A DYNAMIC APPROACH TO IMPROVING THE PRODUCTIVITY OF A SOUTH AFRICAN FOUNDRY INDUSTRY

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ABSTRACT

Systems for refining and handling foundries have evolved rapidly in recent years. However, the South African foundry industry has been contracting since 2007, when its annual output was at 660 400 tonnes. The objective of the current study was to investigate productivity improvement measures that would contribute in improving the productivity of Gauteng foundries. A quantitative cross-sectional survey research design was used for the study, and a purposive sampling technique was chosen to provide insight into the specific study. The quantitative data obtained from the study was analysed using several statistical tools. Exploratory factor analysis with Varimax rotation of 23 Likert-scale questions in the questionnaire was performed on data gathered from 143 participants. Factors with eigen values greater than 1 were retained using the Kaiser selection criterion. These factors were related to foundry management and leadership, labour, and machinery. Analysis of the reliability of the results indicated that Cronbach's alpha for all thirty productivity factors was 0.9472. This $\alpha \geq 0.70$ indicated a good consistency in the selected items in the questionnaire. Based on the results, a proposed productivity framework was developed, contemplating the integration of lean thinking, manufacturing tools, and the Deming cycle, and providing a systematic and holistic approach to problem-solving through the application of the plan-do-check-act (PDCA) cycle in the foundry industry.

OPSOMMING

Stelsels vir die raffinering en hantering van gieterye het die afgelope jare vinnig ontwikkel. Die Suid-Afrikaanse gieterybedryf krimp egter sedert 2007, toe sy jaarlikse produksie op 660 400 ton was. Die doel van die studie was om produktiwiteitsverbeteringsmaatreëls te ondersoek wat sal bydra tot die verbetering van die produktiwiteit van Gautengse gieterye. 'n Kwantitatiewe deursnee-opname navorsingsontwerp is vir die studie gebruik, en 'n doelgerigte steekproeftegniek is gekies om insig in die spesifieke studie te verskaf. Die kwantitatiewe data wat uit die studie verkry is, is ontleed met behulp van statistiese hulpmiddels. Verkennende faktoranalise met Varimax-rotasie van 23 Likert-skaalvrae in die vraelys is uitgevoer op data wat van 143 deelnemers ingesamel is. Faktore met eigen waardes groter as 1 is behou deur die Kaiser-seleksiekriterium te gebruik. Hierdie faktore was verwant aan gieterybestuur en leierskap, arbeid en masjinerie. Ontleding van die betroubaarheid van die resultate het aangedui dat Cronbach se alfa vir al dertig produktiwiteitsfaktore 0,9472 was. Hierdie $\alpha \geq 0.70$ het 'n goeie konsekwentheid in die geselekteerde items in die vraelys aangedui. Gebaseer op die resultate, is 'n voorgestelde produktiwiteitsraamwerk ontwikkel wat die integrasie van lenige denke, vervaardigingsgereedskap en die Deming-siklus oorweeg, en 'n sistematiese en holistiese benadering tot probleemoplossing verskaf deur die toepassing van die plan-doen-kontroleer-reageer (PDCA) siklus in die gieterybedryf.

1. INTRODUCTION

The manufacturing sector contributed 13% to South Africa's gross national product (GNP) in 2019. Foundries thus play a significant role in South Africa in dealing with the challenges of poverty and job creation [1]. The sector remains labour-intensive; thus it contributes to job creation and to the sustainability of the country. A total of 66% of South African foundries are in the Gauteng Province. In 2003 Gauteng had 143 foundries; this number decreased to 141 in 2007 and decreased further to 114 in 2015 [2]. Table 1 below shows the geographical location of the foundries in South Africa.

Table 1: Geographical location of foundries in South Africa [1]

Province	Number of foundries in 2003	Number of foundries in 2007	Number of foundries in 2015	% of total foundries in 2015
Gauteng	143	141	114	66%
KwaZulu-Natal	20	26	20	12%
Western Cape	26	16	14	8%
Eastern Cape	16	10	8	5%
Free State	10	7	5	3%
North West	10	9	4	3%
Northern Cape	6	3	3	2%
Mpumalanga	15	15	2	1%
TOTAL	246	227	170	100%

The sustained decline in the industry shown in Table 1 has resulted in low productivity and the loss of competitive ground in the global market. For example, the low productivity in the Gauteng foundry industry has resulted in limited access to the international market, job losses, a reduction in its contribution to the GNP, and ultimately a lack of competitiveness [3]. This indicates that there is a lack of implementation of productivity improvement techniques in the foundry industry.

Competition is the driving force and the key strategy for productivity improvement in many organisations. Manufacturing organisations that have adopted performance measurement systems tend to improve their productivity — something that is greatly needed by the foundry industry [4]. Productivity is much more important than an organisation's revenues and profits: profits only reflect a financial result, whereas productivity reflects increased efficiency and the effectiveness of the business's policies and processes [6]. Foundry organisations that have applied lean manufacturing tend to improve their operational efficiency and respond to changing environmental pressures [7].

