to complete a given Deck Tailgate process as compared with employees 1, 2, 3 and 5. Thus, employee 4 had to complete his or her tasks within the set target time whilst employees 1, 2, 3 and 5 competed them in far less than the set time, as shown in Figure 2.

Figure 2: unbalanced assembly workload affecting performances for employees 1 to 6



Source: Author's own work.

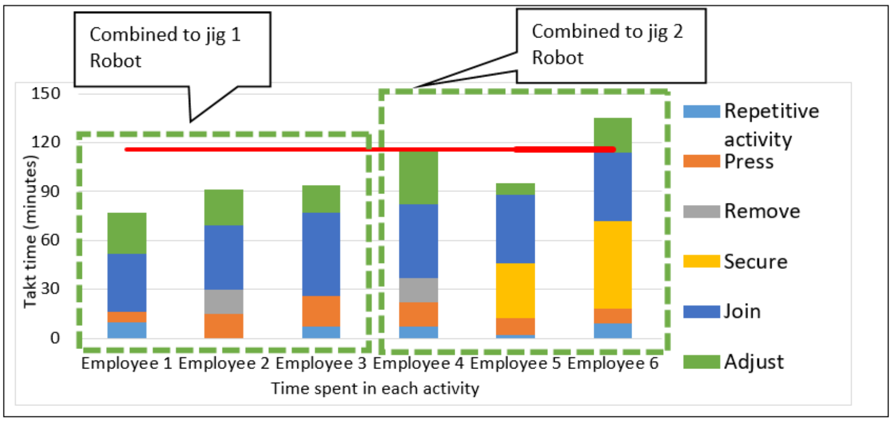
ISSN 1533-9211

DOI 10.17605/OSF.IO/57GZ2

Pre-automation process

The unbalanced workload amongst employees involved in the assembly process necessitated the re-arrangement and re-balancing of the Deck Tailgate process. The re- arrangement initiatives led to consolidation of activities to less manual work. The process served as a base for the introduction of jig robots within the Deck Tailgate assembly, thus automating the section. Josh (2021) defines a jig as a special purpose device used to guide and locate the tool to a pre-defined position on the work-piece. Consequently, the process required fewer employees to be accomplished, resulting in a labour productivity increase and process efficiency improvement. Figure 3 shows a schematic presentation on the re-arrangement of activities as a result of the application of automation in the Deck Tailgate assembly.

Figure 3: re-arrangement of activities in the Deck Tailgate Assembly process



Source: Author's own work.

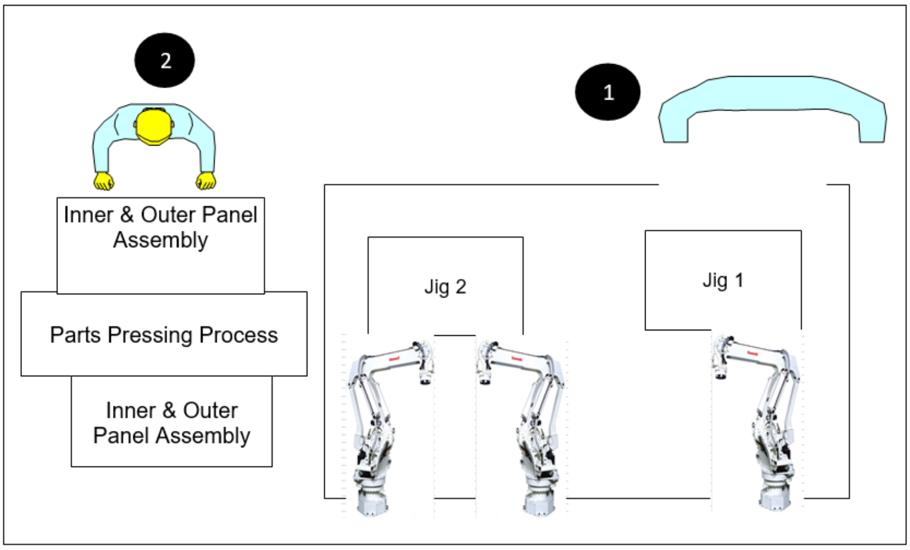
COMPANY'S POSITION POST-AUTOMATION

The unbalanced Deck Tailgate assembly workload shown in Figures 1 and 2 necessitated the re-arrangement of the process for productivity and process efficiency improvement. As indicated, this resulted in the re-arrangement of the assembly process, thus consolidating activities to less manual work. The process was motivated by the introduction of robots within the Deck Tailgate assembly, thus automating the entire section. Consequently, this resulted in the reduction of employees in the section from six to two, resulting in a labour productivity increase and process efficiency improvement (as shown in Figure 6). However, the following Figure 4 presents the layout of the pre-automation Deck Tailgate process.

