

# Lean practices and supply-chain competitiveness in the steel industry in Gauteng, South Africa


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**Background:** The steel industry in South Africa suffered significantly when imported steel took over the market and collapsed big players in the industry in the last decade. The industry requires new business models and paradigms to improve its supply-chain strategies and adopt international standards such as lean supply-chain management practices to become competitive.

**Aim:** In the study the relationships are investigated between lean supply-chain management practices, lean culture, and supply-chain competitiveness in the steel industry in Gauteng Province.

**Setting:** The study was conducted in the steel manufacturing industry in the Gauteng Province, South Africa.

**Methods:** In the study a quantitative method involving 265 supply-chain and operations managers and practitioners was employed. The Statistical Packages for Social Sciences (SPSS version 27.0) was used to analyse the data in which correlations and regression analysis were employed to test the research hypotheses.

**Results:** The results of the study showed that four lean practices, namely Just in Time, Total Quality Management, Strategic Partnerships and Waste Elimination, all predict the establishment of a lean culture. However, Human Resource Management was statistically insignificant. The results further showed that a lean culture predicts competitiveness in the steel supply chain.

**Conclusion:** The adoption of lean supply chain management in the steel industry is an essential contributor to its success.

**Keywords:** supply chain management; lean supply chain management; just-in-time; total quality management; strategic partnership; waste elimination; human resources; lean culture; supply-chain competitiveness; South African steel industry.

## Introduction

The steel manufacturing industry is one of the most important sectors contributing to the highest South African Gross Domestic Product (GDP) growth in South Africa, with the top five steel-consuming industries contributing R600 billion to GDP (15% of the total) and employing more than eight million people. This was mainly linked to its overall productivity, estimated at about 65% (Organisation for Economic Cooperation and Development [OECD] 2020; Statistics South Africa 2018). It was thus a vital part of economic growth in the country (Alabi 2016). The steel manufacturing industry played a significant role in the national economy and the economies of other African states. These include Egypt, Mozambique, Tanzania, Zambia, Kenya, Uganda, Namibia, the DRC, Ghana, and Ethiopia. It created jobs for many South Africans (Du Toit 2014; Worldsteel 2020).

The South African steel industry has been declining constantly since 2010. Challenges prevalent in the sector range from structural problems and persistent excess capacity to market demand negatively impacting trade and employment (Department of Trade and Industry 2018). The effects of the steel crisis are evident across the value chain, from mining primary steel mills to domestic manufacturers struggling to compete, sustaining jobs and the decline in domestic primary steel-production competitiveness (Schoeman, Oberholster & Somerset 2021; Van der Walt 2012).

The emergence of the coronavirus disease 2019 (COVID-19) pandemic worsened the situation in the steel industry, especially the implementation of government lockdown measures intended to save lives. The Trade and Industrial Policy Strategies (TIPS 2020) reported that the

lockdown measures had devastating consequences for the steel sector, with an estimated R1bn being lost in direct cash-flow revenue and labour costs. Evidence of that is South Africa's most important steel-producing company ArcelorMittal, which reported a drop in sales of about 40% due to the national lockdowns (ArcelorMittal South Africa 2020). Further affecting the steel sector is the volatility of the economic environment in the country, characterised by a recession. Also, the sector faces other operational challenges. Among the prominent ones is the inconsistency of direct supply, which could be attributed to a lack of supply-chain competitiveness (SCC) (Hannemann 2014; Motebele 2018).

The inconsistency in supply has resulted in supplier/customer distrust. The inconsistencies in the supply chain could have been caused by the ineffective application of several lean supply-chain management practices such as just-in-time (JIT), total quality management (TQM), strategic partnership (SP), waste elimination (WE) and human resources (HR). Kumar Singh and Modgil (2020) considered that these practices may enhance SCC through their influence on many firms' lean culture. To solve the supply-chain crisis in South African steel manufacturing, firms have been trying to adopt new business initiatives to succeed in a unique and competitive marketplace (Khuluse 2015; Viljoen 2015). Lean supply-chain management (SCM) is an initiative that focuses on practices that eliminate nonvalue-adding activities (Hosseini, Soltani & Mehdizadeh 2018; Małysa & Furman 2021). These practices comprise JIT, TQM, SP, WE and HR; and have been widely used in discrete industries such as automobile manufacturing, electronics, and appliances (Talib et al. 2020). The application of lean practices to a continuous-process industry, such as steel, has been limited (Conejo, Birat & Dutta 2020). It has been argued that this is because such an industry is inherently more efficient and the need for such improvement activities, therefore, relatively less. (Kumar, Singh & Sharma 2014; Van der Walt 2012). Hore (2019) opines that steel manufacturing firms need SPs to gain customers' trust. This could improve the demand, ensuring that products are enhanced as incorporated in Deming's system of profound knowledge (Deming 1986; Ochieng 2021). Given the current crisis experienced by steel manufacturers, this research aims to empirically investigate the influence of lean supply-chain management (LSCM) practices on lean culture and SCC.

