Proceedings of the International Conference on Industrial Engineering and Operations Management
Dubai, UAE, March 10-12, 2020

Productivity Improvement at a Soft Drink Manufacturing Company: A Case Study

Judith Mhlanga and Anup Pradhan
Department of Quality and Operations Management
University of Johannesburg
South Africa
jmhlanga@uj.ac.za; anupp@uj.ac.za

Abstract

This study was conducted to examine the impact of poor-quality management on the productivity of a beverage industry. A South African soft drinks manufacturing company was selected as a case study. The study was carried out among the employees of the company's plant and through observing equipment and wellbeing of company's facilities located in Johannesburg. A sample of 150 workers was drawn from the company, and each employee was asked questions on how productivity can be improved. The results showed that reducing quantity of inputs, such as working time, would enable the company to produce a standardized product. It was also found that proper maintenance of facilities and working equipment and employee's skill improvement would improve operations within the company. Tight supervision and special monitoring of workers have a greater impact on performance and the overall productivity of the company. Thus, the company needs to encourage hygiene and improve employee's skills to adapt to fast changing technologies, and strategies must be adopted accordingly to obtain optimum productivity of the workers and satisfy customers with quality products. By responding to the needs of this contemporary marketing environment, it was believed that it will give the company competitive advantage over its competitors.

Keywords
Quality management, Productivity, New technologies, Beverage industry

1. Introduction

Productivity is defined as the effectiveness of productive effort, measured in terms of the output per unit of input, it is a quantitative relationship between what firm produce and what it has spent on the production (Zamarripa, 1993). Gerald (2004) defines productivity improvement as the process of analysing the performance of the current operating processes and then determining specific strategies that can be put in place (established or implemented) to increase efficiency as well as production output. ‘’Productivity improvement helps businesses and organizations reap benefit from fine-tuning the right productivity processes to accommodate specific operational needs, the benefit from productivity improvement include in overall costs combined with the increase in revenue” (Gerald, 2004).

The application of productivity improvement helps in streamlining an organization or system more efficient and effective by employing faster or simpler working methods, processes and ensures a proactive work system ready to counter deviations from the ideal state. The major thrust of productivity improvement is to achieve productivity and process efficiency by identifying and eliminating problems in work processes and systems. Productivity improvement addresses key problems areas such as mistakes in work processes, redundant (needless or unnecessary) processes, unnecessary tasks and duplicate efforts (Paul, 2007).

Study of productivity improvement is becoming more important against a backdrop of market relations because it allows the company to stay competitive on the market and strengthen the social component in the development of society. An important role in the analysis of productivity is the definition and use of reserves to improve production efficiency. It contributes to the economic use of various resources, identifying and implementing best practices, organization of work, new equipment and technology, to prevent waste, etc. (Muthiah and Huang, 2006).

One of the basic problems in any company is to identify how to improve productivity, and the South African soft drink manufacturing company under study is one of them. Although the company under study is a huge soft drink manufacturing company and it is almost impossible to improve productivity, it is essential to find ways to improve the productivity to stay abreast of the competitors.

The aim of this study is to analyze, measure, and then find ways to increase productivity by developing procedures or strategies to improve productivity. The study aims to improve the productivity of a well-oiled and functioning organization by making adjustments on little things like unnecessary working hours, amount of electricity used for equipment, and increase the amount of drinks produced per minute by adjusting the machines used.

2. Research Methodology

This was a case study which included quantifying single factor and multifactor productivity for the current situation of the company without any changes. Small changes were made to obtain new productivity levels that must be improved, then new productivity levels were calculated using both single factor and multifactor productivity. The productivity change was then estimated by comparing the old productivity results against new productivity results. About 150 workers were involved in the discussion and data collection process. According to Heizer and Render (2014), single and multifactor productivity can be calculated as:

$$Single\ factor\ Productivity = \frac{Units\ produced}{Input\ used}$$

$$Multifactor\ Productivity = \frac{Output}{Labor + Material + Energy + Capital + Miscellaneous}$$

Then the productivity index was calculated as the ratio of actual to standard values, where actual values are productivity values before changes and standard values are productivity values after changes.

$$Productivity\ Index = \frac{Actual}{Standard} \times 100$$

Five basic ways of increasing productivity were used – "increased output is accomplished with smaller inputs, increased output produced by the same quantity of output with fewer inputs, smaller output produced by even less input, and a larger quantity of output is produced by more input but marginal increase in output is larger than the marginal increase in input" (Nemarumane, 2016). The flow chart showing normal and adjusted processes of manufacturing soft drinks is presented in figure 1.

