Proceedings of the 6th Asia Pacific Conference on Industrial Engineering and Operations Management
Bali, Indonesia, August 5-7, 2025

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AP06.20250134
Published: August 5, 2025

Productivity Systems Used for Improving the Operational Process of Making Building Blocks for Productivity Growth within the Small-Scale Masonry Block Manufacturing

Lucky Boy Tebogo Makhubedu,
Faculty of Engineering and Built Environment
University of Johannesburg
South Africa
55 Beit St, Doornfontein, Johannesburg
luckyboym@uj.ac.za

Charles Mbohwa
Distinguished Professor of Sustainability Engineering and Future Technology
College of Science Engineering and Technology
UNISA
South Africa
mbohwc@unisa.ac.za

Abstract

The small-scale masonry block making industry contributes towards the socio-economic development of surrounding communities at the ground level. The industry assists in the development of the building and construction industries, and it is a source of income for small-scale enterprises. Thus, reducing unemployment and alleviating poverty. However, the sector is confronted by challenges that negate productivity improvement systems in improving the efficiency of the small-scale masonry block manufacturing enterprises. The study adopted a quantitative research strategy. A research questionnaire was distributed (face-to-face method) to the participants within the small-scale masonry block manufacturing industry. This study surveyed 252 brick artisans. SPSS version 29.0 was employed to statistically analyse the gathered information. The empirical results suggest that there was a direct correlation between identified productivity improvement systems and productivity growth.

Keywords
Productivity, Manufacturing, Productivity Improvement Systems, South Africa.

1. Introduction
Productivity involves the output (masonry bricks made and services rendered) measured against input (manpower, material, machinery, tools, energy/electricity and building site). Productivity is improved by combining these resources efficiently to optimise profit in the long term (yearly or more than a year) (Aniyikaiye *et al*., 2021; Suhariyanto *et al*., 2022).

The small-scale masonry block-making industry contributes extensively to the socioeconomic growth of surrounding communities at ground level. The masonry block-making sector assists in the development of the building and construction industries, and it is a source of income for both small-scale enterprises and employees. The industry creates occupational prospects for people staying around masonry block-making enterprises (Sampea & Pakidingb, 2015; Matsiketa, 2018). However, unemployment in South Africa is still at its worst compared to Africa and globally at approximately 33.2 per cent and mostly affecting the youth at roughly 46 per cent (Statistics South Africa, 2024).

The industry contributes towards the economy of South Africa (Hilson, Bartels & Hu, 2022; Khanh, Kim, Khoa & Tu, 2023). The industry contributed 12 per cent towards real GDP, an additional 12 per cent towards formal sector employment and a further 42 per cent of the rand value of exports in 2019 (Mnguni & Simbanegavi, 2020). Mnguni & Simbanegavi (2020) further allude to the industry having failed to reach the high standards it set in the early 1990s when it contributed approximately 23 per cent towards the GDP, and it has been on a downward trajectory ever since. Jacobs (2021) shares the same sentiment that over the past 15 years, productivity has remained flat.

Statistics South Africa (2023) reports that the manufacturing industry was the biggest contributor towards the GDP. However, the sector has been overtaken by the financial, real estate, and business services sector, personal services, and the trade, catering, and accommodation industry (as shown in Table 1 below).

Table 1: Industry value added and GDP in South African industries

	Agriculture, forestry and fishing	Mining	**Manufacturing**	Electricity, gas and water	Construction	**Trade, catering and accommodation**	Transport, storage and communication	**Finance, real estate and**	General government services	**Personal services**	Total value added at basic	Taxes less subsidies	GDP at market prices
2016	93 622	220 141	555 880	109 947	155 996	564 281	365 766	938 154	351 165	659 643	4 014 646	435 525	4 450 171
2017	111 545	225 420	554 833	110 275	147 076	556 707	369 580	961 364	356 086	668 356	4 061 243	440 458	4 501 702
2018	112 095	223 613	563 250	111 280	144 861	562 325	380 339	994 663	362 957	672 452	4 127 833	443 950	4 571 783
2019	104 785	222 100	559 322	107 571	139 986	559 935	378 211	1 016 210	367 515	681 249	4 136 884	446 783	4 583 667
2020	123 482	194 863	493 681	101 365	115 076	492 829	320 394	1 025 152	371 405	669 642	3 907 890	402 436	4 310 327
2021	123 672	218 196	526 711	103 295	112 718	523 439	336 408	1 050 933	371 538	705 466	4 081 378	431 666	4 513 044
2022	133 843	202 605	**524 771**	100 745	108 906	**541 821**	364 246	**1 087 014**	371 730	**724 014**	4 159 695	439 566	4 599 261