ISSN 1533-9211

DOI 10.17605/OSF.IO/57GZ2

Figure 4: post-automation layout of the Deck Tailgate process

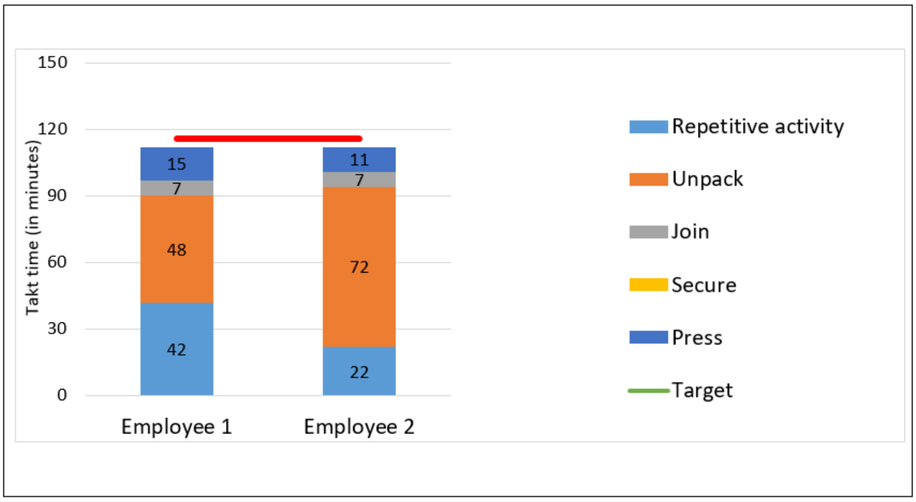


Source: company's quality records (2022)

Post-automation performance implications

This section explains process changes that lead to workload balance emanating from the introduction of robots, thus automating the process. The approach, subsequently, resulted in a balanced workflow in the Deck Tailgate assembly for productivity and process efficiency improvement. Figure 5 shows the workload balance between the two remaining employees.

Figure 5: workload balance between the two remaining employees

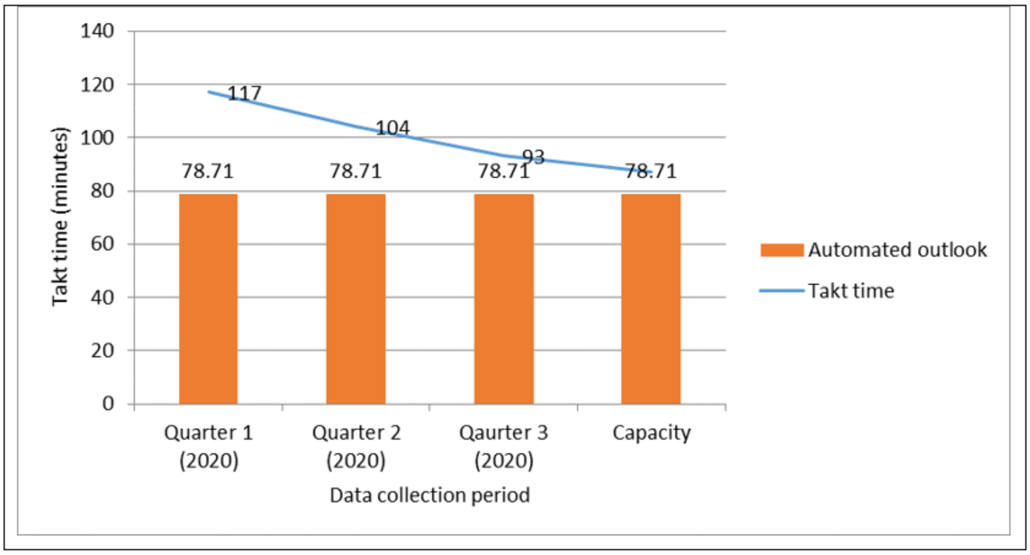


Source: Author's own work.

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

The following Figure 6 shows the extent of Takt time capacity improvements resulting from process changes and automation. It shows the progressive improvements in Takt time from 117 minutes in quarter 1; 104 in quarter 2; 93 in quarter 3; and 78.87 in quarter 4 (as compared to the target Takt time of 78.71 minutes).

Figure 6: Process Improvement Post-Automation



Source: Author's own work.

SUMMARY OF RESULTS

This section presents results for pre- and post-automation means comparison.