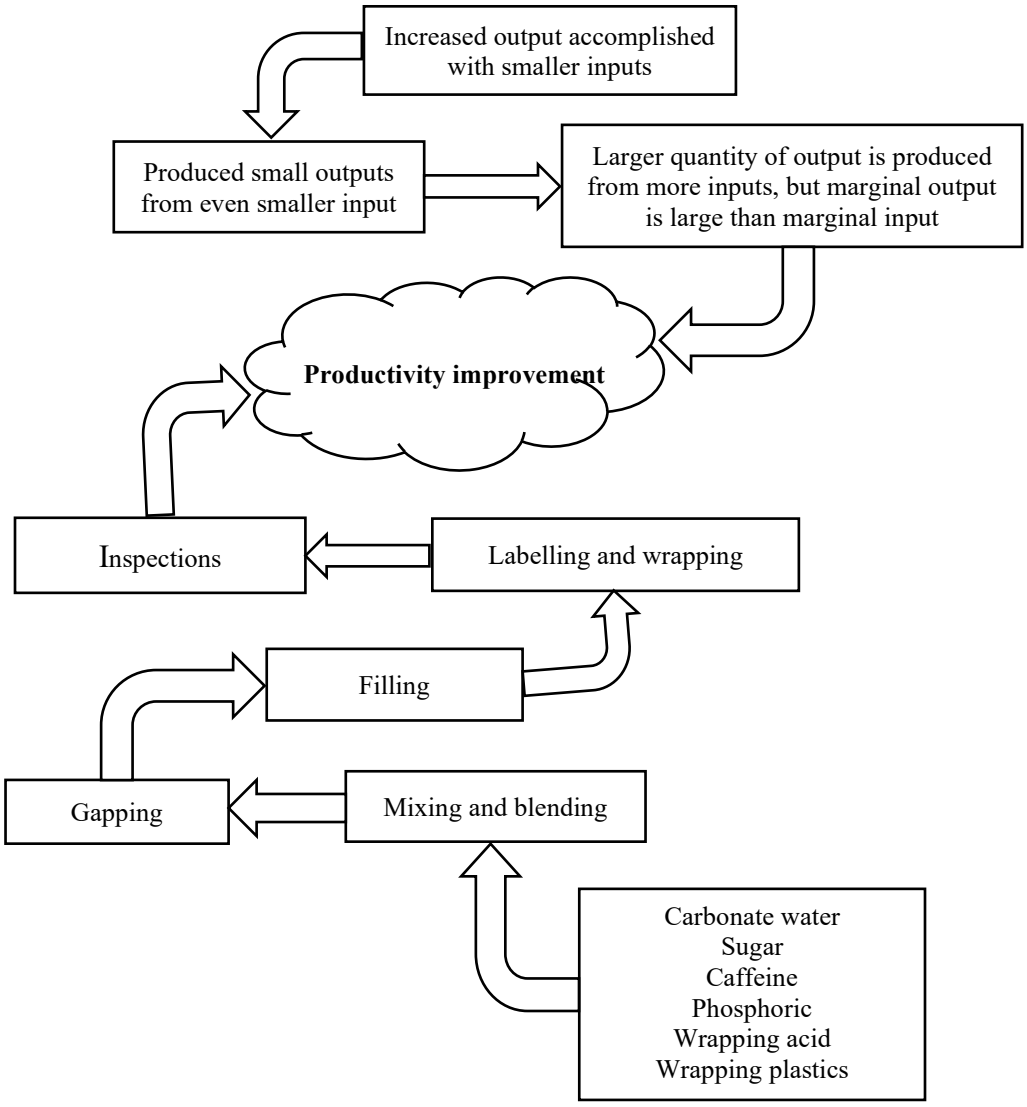

Figure 1. Production of soft drinks pre and post changes

3. Findings and Discussion

3.1 Total Resource Productivity before Changes

The company produce 800 two-litre plastic bottles per minute, which is moved by the conveyor system to the filling machine that fills 40 soft drink bottles with soda per revolution. One revolution takes about 3 minutes, then it is moved by the conveyor system to a machine that inserts the labels on it, then it is moved again by the conveyor system to a machine that wraps the products with two kinds of plastic to avoid defects on the product, and lastly it is moved by fork lifters to the storage room. The company produces 34560000 units @ R11 per bottle (unit) per month.