Source: Statistics South Africa (2023)

The report further reveals that in 2022 the financial, real estate, and business services sector contributed R1 087 014 towards the GDP of South Africa, personal services sector contributed R724 014, while the trade, catering, and accommodation industry contributed roughly R541 821, closely followed by the manufacturing sector with a contribution of R524 771. Though the South African manufacturing industry has been overtaken by the trade, catering and accommodation, personal services and financial, real estate and business services sectors, the production sold within the manufacturing sector dropped from R563 250 in 2018 to R524 771 in 2022, which is in the proportion of approximately 6.83 per cent (See Table 1 above).

1.1 Problem statement

As alluded to in the study's background and based on the estimates documented by Trading Economics (2021) and Statistics South Africa (2021), it is important to note that the GDP and aggregate production output in the manufacturing sector have been declining in recent years. The GDP of South Africa's construction sector dropped from 111,306.36 million rand in the second quarter to 110,760 million rand during the third quarter of 2021. In addition, the report by Statistics South Africa (2023) shows that the manufacturing industry has become a shadow of its former self as the industry has been overtaken by industries involving the financial, real estate, and business services; personal services sector; and the trade, catering and accommodation industry in terms of the contribution towards the GDP of South Africa.

1.2 Objectives

Based on the research problem, the main research question, which is not known, is how productivity improvement systems improve the productivity of SMEs in Gauteng, South Africa, mediated by human, physical and technological capital. In addition, highlighting some of the challenges that impede productivity systems within the small-scale masonry brick manufacturing industry in South Africa.

1.2.1 The subsidiary research objective was formulated as follows:
To examine the relationship between productivity improvement systems (ergonomics, human resource management and business process re-engineering) and the productivity growth of the masonry block manufacturing small-scale enterprises in the Gauteng region, South Africa.

1.3 Research scope

Primarily, the study focused on small-scale masonry block-making enterprises to assess the application of productivity improvement systems in improving the efficiency of the operational process of making masonry blocks. Thus, growing productivity of the masonry block making small-scale manufacturing enterprises. However, this restricts how broadly the study can be used.

1.4 Importance of the study

This paper aims to emphasise barriers that seem to negate improvement in the operational process of making blocks within the small-scale masonry block-making industry. To the researcher's knowledge derived from the extensive literature explored, not enough research studies concentrate on improving operational processes and sustaining productivity, particularly within the small-scale masonry block-making industry. Thus, having an adverse impact on productivity growth, market-related competitiveness and long-term profitability of these enterprises. Furthermore, leading towards small-scale masonry block making enterprises permanently closing their operations. This approach renders the study unique.

2. Literature Review

According to (Mafundu & Mafini 2018; Shahid, Williams & Martinez 2020), the masonry brick making sector falls into two distinctive categories: the formal (registered and/or regulated) and informal (unregistered and/or not regulated). The delineation of SMEs encompasses a broad spectrum of South African enterprises that are registered, unregistered, and not subject to value-added tax. (The Small Enterprise Development Agency, 2016:5).

These businesses are described in terms of their size and revenue generated, depending on the country. For example, SMEs employ roughly 63 per cent of the world's labour force and account for 90 per cent of companies. These enterprises are independent and non-subsidiary companies that hire a certain number of workers, varying from country to country (Berisha & Pula, 2015).

Table 2. South Africa, Republic (RSA) Construction SMEs quantitative articulations

Construction size/class of enterprise	**Total full-time equivalent of paid employees**	**Turnover Less than**
Medium	51-250	Approximately R170.00 million
Small	**11-50**	**Approximately R75.00 million**
Micro	0-10	Approximately R10.00 million

Source: National Small Enterprise Act (2019:2)

In Table 2 above, enterprises that employ between 51 and 250 brick producers are classified as medium-scale businesses, with an approximate profit margin of 170 million rand. Enterprises that hire between 11 and 50 workers are categorised as small-scale construction enterprises, generating about 75 million rand. Additionally, the Act states that businesses employing between 0 and 10 workers are classified as micro-scale enterprises with a profit of approximately 10 million rand (National Small Enterprise Act, 2019).