Pre- and post-automation means comparison

Table 1 compares the means (in percentages) for labour productivity, process efficiency and downtime.

Table 1: Pre- and Post-Automation Percentage Means Comparison

No.	Variable	Pre-automation period (%)	Post-automation period (%)	% mean difference (post – pre)
1.	Labour productivity	85.25	90.50	+5.25
2.	Process efficiency	85.67	91.71	+6.04

Source: author's own analysis

Table 2 indicates that the percentage mean data for pre-automation on labour productivity and process efficiency are 85.25% and 85.67%; respectively. In addition, the percentage mean data for post-automation on labour productivity and process efficiency are 90.50% and 91.71% respectively. Table 2 shows and increase in mean values on labour productivity and process

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

efficiency when post-automation is compared with the pre-automation periods. This indicates the influence of automation in the organisation that participated in the study.

Equality of pre- and post-sample variances

The Bartlett's test was used to verify whether the variances were equal for all the samples (Curwin & Slater, 2002). The following Table 2 presents detailed results of Bartlett's tests for homogeneity of variances for labour productivity and process efficiency.

Table 2: Bartlett's Test for Homogeneity of Variances

Variables	means of transformed data	standard deviations of transformed data	P-Value
Labour productivity	87.875	6.074	0.001
Process efficiency	88.667	5.281	

Source: author's own analysis

The p-value in the Bartlett's tests (at p>0.05) show that a homogeneity of variances has occurred, thus rejecting the null hypothesis. The p-value at 0.001 is low when compared with the significant level of 0.05. It can be concluded that there are distribution changes between the two parts of time-series.

DISCUSSIONS

This study investigates the influence of automation on the improvement of company productivity in an automotive assembly organisation in South Africa. It examined the production and related experiences of the automotive assembly organisation that had adopted an automation strategy in its Deck Tailgate operations. Quarterly time series data on labour productivity and process efficiency were used to analyse data. Results indicate labour productivity and process efficiency improves as a result of the application of automation. It has the ability to raise productivity from 0.8 to 1.4%, annually (McKinsey Global Institute, 2017). However, the improvement was a consequence of the reduction in the number of employees from six to two. Employee reduction is concurred by Autor (2015), who indicates that automation normally leads to the reduction of human participation in the production systems, the introduction of machines for repetitive tasks and the transformation of production to make it as continuous as possible. Riolli and Savicki (2006) are of the view that employee uncertainties that result from operational change increases when the process of change is poorly communicated, or when leaders fail to engage employees in the change discourse leading to perceived marginalisation.

IMPLICATIONS OF RESULTS FOR POLICY AND PRACTICE

Manufacturing organisations operating in South African should revise their performance systems and implement automated technologies that help to achieve productivity goals (Grewal, 2011). This must be based on an understanding of the economic factors affecting

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/57GZ2

automation in operations. Besides the achievement of the study objectives, the following conclusions can be made on the adoption of automation:

1) It has a potential to increase productivity and augment human capacity (Bejakovi & Mrnjavaz, 2020).
2) It reduces downtime whilst improving a company's productivity

The introduction of automation may significantly increase uncertainty amongst employees about skills, jobs and the nature of their work. Consequently, organisational change can increase demands of time and skills, create fissures within team structures and cause insecurity (Wiesenfeld et al., 2001). Uncertainty, in this case, refers to the psychological state of dubiety about the results of a situation (DiFonzo and Bordia, 1998). Employees may exercise different options. They may either stay in their roles, try to find another lateral move within the organisation, upskill or leave the firm (Autor, 2015). Consequently, uncertainty of change increases when the process of change is poorly communicated, or when leaders fail to engage employees in the change discourse leading to perceived marginalisation (Riolli and Savicki, 2006).

STUDY LIMITATIONS

The study was limited to an automotive assembly organisation within the eThekwini Municipality. The investigation was conducted in a single company that has adopted mechanisation in its assembly process. As there are eight registered assembly organisations in South Africa (SAinfo, 2018), the results cannot be extrapolated to other companies within the sector. Future studies ought to use the more advanced Johansen VAR methodology, which relies on large datasets.

CONCLUSION

Numerous studies perceive automation as an approach that results in positive outcomes (Autor, 2015; Bejakovi & Mrnjavaz, 2020; Syverson, 2017). It has the potential to reduce errors, increase productivity and augment human capacity (Bejakovi & Mrnjavac, 2020). It involves the entire process, including bringing material to and from the mechanised equipment (Daso, 2017). Properly implemented and managed, the strategy results in the improvement of the overall business performance. Hence, the study revealed the relationship between labour productivity and the overall company post-automation productivity.