These impressing results are achieved because about 90% of the production is automated. The study focused only on the production department since it is the core of the company, i.e. if the company wanted to increase productivity, they would focus on this department the most than other departments.

Table 1 shows the measurements and calculations of specific resource productivity before changes, including the estimation of the total resource productivity (TRP) before any changes.

Table 1. Specific resource productivity before changes

	Measurements and Calculations	
Output:	34560000 units	
Inputs:		
Manpower		
Operators	34560000/192 = 180000 units/ man-hr	192 hrs @ R120 = R23040
Fork lifters	34560000/480 = 72000 units/ man-hr	480 hrs @ R30 = R14400
Inspectors	34560000/210 = 164571 units/ man-hr	210 hrs @ R85 = R17850
Operation managers	34540000/36 = 960000 units/ man-hr	36 hrs @ R500 = R18000
Cleaners	34560000/240 = 144000 units/ man-hr	240 hrs @ R18.26 = R4382.40
Materials		
Carbonated water	34560000/432000 = 80 units/ litre	432000 lit @ R0.50 = R216000
Sugar	34560000/7257600 = 4.76 units/ gm	7257600 kg @ R2.30 = R16692480
Caffeine	34560000/3663.6 = 9433 units/ kg	3663.6 kg @ R3.50 = R12822.6
Phosphoric acid	34560000/7326720 = 4.72 units/ litre	7326720 lit @ R2.50 = R18346800
Wrapping plastics	34560000/5760000 = 6 units/ wrapper	5760000 @ R1.12 = R6451200
Labels & printing materials	34560000/240 = 144000 units/ kg	240 kg @ R1.70 = R480
Machinery		
Bottle preparation machine	34560000/672 = 51428 units/ machine-hr	672 hrs @ R 70 = R47040
Mixing equipment	34560000/672 = 51428 units/ machine-hr	672 hrs @ R50 = R33600
Filling machine	34560000/672 = 51428 units/ machine-hr	672 hrs @ R90 = R60480
Conveyor	34560000/672 = 51428 units/ machine-hr	672 hrs @ R65 = R43680
Total Inputs = Total labor input + Total material input + Total machinery input = R77762.4 + R41689710.6 + R184800 = R41952183		
Total TRP = Total Output/ Total Input = 34560000 / 41952182 = 0.082 units per Rand		

3.1.1 Manpower

The inputs used to achieve these outstanding results are manpower, materials and machinery. The core of their production team is operation managers who oversee high-level duties, such as attracting talent and setting training standards and hiring producers. They also analyze and improve organizational processes, which in this case is the production process, and work to improve quality, productivity and efficacy.

The operational managers at the company work for 36 hours per month @ R500 per hour, which amounts to R18000 a month. Fork lifters are also essential for the production process, as they ensure that traffic is avoided after the products are produced and wrapping has taken place; they must pack the finished products in the warehouse in way to avoid any traffic because if they don't pack the finished product orderly and quickly the whole production process must be put on hold resulting in the decrees of productivity levels. Therefore, fork lifters are given a lot of overtime. They work 480 hours per month @ R18.26 per hour, which amounts to R14400 a month.

The company employs the best operators available. The production process is almost fully automated, so they need machine operators. Machine operators work for 210 hours per month @ R120 per hour, which amounts to R23040 a month.

Since the company produces a lot of units every day, defects are inevitable, and the defects tend to make a lot dangerous hazards in the workplace such as slippery hazards for workers. So, the company needs cleaners 24/7 in order to keep a safe and clean working environment for their employees. The cleaners work 240 hours per month @ R18.26 per hour, which amounts to R4382.40 a month.