2.1 Brick construction process

The masonry block making process is defined as the ability to efficiently transform or convert resources such as raw materials into finished value-added products that customers will receive (Rinaldi *et al*., 2021; Müller *et al*., 2022).

Physical input resources include clay, sand, water, and fuel in the form of coal and wood (Hasche *et al*., 2020; Rahman *et al*., 2022). Some of these input resources also pertain to human capital, which refers to the workforce (Hu *et al*., 2023). Human capital that can enhance the production of masonry bricks in a manufacturing setting include employees' knowledge, experience and training, all of which contribute to their development and improve overall performance (Gaan *et al*., 2023).

The first phase begins by gathering the resources required to make the blocks of bricks. These resources involved four (4) wheelbarrows of soil (ash and river sand), two (2) bags of Portland Pozzolana Cement (PPC) and at least and 25L polycan water container. The second (2nd) phase focused on mixing the material using a shovel(s). The bricks are moulded to the correct specifications in the third (3rd) phase using a manually operated pressing machine. The moulding brick machine produces two blocks at a time. In the fourth (4th) phase, the blocks are watered and left to dry for a minimum of three days to enhance their quality and durability. Finally, the blocks are covered to absorb the moisture (as shown in Figure 1 below).

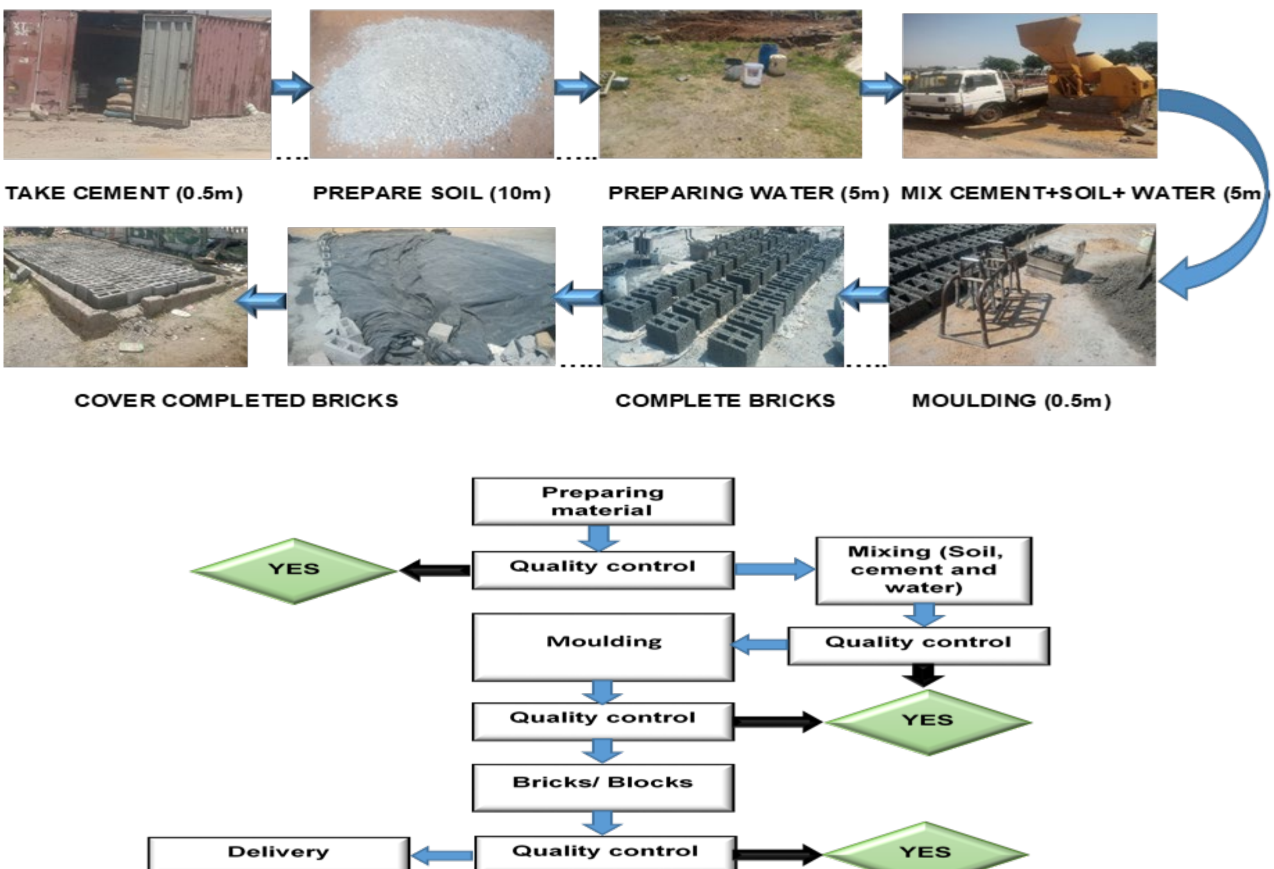

Figure 1. Current form flow chart of the brick production process

2.2 Productivity improvement systems

Productivity improvement systems entail implementing cutting-edge workplace systems and technologies that will greatly improve small businesses' operational processes and productivity in the masonry brick manufacturing (Kyakulumbye & Pather, 2022; Vrontis et al., 2022). These systems can aid the companies producing masonry bricks in coping with the constant volatility in the market, economic climate and the changes in customer behaviour (Justino et al., 2022). The systems communicated below involve human capital management, ergonomics and technology within the masonry block making small-scale enterprises.

2.2.1 Human capital management, ergonomics and business process reengineering

Human resource management, also referred to as human capital, is the capacity of human work required to attain the result of the organisation (Pham et al., 2020). Hunt & Naweed (2023) ergonomic focuses on the wellness of block makers by designing a healthy workplace where employees can excel as well as better living conditions. De Feo (2019) delineates business process management as a system that specialises in the enhancement of key operational processes through planning and controlling, dependent upon process owners and teams (Table 3).

Table 3. Productivity improvement systems challenges

Human Capital Management Challenges	**Author(s)**
Inadequate block makers, and training (skills development)	Delgado (2019); Khouja et al., 2022).