Plan-do-check-act (PDCA) cycles are used for productivity improvement in most manufacturing processes in which tools and techniques inspired by operations management have become influential. The essence of the PDCA cycle is to structure the improvement process in accordance with the scientific method of experimental learning. Maleyeff, Arnheiter and Venkateswaran [8] state that the Six Sigma approach, created by Bill Smith at the Motorola Corporation in the 1980s, seeks to reduce variability to reduce errors and defects by applying the define-measure-analyse-improve-control (DMAIC) cycle. Six Sigma is a highly disciplined process that helps organisations to focus on delivering lower-cost products with improved quality and a reduced cycle time. It is worth noting that a lean system involves several principles for operations management and that Six Sigma focuses on reducing process variability and on the incremental improvement of key performance indicators. Six Sigma is a data-driven approach that seeks to reduce errors and defects by applying the DMAIC methodology [9]. It is important to understand that to embrace PDCA and DMAIC since they emphasise maximising values and reducing costs in organisations by developing quality products, processes, or services [10]. A lack of their application has caused the ineffective performance of the domestic manufacturing sector in recent years, as seen in the weak demand conditions in local and external markets and in increased competition from imported products [11]. As mentioned already, the South African foundry industry faces various difficulties. This study attempted to develop an assessment matrix framework to rank and identify productivity improvement indices in order to enhance productivity and to help prevent job losses through innovative thinking. The importance of mutually beneficial connections arising from productivity improvement methodologies in order to gain competitive advantage needs to be taken into consideration.

2. LITERATURE REVIEW

The South African foundry industry mainly serves the mining, automotive, and general engineering sectors. The decline in the industry has been because of a high volume of import products, rapidly rising energy costs, energy inefficiency, the cost of compliance with environmental regulation, and a widening skills gap [4]. Mpanza, Nyembwe and Nel [12] note that the South African foundry industry has certain competitive advantages, but that its low resource efficiency reduces defects and optimise resources to deliver more value. Competitiveness is an important factor in determining whether a foundry organisation thrives, scarcely gets by, or fails. Gauteng foundries are losing their global competitiveness and productivity [7]. They have become less efficient, and face a number of problems, such as a lack of access to markets and rising input, energy, and labour costs. A lack of quality management systems and technology transfer contributes to South African foundries not being able to compete with other emerging countries. Low productivity rates have a negative impact on the standard of living of South Africans [3]; [5]; [13].

It is imperative that foundry organisations have effective approaches to productivity, and that these are an integral part of their business planning. Productivity could be improved by identifying all of the input resources and ensuring they were used optimally to produce the highest output. Productivity measures are useful on a number of levels [14], such as using available capital and labour effectively in order to turn them into the products and services that a company could offer its customers. These productivity measures serve as scorecards for the effective use of resources. Production or business managers are concerned with productivity, as it relates to competitiveness. Workers are the main determinant of productivity [15], and government leaders are concerned with national productivity because of its close relationship to a nation's standard of living [6].

South Africa has been attracting negative press commentary because of its low productivity caused by ineffective use of resources and a lack of customer satisfaction, which have a direct impact on competitiveness. Foundry organisations need to focus their customer business strategies in relation to quality, cycle time, cost, and effectiveness [7]. However, most South African foundries are unable to meet the needs of their customers, and so they find themselves failing to take advantage of opportunities in the industry [4]. To comprehend this problem, it is important to understand how foundry organisations could be globally competitive. A useful measure that is closely related to productivity is process yield [5]. This involves a company putting the necessary measures in place to increase productivity either by changing its technology or by providing employee with technological skills. This would make productivity improvements much easier to achieve. High levels of productivity are largely responsible for producing highly trained employees, investment in plants and equipment, research and development, new methods of production, and new technologies [16].

Productivity can be further defined as a tool of measurement that determines the efficiency of the organisation in respect of the ratio of output produced to inputs used [14]. It is also important to understand that various factors such as technology, plant layout, equipment, and machinery affect productivity. For businesses, productivity growth improves profitability and enhances their competitive position in the market.

A foundry is a factory that is equipped for making moulds, melting and handling molten metal, performing the casting process, and cleaning the finished casting [17]. Metal castings include a large and diverse family of processes that can be categorised in many ways. For example, molten metal is cast into shapes using moulds and various patterns [18]. Metal casting refers to the process through which the molten metal is allowed to flow by gravity or under pressure into a mould, where it solidifies in the shape of the mould cavity [19]. The metal casting is removed from the mould, after which it is machined and heat-treated. Foundries produce castings that are close to the final product shape of the mold cavity. Thus the types of casting process that are used differ between foundries; the casting process depends on the quantities and sizes of the castings to be produced.

Foundries have an important place in manufacturing, since castings are required as an input in almost every industrial sector: automotive, mining, construction, and industrial. Castings are made of a range of ferrous and non-ferrous metals. For example, Beeley [20] explains that a foundry produces metal castings from either ferrous or non-ferrous metals, including copper, aluminium, zinc, lead, nickel, and all their various alloys such as brass and bronze. Ferrous foundries process iron and steel. Among such metals, grey iron is produced globally, and is widely used for engineering components such as gearbox enclosures and valves [21]. According to Modern Casting [7], grey iron accounted for 44% of the tonnage produced in 2016, followed by ductile iron at 26%. Ductile iron is also a ferrous metal that is specifically used in many automotive, mining, and agricultural components [22]. Aluminium and cast iron can also be used to produce castings in foundries, and has the capability of being extruded into complex shapes to exact tolerances. Modern Casting [4] reported that non-ferrous metals account for 20% of the world's castings produced in 2016. South Africa can produce both non-ferrous and ferrous metal castings in a wide range, from small items such as household taps to large 100-ton crusher components [7].