Although the company employs modern technologies detect defects, they still need inspectors to evaluate, analyze and ensure that the product is qualified to be the brand product. Since the company produces millions of units every day, the company has introduced technology that inspects the quality of the product which makes the job easier for the inspectors. Inspectors work for 195 hours per month @ R80 per hour, which amounts to R15600 a month.

3.1.2 Materials

The study covered only materials used in the production process. These materials employed are either part of the branding or ingredients used to produce the product.

Materials used to produce 3456000 units @ R11 per unit per month include carbonated water, sugar, caffeine, phosphoric acid, wrapping plastics, labels and printing materials. The company used 432200 litters of carbonated water @ R0.50 per litre amounting to R216000 per month, 7257600 kg of sugar @ R2.30 per kg amounting to R16692480 per month, 36663.3 kg of caffeine @ R3.50 per kg amounting to R12822.6 per month, 7326720 litres of phosphoric acid @ R1.12 per litre amounting to R18346800, 57600000 plastic rolls @ R1.12 per roll amounting to R6451200 per month, and 240 kg of labels and printing materials @ R1.70 per kg amounting to R480 per month.

3.1.3 Machinery

The company uses four major machines in the production process, which are bottle preparation machine, mixing machine, filling machine, and the conveyor system. Since machines play a huge rule in the production process, they need to run 24/7 to produce 34560000 units per month.

The company runs the bottle machine for 672 hours @ R70 per hour which amounts to R47040 per month, the mixing machine runs for 672 hours @ R50 per hour which amounts to R33600 per month, filling machine runs for 672 hours @ R90 per hour which amounts to R60480 per month, and the conveyor system also runs for 672 hours @ R60 per hour which amounts to R43680 per month.

3.3 Changes Made

Operation managers are assigned to make changes to improve the productivity of the organization; and even though the organization being studied is well established, there is still a room for improvement (Aghazadeh, 2003). The study focused only on the production department, since it is the heartbeat of the company and it was less complex to increase the productivity levels focusing on one department. To increase productivity, the study focused on five basic way to increase productivity.

Based on the five ways to increase productivity, the study focused on making few changes to the production department of the company. The first change made was to remove unnecessary working hours, especially looking at employers who are not needed in the organization 24/7, and are just there to maintain the standard and to improve the productivity. The other change made was to increase the current number of units produced per month (34560000 units) by making little adjustments on few selected machines. For instance, increasing the number of bottles that the filling machine was filling from 40 bottles to 50 bottles per revolution. It was observed that running machines was costing the company a lot, so it was suggested to use renewable energy such as solar panels to lower the cost, mainly because the company is located in an area which receives a lot of solar radiation throughout the year.

3.3 Total Resource Productivity after Changes

The main objective of the study is to make necessary changes that will allow the company to be in a better position to improve their productivity. After the changes, the productivity improved from 34560000 @ R11 to 39740000 @ R8 units per month which increased the monthly production by 5180000 units. Minor but effective changes enabled the productivity improvement by 15%.

Table 2 shows the measurements and calculations of specific resource productivity after changes, including the estimation of the TRP after performing small changes.

Table 2. Specific resource productivity after changes

	Measurements and Calculations	
Output:	39744000 units	
Inputs:		
Manpower		
Operators	39744000/180 = 220800 units/ man-hr	180 hrs @ R100 = R18000
Fork lifters	39744000/450 = 88320 units/ man-hr	450 hrs @ R30 = R13000
Inspectors	39744000/195 = 203815 units/ man-hr	195 hrs @ R80 = R15600
Operation managers	39744000/34 = 1168941 units/ man-hr	34 hrs @ R400 = R13600
Cleaners	39744000/235 = 169123 units/ man-hr	235 hrs @ R18 = R4230
Materials		
Carbonated water	39744000/417321 = 95.24 units/ litre	417321 lit @ R0.45 = R187794
Sugar	39744000/75123920 = 5.56 units/ kg	71523920 kg @ R2 = R14307840
Caffeine	39744000/3974.4 = 10000 units/ kg	3974.4 kg @ R3.35 = R13314.24
Phosphoric acid	39744000/7670592 = 5.18 units/ litre	7670592 lit @ R2.20 = R16875302
Wrapping plastics	39744000/6624000 = 6 units/ roll	6624000 @ R1.05 = R6955200
Labels & printing materials	39744000/220 = 180654 units/ kg	200 kg @ R1.70 = R290
Machinery		
Bottle preparation machine	39744000/672 = 59142 units/ machine-hr	672 hrs @ R 55 = R36960
Mixing equipment	39744000/672 = 59142 units/ machine-hr	672 hrs @ R45 = R30240
Filling machine	39744000/672 = 59142 units/ machine-hr	672 hrs @ R78 = R52416
Conveyor	39744000/672 = 59142 units/ machine-hr	672 hrs @ R60 = R40320
Total Inputs = Total labor input + Total material input + Total machinery input = R64930 + R38339737.04 + R159936 = R36564603.04		
Total TRP = Total Output/ Total Input = 39744000 / 38564603.04 = 1.03 units per Rand		