Lack of training (Skills development)	Rauch et al., (2020); Cobîrzan et al. (2022)
Lack of education (knowledge)	Windapo (2020)
Incompetent management	Kolodziejek & Tey (2016); Singh et al., (2019); Pham et al. (2020)
Ergonomic Challenges	**Author(s)**
lack of health and safety compliance	Delgado, (2019); Pham et al., (2020)
Musculoskeletal disorders (bending and kneeling)	Maity et al. (2015); Middlesworth (2020)Widodo et al., (2020)
Physical stress	Evans and Lindsay (2017)
Business Process Reengineering Challenges	**Author(s)**
Non-existence of essential infrastructure - social (healthcare) and economic (water supply and sanitation)	Adu et al. (2019); Karmaoui et al., (2022)
Poor operational and brick production process	Arevalo-Barrera et al., (2020)
Outdated process	Singh et al., (2022)
Global economic challenges	Shahul Hameed et al., 2021

2.2.2 Application of Human capital management, ergonomics and business process reengineering

Khayinga and Muathe (2018) reason that through human resource management, enterprises can empower their workforce by putting money into their training and education development with the desire to initiate a rapid incline in organisational success, namely profit optimisation, a competitive advantage and economic growth. Adu *et al*. (2019:31), masonry brick-making small and medium-scale enterprises must have the abilities required to properly manufacture their products. According to Hussain *et al*., (2019), it is important to avoid ergonomic risk factors by using engineering controls, administrative or work practice controls and encouraging the use of personal protective equipment. Sunaryo (2020) states that the practice of integrating technology with physical work in masonry brick manufacturing enterprises comes naturally in the working environment. Sunaryo (2020) further highlights that the principles of ergonomics guide the integration between technology and operational process and if properly applied, it can lead to the efficient use of equipment, thus maximising production output. Reorganising current brick production workflows, diagnosing and analysing major challenges within each operational and production process, identifying the degree of mechanical wear and tear, introducing information related technology and developing long-term solutions to sustain continuous productivity growth (Singh *et al*., 2022).

3. Methods

A quantitative methodical research approach was utilised. Data was gathered using a convenient sampling strategy. Because this study focused on both the descriptive and predictive purposes of a correlational research study, this research design was most appropriate for this specific investigation. (Masia & Pienaar, 2011), to choose an appropriate small-scale masonry block enterprise, a purposeful sampling strategy was used. A questionnaire using a five-point Likert scale was used to gather primary data within the small-scale masonry block manufacturing enterprises in

Gauteng, South Africa. It asked respondents to score management components of human capital investment and employee motivation between "strongly disagree" and "strongly agree".