When employees are not motivated, irrespective of how skilful they are, their performance will fall below expectations. The use of reward systems is one of the core strategies to achieve manufacturing excellence and good financial and operational performance. The PDCA cycle is characterised by its focus on continuous improvement; therefore, one could regard it as one of the tools that bring about improvements in the foundry industry [9]. Many believe that the application of the PDCA cycle helps solving managing change and very useful for testing improvement measures on a small scale before updating procedures [10]. This is because, when applied correctly in any manufacturing operation, one is continually looking for better systems of improvement while ensuring that senior managers or supervisors take corrective actions. The PDCA cycle (also known as an iterative four-step management approach) is used for controlling and continually improving processes. The PDCA method has enormous applications when developing a new or improved design of a process, when defining a repetitive work process, and when implementing any change [23].

Human capital becomes one of the determining variables for the improvement of employee productivity. The return on investments in human capital is expected to be improvements in performance, productivity, flexibility, and the capacity to innovate, thus increasing levels of knowledge and competence [5]. Empowering employees through training and skills development would lead to higher productivity in the foundry industry. This, in turn, would help foundry businesses to recover faster from crises and so continue to contribute their services to communities in the face of low productivity.

Employee motivation has a very basic relationship to capacity, as do absenteeism and labour turnover [10]; [20]; [21]. The actual foundry process requires skilled labour for its pattern makers, toolmakers, and other technical skills [8]. It is important to identify and evaluate the factors specifically affecting human capital productivity, since the foundry sector remains labour-intensive. The operations function is responsible for addressing and continually reviewing the skills, technological advancements, and experience of their current employees, and must be able to align those competencies with global standards.

Knowledge transfer affects manufacturing productivity [15]. Inadequate raw material and underdeveloped skills among employees can influence productivity [17]. The major issues facing the foundry industry are the rapid rise in energy costs, the requirement of world market prices for metal scrap and other input materials, and the associated resistance to adopting new technologies [1]. The key input materials in a foundry include the metal, virgin metal, scrap metal, and other chemical additive binders [5].

3. RESEARCH METHODOLOGY

A quantitative design using the cross-sectional survey approach was used for the study. The positivist approach, or quantitative research approach, stresses observable facts and eliminates subjective thought [24]. The research adopted a descriptive research design to investigate how Gauteng foundries could improve productivity and reduce job losses. In the context of descriptive research, according to Leedy and Ormrod [25], the researcher collects data and examines it from various angles in order to construct a rich and meaningful picture of a complex, multidimensional situation. A self-developed questionnaire was used to identify the factors contributing to low productivity in the Gauteng foundry industry. Owing to the small number of employees in Gauteng foundries, questionnaires were emailed to all of the shop floor employees (114 of them) of the Gauteng foundry companies. The questionnaire was developed using a 1-to-5-point Likert scale (where 1 represented 'strongly disagree or least important' and 5 represented 'strongly agree and very important'), with each of the variables as components for the development of a productivity improvement framework [6]. These variables were ranked and used to identify productivity improvement indices that would enhance productivity and improve the competitiveness of the Gauteng foundry industry.

The data obtained from this study was analysed using a number of statistical tools in the Statistical Package for the Social Sciences (SPSS) version 25.0.

3.1. Reliability and validity

According to Creswell [24], the reliability of an instrument means the extent to which the instrument measures that which was intended. A structured questionnaire was used to elicit information from the respondents. Experts in the same field were consulted in order to validate the instrument, and Cronbach's alpha was used to measure its reliability. In this case, the validity and reliability of the questionnaire were carefully considered. To apply these measures, the study included a thorough and ongoing evaluation of the instruments for their validity and reliability (Leedy & Ormrod, 2010). The questionnaire was also subject to construct validity criteria. It was required to have content validity relative to the domain being measured — in this case, the application and knowledge of productivity improvement [25].

The foundry managers and shop-floor employees were carefully and precisely chosen for their experience in the field and their thorough knowledge of productivity improvement in the foundry industry.

3.2. Ethical considerations

Prior to the survey, the researcher requested permission from management and the industry association to conduct the study. This informed consent was used to obtain permission from the respondents and their companies.

3.3. Data analysis

The data was analysed using a combination of descriptive and non-parametric statistics, and the statistical package SPSS was used for the data processing [26]. Descriptive statistics were used to determine the relative importance of the critical aspects for the productivity measurement of the foundry industry. In order to show the statistical findings, the study used tables, graphs, percentages, and frequency distribution tables. The chi-square statistical test is often applied to analyse categorical data, and was used in this study to test for the differences between two independent proportions [27]. Factor analysis used to examine how underlying constructs influenced the responses to a number of measured variables. Factor analysis was performed when examining the pattern of correlations (or covariance) between the observed measures. According to Field [26], when measures are highly correlated (either positively or negatively), they are likely to have been influenced by the same factors, while those that are relatively uncorrelated are influenced by different variables.