3.3.1 Manpower

During the study, it was observed that some of the employees were working unnecessary hours that reduced the productivity and increased the fatigue levels of the company, so working hours of some employees were reduced. After the changes, the working hours and pay rate of machine operators were reduced by 12 hours and R20 per month, respectively.

Fork lifters are one of the most important workforces in the company and it was essential not to affect their moral levels, hence only working hours was reduced for them. However, their working hours were reduced by 30 hours per

month to reduce fatigue in the group. The working hours and pay rate of inspectors were reduced by 15 hours and R5 per month, respectively. Likewise, the working hours and pay rate of operation managers were also reduced by 2 hours and R100 per month, respectively. Lastly, the working hours and pay rate of cleaners were reduced by 5 hours and R0.26 per month, respectively. It was observed that cleaners didn't need to work that frequently because not a lot of people work at the assembly lines or area.

3.3.2 Materials

Out of the five basic ways to increase productivity, one alternative is to increase the inputs and output. After increasing the output by 15%, more materials were needed to make additional 5180000 units every month.

The company used 417321 litters of carbonated water @ R0.45 per litre which amounted to R187794 per month providing a monthly saving of R28206; 7153920 kg of sugar @ R2 per kg which amounted to R14307840 per month providing a monthly saving of R2386.64; 3974.4 kg of caffeine @ R3.35 per kg which amounted to R13314.24 per month providing a monthly saving of R491.64; 7670592 litres of phosphoric acid @ R2.20 per litre which amounted to R16875302.4 providing a monthly saving of R1471497.6; 6624000 plastics @ R1.05 per wrapping plastic which amounted to R6955200 per month which cost the company R504 extra; and lastly 200 kg of labels and printing materials @ R1.70 per kg which amounted to R290 per month that saved the company R190 every month. Since the quantity of some of the input material increased, this allowed the company to negotiate better prices with the suppliers.

3.3.3 Machinery

It is expensive to operate machines 24/7 because they use electricity, so solar panels were identified as alternative source of energy to assist in reducing the cost of running machines. After the introduction of solar panels, the organization was able to reduce the cost of running the machines. The company currently runs the bottle machines for 672 hours @ R55 per hour which amounts to R36960 per month providing a monthly saving of R10080 after the changes, the mixing machine runs for 672 hours @ R45 per hour which amounts to R30240 per month providing a monthly saving of R3360, the filling machine runs for 672 hours @ R78 which amounts to R52416 per month providing a monthly saving of R8064, and lastly the conveyor system runs for 672 hours @ R60 per hour which amounts to R40320 per month providing a monthly saving of R3360.

3.4 Productivity Index and Improvements

Table 3 presents the estimation of productivity index before and after changes were made. Except for wrapping plastics, all other resource productivity have improved from 6% to 23%.