4. Results and discussion

SPSS version 29.0 was used to analyse quantitative data. The statistical descriptive, reliability test and correlation analysis, and participant response rate based on demographic data are all included in this analysis. From 322 (n = 100%) research questionnaires, approximately 252 were completed. This yielded a valid response rate of 78%, thus generating a failure to return rate of 22% (See **Table 4** below). The research questionnaires were from participants mainly from the region of Gauteng (Johannesburg and Tshwane/Pretoria Metropolitan Municipalities) as these cities have a high number of small-scale masonry brick enterprises due to high employment opportunities, best educational institutions and increased urbanisation.

Table 4. The response rate, data collection site and the generated statistics

Response rate	**Data collection site and statistics**
Research targeted	The masonry block manufacturing small-scale enterprises
Location/area of study	South Africa, Gauteng – in the regions of Johannesburg and Tshwane (Pretoria)
Sum of the questionnaires distributed	322
Participants	252
The study's rate of response	78%
Failure to return rate	22%
Targeted respondents	Owners, supervisors and brick artisans

The information gathered from masonry brick manufacturing small-scale enterprises was summarised into a frequency distribution table focusing on the demographic variables as depicted in Table 5 below. The demographic characteristics of the respondents in the small-scale masonry brick manufacturing businesses in Gauteng, South Africa, are measured in this section of the study.

Table 5. Demographic profiling in the masonry manufacturing small-scale industry

Age of the respondent	Frequency	Valid response rate
18-24 years	11	4.4
25-34 years	52	20.6
35-44 years	71	28.2
45-54 years	89	35.3
55 years or older	29	11.5
Total	252	100
Highest level of education	Frequency	Valid response rate
Below matric/ Grade 12	52	20.6
Matric	108	42.9
Diploma/ Degree	66	26.2
Post graduate diploma/ Master's Degree	21	8.3
Other (please specify)	5	2.0
Total	252	100
Enterprise years in operational	Frequency	Valid response rate
Years	36	14.3
5-10 years	71	28.2
11-20 years	116	46.0
21-30 years	20	7.9
0ver 31 years	9	3.6
Total	252	100
Number of employees	Frequency	Valid response rate
Between 20 and 50	225	89.3
Between 51 and 200	27	10.7
Total	**252**	**100**

As presented in **Table 5**, with a total of 252 respondents, the survey results showed that the majority of the respondents ranged between the age group of 35 - 55 years, as they made up 63.5% (n = 160). 20.6% (n = 52) of the participants fell between the age group of 25 - 44 years, while 11.5% (n = 29) of those who participated in the study were 55 years or older. The remaining 4.4% (n = 11) were younger than 25 years of age. The age of the participants in this study shows a favourable overview. There is a perception that age is associated with experience; thus, the more experience an employee has, the more productive they are. Furthermore, the findings reveal that the employment market in the masonry brick manufacturing industry preferred employing mature people rather than those who are young.

This study reveals, as shown in **Table 5**, that of the 252 respondents, the majority, at 42.9% (n = 108), have a Matriculation or Grade 12 certificate, while 20.6% (n = 52) did not achieve a Matriculation or Grade 12 certificate. The survey results further indicate that 26.2% (n = 66) have a Diploma or a Degree, 8.3% (n = 21) of the respondents attained a Post Graduate Degree. Only 2% (n = 5) of the respondents hold a college certificate or a technical certificate. This implies that education plays an important role in the masonry brick manufacturing small-scale enterprises and as more respondents' had some level of education it indicates that it is significant in sustaining and enhancing productivity within the industry.

As depicted in **Table 5**, the results indicate that a large proportion - 46% (n = 110) - of the small-scale enterprises in Gauteng have been rendering their services to customers for 11 to 20 years. 28.2% (n = 71) of the small-scale enterprises have been operating for 5 to 10 years, 14.3% (n = 36) have been running their businesses for 1 to 5 years, while 7.9% (n = 20) of these companies have been operational for 21 to 30 years, and the oldest small-scale enterprise – 3.6% (n = 9) – has been operational for at least 30 years. It is apparent that these small-scale manufacturing enterprises have a rich history and have been active for years. They therefore play a significant role in the social and economic development of communities and contribute towards the GDP and economic development of South Africa, particularly at ground level.