4. RESEARCH FINDINGS AND RESULTS

From the 190 disseminated questionnaires, 147 responses were obtained — a response rate of 77%. According to this findings, lack of participation was that some of the respondents felt that this information would be given to their managers and so would affect their job security. In some instances, the management felt that the research would not assist them in ensuring that their foundries were kept open, given the tough economy situation faced by the industry.

Figure 1 shows the participants' number of years of experience in the foundry industry. The total number of responses for this question was 147; the highest percentage was obtained from 41% of the participants who had worked in the foundry industry for less than five years. A further 15% of the participants had worked in the industry either for between six and ten years or for between 11 and 15 years, while 18% had worked for more than 20 years. Notably, the least experienced participants were the ones with 16 to 20 years' experience (see Figure 1).

Years working in the Foundry industry (N = 147)

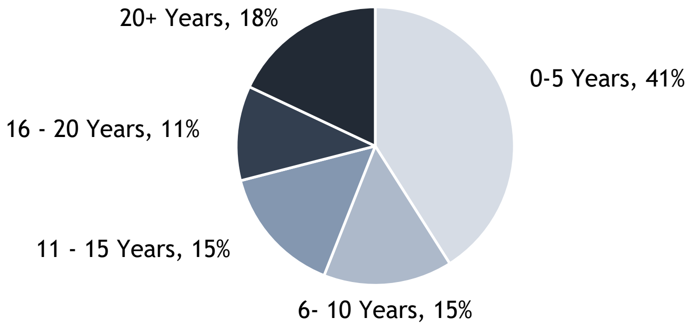

Figure 1: Number of years working in the foundry industry.

Source: Author (2020)

Based on the above interpretation of the results, the research concluded that the experience that an employee had in the industry had no impact on their contribution to finding a solution to the productivity improvement problem. Those with less experience were the key people who wanted to see productivity improvement in the industry and who were keen to participate and give input. Figure 2 below indicates that 33% of the foundry workers' highest level of education was grade 12. Only 13% of the participants had a postgraduate degree, while other participants in the research had either a diploma or an apprenticeship, with a small percentage having no grade 12. With the foundry process requiring specialised trade test skills, the results below paint a worrisome picture of skills development in the industry. The proposed model must emphasise the training and skills development of foundry employees in order to keep up with the industry's global counterparts and remain relevant and competitive. It is a great concern that over 40% of the participants had grade 12 or a lower qualification. The Gauteng foundry industry must invest in upskilling its employees in order to improve its productivity.

Highest level of education (N = 147)

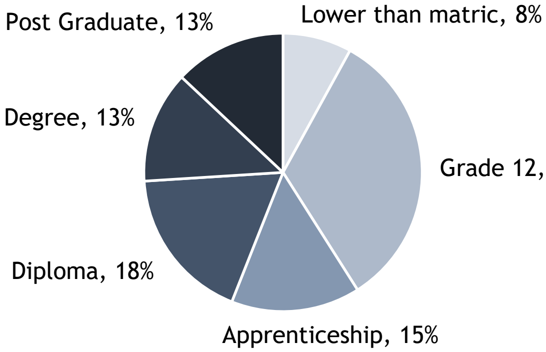

Figure 2: Highest level of education of the participants.

Source: Author (2020)

Figure 3 below indicates that 33% of the foundry departments had fewer than five employees, while only 16% had more than 20 employees. Other departments had between six and 20 employees. These results show that almost 50% of the foundries in this study had fewer than 10 people per department. This indicates that the foundries need to investigate whether all departments are staffed adequately, as this could lead to low productivity and have an impact on staff morale and commitment. The 16% indication that some foundry departments had more than 20 people working in them shows that the foundry process is still labour-intensive and that employees play a fundamental role in its productivity (see Figure 3). Figure 4 below indicates that 40% of the foundries that participated in the research ran a production operation, 31% were jobbing foundries, and 29% ran a mix of jobbing and production operations. It was also noted that 44% of the foundries still use labour-intensive methods of operation, while a smaller percentage (18%) had moved to a fully automated method of operations (see Figure 4). A total of 38% of the foundries were still using a combination of automated and labour-intensive methods. That almost 50% of the foundries were using labour-intensive methods of operation indicates the importance of employee training and upskilling (see Figure 5). This also calls for a more aggressive approach to the introduction of technology and innovation in the sector. Global markets are becoming more technologically advanced, and the sector needs to move in that direction as well. Adopting new technologies goes hand-in-hand with worker training and development, which would ensure sustainability and efficiency in the workforce.