Table 3. Productivity index before and after changes

Inputs	Productivity Index	Remarks
Manpower:		
Operators	220800/ 180000 * 100 = 122.67	22.67% above standard
Fork lifters	88320/ 72000 * 100 = 122.67	22.67% above standard
Inspectors	203815.38/ 164571.43 * 100 = 123.85	23.85% above standard
Operations managers	1168941.18/ 960000 * 100 = 121.76	21.76% above standard
Cleaners	169123.40/ 144000 * 100 = 116.81	16.81% above standard
Materials		
Carbonated water	95.24/ 80 * 100 = 119.01	19.01% above standard
Sugar	5.56/ 4.76 * 100 = 116.81	16.81% above standard
Caffeine	10000/ 9433.34 * 100 = 106.01	6.01% above standard
Phosphoric acid	5.18/ 4.72 * 100 = 109.75	9.75% above standard
Wrapping plastics	6/ 6 * 100 = 100.00	On standard
Labels and printing materials	180654.55/ 144000 * 100 = 125.45	25.45% above standard

Machinery		
Bottle preparation machines	59142.86/ 51428.57 * 100 = 115.53	15.53% above standard
Mixing machines	59142.86/ 514128.57 * 100 = 115.53	15.53% above standard
Filling machines	59142.86/ 514128.57 * 100 = 115.53	15.53% above standard
Conveyor	59142.86/ 514128.57 * 100 = 115.53	15.53% above standard
TRP	1.03/0.082 * 100 = 112.56	12.56 above standard

4. Conclusion

A South African soft drink manufacturing company was studied to examine the factors that were adjusted to increase the overall productivity of the company. Based on the results of productivity index, it was found that the productivity of the company was improved, which was achieved by reducing the amount of productivity factors identified during the study, and changes were made to increase the level of output for the same quantity of inputs or even lesser inputs. This is aligned with Wilt et al. (2010), who stated that productivity is achieved by reducing the amount of inputs used to produce the same outputs or increasing the inputs to produce more outputs. The improved productivity makes the company more productive and competitive.

References

Aghazadeh, S.M., A new mandate for operations managers, *Work Study*, vol. 52, no. 6, pp. 310-316, 2003. Available: https://emeraldinsight.com/doi/full/10.1108/00438020310496578, October 8, 2019.

Gerald Cole. 2004. Management theory and practice G.A. Cole. South- western Cengage learning. ghd8-7-k7-18ul, Geraldine Lyons.

Heizer, J., and Render, B., *Operations Management: Sustainability and Supply Chain Management*, 11th edition, Pearson, 2014.

Nemarumane M., 2016. organizational effectiveness vol 32, no page 96, reserved @ academic development Centre.

Muthiah, K.M., and Huang, S.H., A review of literature on manufacturing systems productivity measurement and improvement, *International Journal of Industrial and Systems Engineering*, vol. 1, no. 4, pp. 461-484, 2006. Retrieved 10 7, 2019, from http://pqprc.ac.ir/userfiles/groups/a review of literature on manufacturing systems.pdf

Paul sander. psychology learning & teaching, vol. 4, 1: pp. 15-21., first published mar 1, 2007.

Wilt, M.A., Miranda, R., Johnson, C.D., and Love, P.S., Measuring and Improving Productivity in General Radiology, *Journal of The American College of Radiology*, vol. 7, no. 10, pp. 774-777, 2010. Available https://ncbi.nlm.nih.gov/pubmed/20889106, October 8, 2019.

Zamarripa, E.J., Research Productivity: A Definition, *Ment Retard.*, vol. 31, no. 5; pp. 320-325, 1993. Available: https://ncbi.nlm.nih.gov/pubmed/8271943, October 7, 2019.

Biographies

Judith Mhlanga is currently a fulltime Assistant Lecturer and a prospective Masters student under the Department of Quality and Operations Management at the University of Johannesburg.

Anup Pradhan is currently a Senior Lecturer in the Department of Quality and Operations Management, University of Johannesburg, South Africa. He received BSc in Agricultural Engineering from Bangladesh Agricultural University, Bangladesh, ME in Agricultural Engineering from Asian Institute of Technology, Thailand, and PhD in Biological and Agricultural Engineering from University of Idaho, USA. He has held posts at Institute of Engineering and Alternative Energy Promotion Centre in Nepal. His research interests include life cycle assessment, renewable energy, farm mechanization, operations management, smart factory, smart grid management, applied research and optimization, organizational productivity, knowledge management. He is NRF rated researcher in South Africa and a registered engineer with Nepal Engineering Council (NEC). He is a member of American Society of Agricultural and Biological Engineers (ASABE), Engineering Council of South Africa (ECSA), Nepal Engineer's Association (NEA), Gamma Sigma Delta, Golden Key International Honor Society.