Table 5 above highlights the fact that the majority – 89.3% (n = 225) – of the participants employed at small-scale enterprises, followed by a small proportion of respondents – 10.7% (n = 27) – were from medium-scale businesses operating within the Gauteng province.

The generated Cronbach's alpha values for all the latent variables were above 0.7. Thus, suggesting that the responses were highly consistent and reliable (Rouf & Akhtaruddin, 2018; Bhutta, Kausar & Rehman, 2019; Nunes, Monteiro & Nunes, 2020).

The concept of Pearson's product-moment correlation matrix is defined as a statistical technique used to ascertain the nature of a relationship between two identified independent and dependent variables (Sekaran & Bougie, 2013). The statistical tool is used to measure the degree of strength and the linear correlation coefficient r (upward/ downward) between the identified variables of the study (Willemse & Nyelisani, 2019:127). **Table 6** below guides the interpretation of the generated correlation coefficient (r) between the identified variables:

Table 6. Interpreting the Degree of Strength

Size of r	General interpretation
±0.85 to 1.0	Very strong or perfect relationship
±0.65 to 0.85	Very good to strong relationship
±0.35 to 0.65	Weak or good relationship
±0.0 to 0.35	Very weak or no relationship

Adapted from Cohen et al., (2002); Willemse & Nyelisani (2019)

The correlation analysis measures the direction, association and magnitude of the relationships between productivity improvement systems (Ergonomics, Human Resource Management and Business Process Reengineering) and productivity growth in the masonry block manufacturing small-scale enterprises. It can be deduced from the empirical results that there is a significant positive correlation ranging from r = 0.233 to 0.311 in the relationships between productivity improvement systems (ERG, HRM and BPR) and productivity growth (PG). Furthermore, this implies that the strength of the relationship between these constructs are weak. The results also generated a p value < 0.01 (as indicated **in Table 7 below).**

Table 7. Correlation analysis between identified systems and productivity growth

		ERG	HRM	BPR	PG
ERG	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	252			
HRM	Pearson Correlation	.825**	1		
	Sig. (2-tailed)	<,001			
	N	252	252		
BPR	Pearson Correlation	.774**	.807**	1	
	Sig. (2-tailed)	<,001	<,001		
	N	252	252	252	
PG	Pearson Correlation	.233**	.244**	.311**	1
	Sig. (2-tailed)	<,001	<,001	<,001	
	N	252	252	252	252

BPR = Business Process Reengineering; ERG = Ergonomics; HRM = Human Resource Management; PG = Productivity Growth
***. Correlation is significant at the 0.01 level (2-tailed).*

6. Conclusion and recommendations

Ergonomics (ERG), Business Process Reengineering (BPR) and Human Resource Management (HRM) were found to be the best contributors towards the productivity growth of small-scale masonry block manufacturing enterprises. It is recommended that the small-scale masonry block manufacturing industry incorporate with medium and well-established companies through the support of the government for benchmarking on Business Process Reengineering

(BPR). It is recommended that the research study be extended to other Metropolitan Cities in Gauteng South Africa, considering the same study within the small-scale masonry brick manufacturing industry.

References

Aniyikaiye, T.E., Edokpayi, J.N., Odiyo, J.O. and Piketh, S.J. Traditional Brick Making, Environmental and Socio-Economic Impacts: A Case Study of Vhembe District, South Africa. Sustainability, 13(19), p.10659, 2021.

Bhutta, E., Kausar, S. and Rehman, A. Factors affecting the performance of market committees in Punjab, Pakistan: an empirical assessment of performance through smart PLS mediation analysis. Journal of Agricultural Research (03681157), 57(3), 2019.

Creswell, J.W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Fourth Edition. United States of America: SAGE Publications, Inc., 2014.

Gaan, N., Malik, S. and Dagar, V. Cross-level effect of resonant leadership on remote engagement: A moderated mediation analysis in the unprecedented COVID-19 crisis. European Management Journal, 15 (975), pp.1-16, 2023.

Ghobadian, A., Talavera, I., Bhattacharya, A., Kumar, V., Garza-Reyes, J.A. and O'regan, N. Examining legitimatisation of additive manufacturing in the interplay between innovation, lean manufacturing and sustainability. International Journal of Production Economics, 219, pp.457-468, 2020.