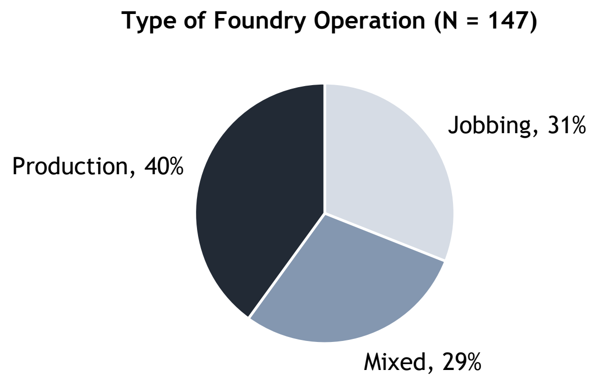

Figure 3: Type of foundry operation

Source: Author (2020)

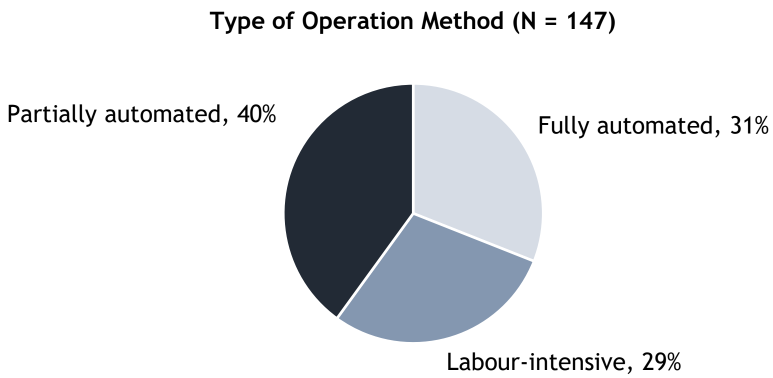

Figure 4: Type of operation method

Source: Author (2020)

4.1. Understanding productivity

This question attempted to arrive at an understanding of productivity, and whether any practices in the foundries related to achieving improved productivity. Figure 5 shows that less than 4% of the 147 participants said that their foundries did not apply any productivity improvements or did not measure productivity by either material or labour, while 24%%, 56%, and 15% respectively of the participants strongly agreed, agreed, or were neutral. An important observation is that more than 43% of the participants believed that management needed to educate their employees about productivity.

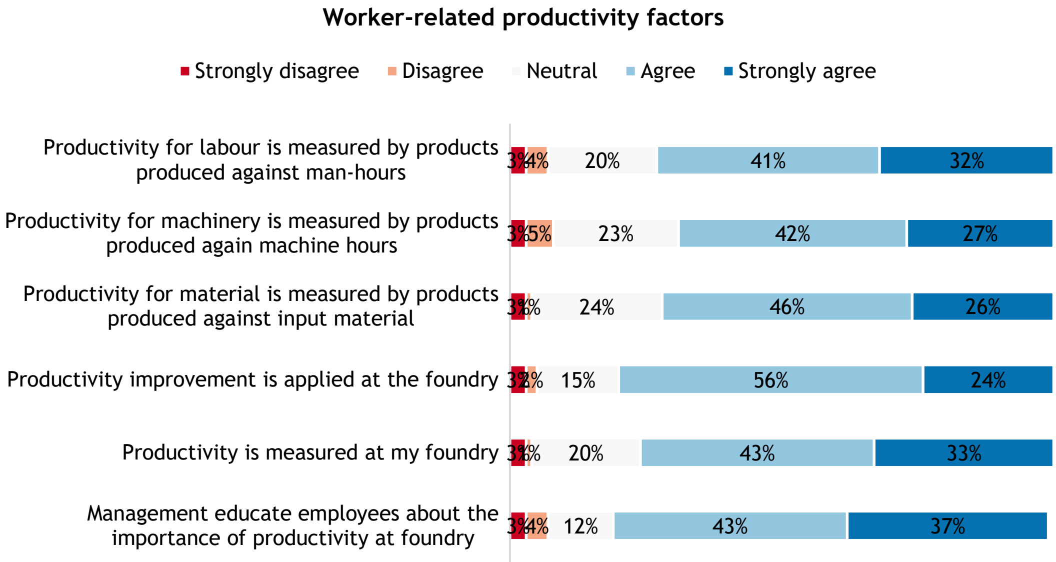

Figure 5: Understanding productivity

Source: Field work 2020

4.2. Tools or techniques to improve productivity

This section attempted to determine whether the foundries believed that productivity improvement tools or techniques could improve the sector. Based on Figure 6, it was encouraging that 78% of the respondents believed that productivity improvement techniques could be integrated into their current production process systems and that adopting productivity improvement techniques was vital for the foundry industry. Less than 10% of the respondents said no, while less than 13% said that they did not know. It was quite a concern that 44% of the respondents indicated that not all employees knew about the productivity of their foundry. However, 49% responded that their foundries were planning to use productivity improvement techniques in the near future (see Figure 6).