References

1) Action and Research Centre. (2017). The age of automation, available at: https://www.thersa.org/globalassets /pdfs/reports /rsa_the-age-of-automation-report.pdf.

2) Almandeel, S.M. (2014). The Impact of Employees' Personality Traits in Perceiving Leadership Styles and Organizational Attitude in Saudi Banking Context, Doctoral Dissertation, University of Portsmouth, Portsmouth.

3) Arbuckle, J. (2013). AMOS 22, User's Guide, Small Waters Corporation, Chicago, IL.

4) Aronowitz, S. & Di Fazio, W. (1994). The Jobless Future, University of Minnesota Press, Minneapolis.

5) Autor, D.H. (2015). Why are there still so many jobs? The history and future of workplace automation, Journal of Economic Perspectives, 29 (3), 3-30.

6) Baillien, E. & De Witte, H. (2009). Why is organizational change related to workplace bullying? Role conflict and job insecurity as mediators, Economic and Industrial Democracy, 30 (3), 348-371.

7) Battini, D., Manzini, R., Persona, A. & Regattieri, A. (2006). TPM approach and new buffer design paradigm in plant layout, 12th ISSAT International Conference on Reliability and Quality in Design, Chicago, IL, August 3-5.

8) Bejakovi, C, P. & Mrnjavac, Z. (2020). The importance of digital literacy on the labour market", Employee Relations, International Journal, 42 (4), 921-932.

9) Bix, A.S. (2000). Inventing Ourselves out of Jobs? America's Debate over Technological Unemployment 1929-1981, Johns Hopkins University Press, Baltimore.

10) Bryman, A. & Bell, E. (2007). Business Research Methods, Oxford Press: USA.

11) CEIC. (2020). Labour Productivity Growth by Country Comparison, [Online] Available at: www.ceicdata.com/en/indicator/countries/labour-productivity-growth [Accessed 14 June 2021].

12) Curwin, J. & Slater, R. (2002). Quantitative Methods for Business Decisions, British Library Cataloguing Data: London.

13) Daso, F. (2017). Bill Gates and Elon Musk are worried for automation - but this robotics company founder embraces it, Forbes, available at: www.forbes. com/sites/frederickdaso/2017/12/18/bill-gateselon-musk-are-worried-about-automation-butthis- robotics-company-founder-embraces-it/

14) Deshmukh, A.V., Talavage, J.J. & Barash, M.M. (1998). Complexity in manufacturing systems, part 1: analysis of static complexity, IIE Transactions, 30 (2), 645-655.

15) DiFonzo, N. & Bordia, P. (1998). A tale of two corporations: managing uncertainty during organizational change, Human Resource Management, 37(3-4), 295-303

16) Doherty, C. & Kiley, J. (2019). Americans have become much less positive about tech companies' impact on the US, Pew Research Center, available at: www.pewresearch.org/ fact-tank/2019/07/29/americans-have-becomemuch-less-positive-about-tech-companiesimpact-on-the-u-s/

17) Fernandez, D. & Aman, A. (2018). Impacts of robotic process automation on global accounting services, Asian Journal of Accounting and Governance, 9 (2), 123-132.

18) Ferrie, J.E. (2001). Is job insecurity harmful to health? Journal of the Royal Society of Medicine, 94(2), 71-76.

19) Ferrie, J.E., Shipley, M.J., Stansfeld, S.A. and Marmot, M.G. (2002). Effects of chronic job insecurity and change in job security on self-reported health, minor psychiatric morbidity, physiological measures, and health related behaviours in British civil servants: the Whitehall II study, Journal of Epidemiology and Community Health, 56(6), 450-454.

20) Grewal, S. (2011). Manufacturing Process Design and Costing: An Integrated Approach, Springer, London.

21) IVA. (2005). Framtida Produktion, Produktion fo¨r konkurrenskraft – panelrapport (In Swedish), Panel Report, available at: www.ivawebb.se/produktion/download/rapporter/Framtida% 20Produktion.pdf (accessed 9 May 2021).

22) Josh, P.H. (2021). Jigs and Fixtures, Tata McGraw-Hill Publishing Company Limited.

23) Kuzgunkaya, O. & ElMaraghy, H. (2006). Assessing the structural complexity of manufacturing systems configurations, International Journal of Manufacturing Systems, 18 (3), 145-171.

24) Lebednik, C., (2012). Tools and Techniques for Quality Control in the Automobile Industry, Available at: http://www.ehow.com/list_7559133_tools-quality-control-automobile-industry.html (Accessed: 17 May 2021).