Hilson, G., Bartels, E. and Hu, Y. Brick by brick, block by block: building a sustainable formalization strategy for small-scale gold mining in Ghana. Environmental science & policy, 135, pp.207-225, 2022.

Hu, J., Hu, M. and Zhang, H. Has the construction of ecological civilization promoted green technology innovation?. Environmental Technology and Innovation, 29, p.102960, 2023.

Hunt, D. and Naweed, A. The risk of risk assessments: Investigating dangerous workshop biases through a socio-technical systems model. Safety Science, 157, p.105918, 2023.

Hussain, M.M., Qutubuddin, S.M., Kumar, K.P.R. and Reddy, C.K. Digital human modeling in ergonomic risk assessment of working postures using RULA. In Proceedings of the international conference on industrial engineering and operations management Bangkok, Thailand, March (pp. 5-7), 2019.

Heizer, J.H. and Render, B. Principles of operations management. Tenth Edition. New York: Pearson Educación, 2017.

Justino, M.V., Tengeh, R.K. and Twum-Darko, M. A Revised Technology–Organisation–Environment Framework for Brick-and-Mortar Retailers Adopting M-Commerce. Journal of Risk and Financial Management, 15(7), p.289, 2022.

Khanh, H.D., Kim, S.Y., Khoa, N.V. and Tu, N.T. The relationship between workers' experience and productivity: a case study of brick masonry construction. International Journal of Construction Management, 23(4), pp.596-605, 2023.

Kyakulumbye, S. and Pather, S. Understanding ICT adoption amongst SMEs in Uganda: Towards a participatory design model to enhance technology diffusion. African Journal of Science, Technology, Innovation and Development, 14(1), pp.49-60, 2022.

Mafundu, R.H. and Mafini, C. Internal constraints to business performance in black-owned small to medium enterprises in the construction industry. The Southern African Journal of Entrepreneurship and Small Business Management, 11(1), pp.1-10, 2019.

Makhubedu, L.B.T., Nwobodo-Anyadiegwu, E. and Mbohwa, C. The effect of human capital investment and motivation on miners' productivity at a South African platinum mine. Readings book, 411, 2017.

Mnguni, P. and Simbanegavi, W. South African Manufacturing-A situational analysis (No. 10410). South African Reserve Bank, 2020.

National Small Enterprise Act. Revised Schedule 1 of the National Definition of Small Enterprise in South Africa. Government Printer. Pretoria. Republic of South Africa, 2019.

Nithiya, R., Chris, A.L., Vinodh, K.R. and Anbalagan, C. Experimental investigation on bricks by using various waste materials. International Journal of Latest Trends in Engineering and Technology (IJLTET), 6(3), pp.395, 2016.

Pakhomova, E.G., Dubrakova, K.O. and Aseev, V.Y. The influence of the coefficient of variation on the process reliability of brick production. Journal of Applied Engineering Science, 19(2), pp.533-536, 2021.

Pham, K.T., Vu, D.N., Hong, P.L.H. and Park, C. 4D-BIM-based workspace planning for temporary safety facilities in construction SMEs. International Journal of Environmental Research and Public Health, 17(10), p.3403, 2020.

Rahman, S.S., Siddiqua, S. and Cherian, C. Sustainable applications of textile waste fiber in the construction and geotechnical industries: a retrospect. Cleaner Engineering and Technology, p.100420, 2022.

Rinaldi, M., Caterino, M., Fera, M., Manco, P. and Macchiaroli, R. Technology selection in green supply chains-the effects of additive and traditional manufacturing. Journal of Cleaner Production, 282, p.124554, 2021.

Rouf, M.A. and Akhtaruddin, M. Factors affecting the voluntary disclosure: a study by using smart PLS-SEM approach. International Journal of Law and Management, 60(6), pp.1498-1508, 2018.

Sampe, F. and Pakiding, D.L. Perception of Traditional Small Scale Brick-making owner on firewood usage for Brick-making process. Procedia-Social and Behavioral Sciences, 211, pp.653-659, 2015.

Sekaran, U., and Bougie, R. Research Methods for Business. Sixth Edition. United Kingdom: John Wiley and Sons Ltd, 2015.