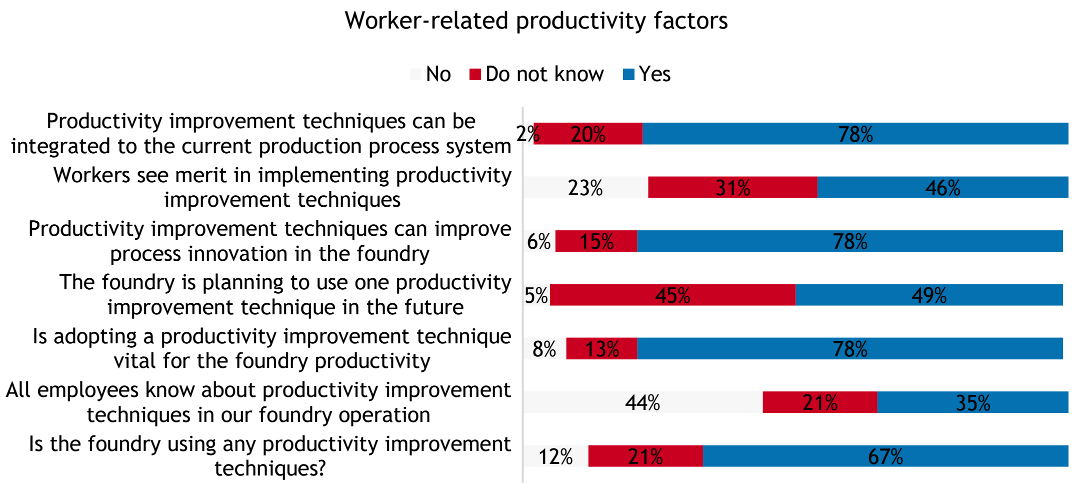

Figure 6: Could productivity improvement tools or techniques improve productivity in the foundry sector?

Source: Field work 2020

4.3. Productivity techniques currently being used in the foundries

This question determined what productivity improvement tools or techniques were currently being used by the foundries. Figure 7 below gives a concerning result: 42% of the participants stated that their foundries were not using any productivity improvement techniques. It was encouraging that 14% of the participants stated that they were using continuous improvement techniques, and 10% of the participants declared that their foundries were using new software and new machines (see Figure 7). This is an indication that the industry was slowly moving to change and to adopt new technologies.

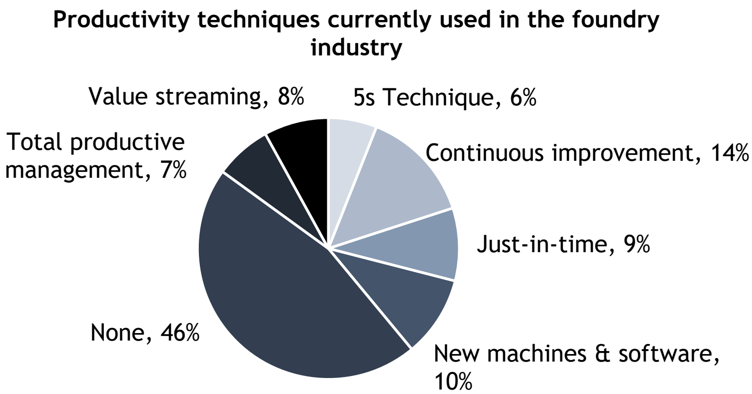

Figure 7: Productivity improvement tools or techniques to improve productivity in the foundry sector

Source: Field work 2020

4.4. Reliability analysis

Leedy and Ormrod [25] refer to reliability as the consistency with which a measuring instrument yields a certain result when the measured entity has not changed. SPSS version 25 was used to compute Cronbach's alpha reliability coefficient on the questions/statements (the measuring instrument in this case) that were put to the Gauteng foundry industry. The Cronbach's alpha reliability results are shown in Table 2. These were found to be more than 0.70, which was an acceptable level. Factors that had a coefficient of less than 0.70 were deleted from the analysis. The analysis of the reliability of the results indicated that Cronbach's alpha for all thirty productivity factors was 0.9472; thus $\alpha \geq 0.70$ indicated a good consistency for the selected questions in the questionnaire.

Table 2: Cronbach's alpha results

	Cronbach's reliability and validity factor and item analysis summary	**Number of items per factor**	**Cronbach's alpha**
Scale 1	Factors contributing to low productivity: Leadership and management	11	0.9472
Scale 2	Factors contributing to low productivity: Labour	7	0.9231
Scale 3	Factors contributing to low productivity: Equipment or machinery	6	0.8980
		24	

4.5. Exploratory factor analysis

Cooper and Schindler [28] explain that exploratory factor analysis (EFA) is a technique used to determine whether the sample is adequate for an exploratory research study. EFA was conducted by means of two statistical measures generated by SPSS, namely the Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy (MSA) [29]; [30].

Factor analysis

Exploratory factor analysis with the Varimax rotation of 23 Likert-scale questions from the questionnaire was performed on the data gathered from the sample of 143 participants. The KMO and Bartlett's test interpretation was applied, in which only factors with eigen values greater than 1 are retained. Three scales were retained, accounting for about 70% of the total variance. Table 3 below shows the factor loadings, eigenvalues, the differences, and the cumulative percentages of the factors. As shown in Table 3, three scales were extracted from the first exploratory analysis. The first group of factors was entitled 'Foundry management and leadership'; this group related to the management and leadership of a foundry and its impact on productivity. The second group of scales was entitled 'Labour-related scales', as it dealt with factors affecting workers and their understanding and knowledge of productivity. The third group of factors was entitled 'Machinery-related factors', as it affected machines and equipment in the foundry operation. The factor-loading matrix is shown for the factors contributing to low productivity in a foundry. The results of an orthogonal rotation of the solution are shown in Table 3. All of the factors that were less than 0.40 were excluded and were not loaded.