25) Lingmont, D.N. & Alexiou, A. (2020). The contingent effect of job automating technology awareness on perceived job insecurity: exploring the moderating role of organizational culture, Technological Forecasting and Social Change, 161 (2), 1203-1208.

26) MacLeod, C. (2007). Heroes of Inventions: Technology, Liberalism and British Identity 1750-1914, Cambridge University Press, Cambridge.

27) Manyika, J. (2017). A future that works: AI automation employment and productivity, McKinsey Global Institute Research, Tech. Rep, available at: www.mckinsey.com/ featured-insights/digital-disruption/harnessing automation- for-a-future-that-works.

28) MarketWatch (2017). Automation could impact 375 million jobs by 2030, new study suggests, available at: https://www.marketwatch.com/story/automation-could-impact-375-million-jobs-by- 2030-new-study-suggests-2017-11-29 (accessed 10 August 2021).

29) McCarthy, D. & Rich, N. (2004). Lean TPM – A Blueprint for Change, Elsevier, Oxford.

30) McKinsey. (2017). A future that works: automation, employment, and productivity, available at:https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Digital%20Disruption/ Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-thatworks_ Full-report.ashx (accessed 10 August 2021).

31) McKinsey Global Institute. (2017). A future that works: automation, employment, and productivity, available at: https://www.mckinsey.com/~/media/Mckinsey/featured insights/Digital Disruption / Harnessing automation for future that works /MGI-A future- that-works-Executive-summary.ashx.

32) Milliken, F.J. (1987). Three types of perceived uncertainty about the environment: state, effect, and response uncertainty, Academy of Management Review, 12 (1), 133-143.

33) Mokyr, J., Vickers, C. and Ziebarth, N. (2015). The history of technological anxiety and the future of economic growth: is this time different? Journal of Economic Perspectives, 29(3), 31-50.

34) Mourtzis, D., Doukas, M. & Psarommatis, F. (2012). A multi-criteria evaluation of centralized and decentralized production networks in a highly customer-driven environment, CIRP Annals Manufacturing Technology, 61 (1), 427-430.

35) Muffatto, M. (1999). Evolution of production paradigms: the Toyota and Volvo cases, Integrated Manufacturing Systems, 10 (1), 15-25.

36) Neisser, H.P. (1942). Permanent technological unemployment: demand for commodities is not demand for labour, The American Economic Review, 32(1), 50-71.

37) Rahman, C.M. & Hoque, M.A. (2014). Evaluation of total productive maintenance implementation in a selected semi-automated manufacturing industry, International Journal of Modern Engineering and Research, 4(8), 19-31.

38) Riolli, L. & Savicki, V. (2006). Impact of fairness, leadership, and coping on strain, burnout, and turnover in organizational change, International Journal of Stress Management, 13(3), 351-377.

39) SAinfo. (2018). South Africa's automotive industry, viewed 23 June 2021, from http://www.southafrica.info/doing_business/economy/key_sectors/ motorindustryboost.html.

ISSN 1533-9211

DOI 10.17605/OSF.IO/57GZ2

40) Schwab, K. (2015). The fourth industrial revolution, Foreign Affairs, available at: www.foreignaffairs.com/articles/2015 12-12/ fourth-industrial-revolution.

41) Smith, A. (2018). Public attitudes toward computer algorithms, Pew Research Center: Internet, Science & Tech, available at: www.pewresearch.org/internet/2018/11/16/publicattitudes- toward-computer-algorithms/

42) Syverson, C. (2017). Challenges to mismeasurement explanations for the US productivity slowdown, Journal of Economic Perspectives, 31 (2), 65-186.

43) The Conference Board. (2015). Productivity brief 2015: Global productivity stuck in the slow lane with no signs of recovery in sight, Business World, New York.

44) Webb, M. (2019). The impact of artificial intelligence on the labour market", SSRN eLibrary, available at: https://papers.ssrn. com/abstract=3482150.

45) Webster, F. (2002). Theories of the Information Society, Routledge, London.

46) Wiesenfeld, B.M., Brockner, J., Petzall, B., Wolf, R. & Bailey, J. (2001). Stress and coping among layoff survivors: a self-affirmation analysis, Anxiety, Stress and Coping, 14(1), 15-34.

47) Woirol, G. (1996). The Technological Unemployment and Structural Unemployment Debates, Greenwood Press, Westport, CT.

48) Yin, R.K. (2008). Handbook of Applied Research: California. Sage: Thousand Oaks.