Statistics South Africa. Three facts about the manufacturing industry. Statistical Release, July, 2021. Available from: https://www.statssa.gov.za/?p=16493, 2021.

Statistics South Africa. Gross domestic product, Second quarter 2023. Statistical Release, December, 2023. Reports, 2023.

Sunaryo, S. Break-even analysis of clay transport as raw materials in small bricks industry using Grandong based appropriate technology in rural areas. International Journal of Scientific and Engineering Research, 11(2), pp.384-392, 2020.

Trading Economics. South Africa GDP from Construction, 2021.

Vizzon, J.S., Carmo, L.F.R.R.S.D., Ceryno, P.S. and Fiorencio, L. Business process redesign: an action research. Gestão & Produção, 27, 2020.

Vrontis, D., Chaudhuri, R. and Chatterjee, S. Adoption of Digital Technologies by SMEs for Sustainability and Value Creation: Moderating Role of Entrepreneurial Orientation. Sustainability, 14(13), p.7949, 2022.

Willemse, I., and Nyelisani, P. Statistical Methods and Calculation Skills. Fourth edition. Cape Town: Juta and Company (Pty) Ltd, 2015.

Biographies

Lucky Boy Tebogo Makhubedu holds a Master of Technology Degree (MTech in Operations Management) and is a lecturer in the Faculty of Science, Department of Statistics and a doctoral student in the Faculty of Engineering and the Built Environment (FEBE) at the University of Johannesburg, South Africa. His research interests are in continuous productivity improvement in the fields of mining, construction and manufacturing operations, operational research and the application of productivity improvement systems and value-adding drivers, and he has published more than 7 academic papers. He has presented at local and international conferences.

Professor Charles Mbohwa is a distinguished Professor of Sustainability Engineering and Future Technology; College of Science Engineering and Technnology at UNISA. He was a Pro-Vice Chancellor Strategic Partnerships and Industrialisation at University of Zimbabwe and an affiliated Professor in the Faculty of Engineering and the Built Environment. He is an established researcher and professor in the field of sustainability engineering and energy. He was the Chairman and Head of Department of Mechanical Engineering at the University of Zimbabwe from 1994 to 1997 and was Vice-Dean of Postgraduate Studies Research and Innovation in the Faculty of Engineering and the Built Environment at the University of Johannesburg from 2014 to 2017. He has published more than 350 papers in peer-reviewed journals and conferences, 10 book chapters and three books. He has a Scopus h-index of 11 and Google Scholar h-index of 14. Upon graduating with his BSc Honours in Mechanical Engineering from the University of Zimbabwe in 1986, he was employed as a mechanical engineer by the National Railways of Zimbabwe. He holds a Masters in Operations Management and Manufacturing Systems from University of Nottingham and completed his doctoral studies at Tokyo Metropolitan Institute of Technology in Japan. He was a Fulbright Scholar visiting the Supply Chain and Logistics Institute at the School of Industrial and Systems Engineering, Georgia Institute of Technology, a Japan Foundation Fellow, is a Fellow of the Zimbabwean Institution of Engineers and is a registered mechanical engineer with the Engineering Council of Zimbabwe. He has been a collaborator in projects of the United Nations Environment Programme. He has also visited many countries on research and training engagements including the United Kingdom, Japan, German, France, the USA, Brazil, Sweden, Ghana, Nigeria, Kenya, Tanzania, Malawi, Mauritius, Austria, the Netherlands, Uganda, Namibia and Australia. He has had several awards including British Council Scholarship, Japanese Foundation Fellowship, Kubota Foundation Fellowship; Fulbright Fellowship.

Dr Nelson Sizwe Madonsela holds a doctoral degree (Ph.D. in Engineering Management) from UJ and obtained his Master of Technology degree in Operations Management from UJ. He received a Bachelor of Technology degree in Quality from the University of South Africa (UNISA) and a National Diploma in Information Technology (Software Development) from Tshwane University of Technology (TUT). His research focuses on Business Artificial Intelligence and operation management, focusing on operational excellence. He also focuses on areas such as quality management systems, digital transformation, and project management. He has presented at local and international conferences and authored book chapters. Dr. Madonsela has helped provide high-level strategic and technical guidance in quality management and advanced project management to upskill the workforce among industries within South Africa. Additionally, he serves as a National Advisor on curriculum development, teaching and learning methods, and best practices in quality and operations management in several South African universities.