Table 3: Exploratory factor analysis — Principal component factors un-rotated

Factor item	Factors contributing to low productivity in your foundry	Factor loading	Eigen value	Difference	Proportion	Cumulative
1	Management educate employees about the importance of productivity at foundry	0.9508	13.16114	11.54849	0.5722	0.5722
2	Productivity is measured at my foundry	0.939	1.61265	0.36061	0.0701	0.6423
3	Productivity improvement is applied at the foundry	0.9445	1.25204	0.30529	0.0544	0.6968
4	Productivity for material is measured by products output against input material	0.8624	0.94675	0.17076	0.0412	0.7379
5	Productivity for machinery is measured by products output against machine hours	0.8515	0.77599	0.09542	0.0337	0.7717
6	Productivity for labour is measured by products output against man-hours	0.8539	0.68057	0.10867	0.0296	0.8013
7	Productivity levels are communicated at all times	0.9249	0.5719	0.0326	0.0249	0.8261
8	The foundry offers staff productivity-improvement training	0.8903	0.5393	0.10543	0.0234	0.8496

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Table 3 (cont.): Exploratory factor analysis — Principal component factors un-rotated

Factor item	Factors contributing to low productivity in your foundry	Factor loading	Eigen value	Difference	Proportion	Cumulative
9	Workers are encouraged to lead productivity-improvement initiatives	0.8520	0.43387	0.01676	0.0189	0.8684
10	Workers with extensive experience play a role in productivity-improvement initiatives	0.9056	0.41711	0.04982	0.0181	0.8866
11	Management involves employees in production-improvement targets	0.8579	0.36729	0.02393	0.0160	0.9025
12	Standard operating procedures are followed	0.9494	0.34336	0.0299	0.0149	0.9175
13	Machine maintenance is a high priority at our foundry	0.8476	0.31347	0.04453	0.0136	0.9311
14	Machine downtime is minimised at all times	0.8684	0.26894	0.03497	0.0117	0.9428
15	Each machine has process instructions for the operator	0.8989	0.23396	0.04095	0.0102	0.953
16	All maintenance schedule setup times are tracked	0.8548	0.19302	0.00436	0.0084	0.9614
17	Machines are never left idling	0.7978	0.18866	0.02416	0.0082	0.9696
18	The foundry invests in new technology to improve machine efficiency	0.9303	0.1645	0.01622	0.0072	0.9767
19	Management communicates productivity targets to all employees	0.8981	0.14828	0.00466	0.0064	0.9832
20	Management encourages workers at all times	0.8840	0.14362	0.01582	0.0062	0.9894
21	The foundry targets are monitored at all times	0.9554	0.1278	0.06797	0.0056	0.9950
22	Management involves workers when implementing productivity-improvement strategies	0.9383	0.05983	0.00386	0.0026	0.9976
23	Management encourages teamwork among employees	0.9127	0.05597	-	0.0024	1.0000

LR test: independent vs saturated: chi2 (253) = 2014.15   Prob > chi2 = 0.0000

Table 4: Exploratory factor analysis — Orthogonal Varimax (Kaiser off)

Factor	Factor description	Variance	Difference	Proportion	Cumulative
Factor 1	Foundry leadership and management	6.74800	1.66141	0.2934	0.2934
Factor 2	Labour- or worker-related factors	5.08660	0.89537	0.2212	0.5145
Factor 3	Equipment- or machinery-related factors	4.19122	0.00902	0.1822	0.6968

LR test: independent vs saturated: chi2 (253) = 2014.15 Prob > chi2 = 0.0000

These tests provided an in-depth analysis and exploration of the relationships between the variables and of their nature and extent in order to classify and make possible predictions [31]. The chi-square statistic was used to test the significance most appropriate for nominal items, although it could also be used with ordinal variables or a combination of both. Both the KMO measure and Bartlett's test yielded favourable results. According to Hair et al. [27], a KMO measure of 0.95 is a highly favourable outcome. Bartlett's test resulted in a highly significant approximate chi-square value of 9784.7 (p-value < 0.01), indicating that non-zero correlations existed between the relevant items.

Table 5: KMO and Bartlett's test results

KMO and Bartlett's test		
Kaiser-Meyer-Olkin test of sampling adequacy		0.895
Bartlett's test of sphericity	Approximate chi-square	1991.12
	Degrees of freedom	253
	Significance p-value	0.00

The proposed framework in Figure 8 contains the key productivity improvement indicators that must be applied in order to improve productivity in the Gauteng foundry sector. This framework is anchored in three key factors that must be addressed for that purpose. These are supported by tools that are implementable and sustainable in order to improve productivity. Productivity improvement is a journey that requires continual implementation; so, the proposed framework gives further direction on how it should be implemented, monitored, and sustained by the Gauteng foundry industry. The positive attribute of the proposed framework is that it is centred on continuity and sustainability while ensuring that all stakeholders in the foundry industry are involved and play a meaningful role in implementing the framework. This is done to minimise the risk of resistance and a lack of support for the proposed framework.

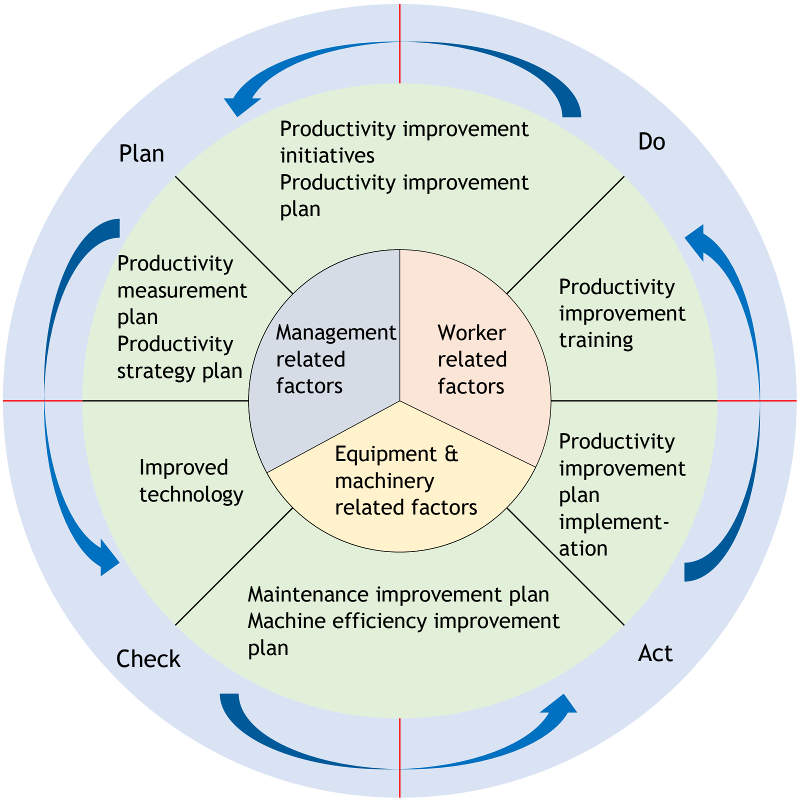

Figure 8: Proposed productivity improvement framework for the Gauteng foundry Industry

The results show that the productivity improvement framework for the foundry industry in Gauteng is based on three factors: management and leadership, labour or workers, and machinery and equipment. The developed productivity improvement framework encompasses the productivity indices that could meaningfully enhance productivity in foundry manufacturing organisations. The nine factors — location, machinery, human capital (knowledge), foundry industry workforce, layout and facilities, equipment, finance, competitiveness, and support programmes from the government — were revealed as the key drivers that could expedite strategies that would stimulate competitiveness and improve the layout and facilities of the foundry manufacturing organisations. These need to be prioritised in order to propel the organisations' productivity. It is important to understand the factors driving productivity so that the supervisors and/or production managers could use the PDCA cycle to solve the problems that hinder productivity in the foundry manufacturing system and to make decisions that could improve productivity. This framework has been explored and linked to the research results.

4.6. Limitations of the study

The findings of this study are limited because the sample was based on foundry organisations based in the Gauteng Province of South Africa; therefore, the findings cannot be applied to other settings — for example, the clothing manufacturing process. With respect to the sample, only shop-floor employees and managers of the foundries were asked to complete the questionnaires. This, in turn, means that the results might not be appropriate in other employees working in different sector of South Africa. Since the study did not cover in detail the role of employee training and productivity improvement, it is recommended that a holistic approach be applied to focus on training, upskilling, and identification of the required skills that would improve productivity in the foundry sector.

5. RECOMMENDATIONS

Future studies could focus on the application of this framework to a foundry case study. An in-depth study could also be conducted to involve all of the relevant government stakeholders and departments in assessing their role and strategy in uplifting the foundry industry and improving its contribution to the country's economic growth. In order to improve productivity, this study recommends that effective productivity improvement training be offered to all workers. This would not only increase their knowledge of productivity, but would also enable them to apply the productivity improvement techniques and tools and make them part of their daily work. Second, workers must be included in the planning and drafting of the productivity improvement plans. It is concluded, therefore, that productivity improvement tools, when applied, would result in improved productivity in the Gauteng foundry industry.

6. CONCLUSION

This study has attempted to investigate productivity improvement measures that would contribute in to improving the productivity of foundries in a developing country. The literature review presented various ground rules in the foundry sector. The main findings of this study showed that there was low productivity and an inadequate knowledge of productivity improvement tools or techniques in foundries. Management were not encouraging team work among employees, nor involving employees when implementing productivity improvement approaches; the foundry targets were not properly monitored at all times; management communicated productivity targets poorly to all employees; and maintenance schedule set-up times were not properly tracked. The proposed framework has key productivity improvement indicators that must be applied in order to improve productivity in the Gauteng foundry sector, and is anchored in three key factors that must be addressed for that purpose. These findings reinforce the conclusion that there is a significant relationship between productivity improvement and the foundry industry. A good understanding of the proposed productivity improvement framework for the Gauteng foundry Industry has been discussed in detail, and the barriers faced by foundry directors or managers in South Africa's manufacturing industry have been identified. Suggestions or recommendations regarding these have also been discussed.

7. DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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