Against the above backdrop, this study investigated the relationship between LSCM practices, lean culture and SCC in the steel industry in Gauteng Province. The specific objectives of the study are to (1) test the connection between LSCM practices and lean culture and (2) test the association between lean culture and SCC. The steel industry is an important driver of South Africa's diversified economy, making continual research necessary to generate information for solving its problems. Moreover, the body of empirical knowledge applying LSCM practices to the South African steel industry is still limited. What is available, are studies by Domingo (2013), who looked at implementing lean techniques

as drivers of on-the-shelves product availability in the South African food retail industry.

Also, Khuluse (2015) investigated the level of adoption of lean practices among South African's small and medium-size enterprises (SMEs). Viljoen (2015) established the strategic impact of selected lean factors on the operational performance of a selected South African gold plant. Dondofema, Matope and Akdogan (2017) provided a literature review study of the state of adoption of lean techniques in the broader South African economic environment. Fourie and Umeh (2017) focused on using lean factors in the maintenance environment. Lastly, Govender and Jasson (2018) explored the benefits and challenges of adopting lean practices as efficiency tools in the South African hospitality industry. However, the current study adopts a different approach in linking LSCM to SCC, a nexus that is fairly untested in the South African steel industry.

The article is organised as follows: The next section presents the review of the literature on the South African steel manufacturing industry and the respective constructs of the study. Thereafter, the conceptual model and hypotheses are presented, followed by the research methodology, data analysis and discussion of the results. The article concludes by providing theoretical and managerial contributions, limitations, and conclusive remarks.

## Literature review

### South African steel manufacturing industry

South Africa's large, well-developed steel industry, with vast natural resources and a supportive infrastructure, represents roughly a third of all South Africa's manufacturing. It comprises basic iron ore and steel, basic nonferrous metals, and metal products. The basic industries manufacture primary iron and steel products from smelting to semi-finished stages (Cape Gate Group of Companies 2019). Primary steel and semi-finished products include billets, blooms, slabs, forgings, reinforcing bars, railway track material, wire rods, seamless tubes, and plates (Kariuki 2013). South Africa was the world's 25th-largest crude steel producer in 2018, with an output of 6.8 million tons (Mt) (Department of Trade and Industry 2019). South Africa exported 2.7 Mt of semi-finished and finished steel products worth \$2.4bn (R42. 272,341,933.68). The country produced 5.4 Mt of iron and exported 662.4 kiloton (kt) of iron worth \$245.2 million (R4.318,969,071.50). The volume of basic iron and steel products produced increased by 1.6% between March 2019, while the sales value of these products at current prices, rose by 9% over the same period. High production costs, the inconsistent supply of electricity, and poor domestic demand continue to significantly impact the performance of local manufacturers and wholesalers of basic iron and steel (Statistics South Africa 2019). Steel manufacturing firms must consider the concept of competitiveness to survive in the global marketplace by fulfilling the customers' requirements for high-quality and low-cost products (Kariuki 2013; Mondliwa, Goga & Roberts 2021). The industry is one of the

most important sectors contributing to the highest GDP growth in South Africa. Together, the top five steel-consuming industries contribute R600bn to GDP (15% of the total) and employ more than 8 million people as of 2018 third quarter (Statistics South Africa 2018; Zalk 2021). It is thus a vital part of economic growth for the country (Alabi 2016; Kan, Mativenga & Marnewick 2020).

Moreover, the industry plays a significant role in the national economy and the economies of other African countries, including Egypt, Mozambique, Tanzania, Zambia, Kenya, Uganda, Namibia, the DRC, Ghana, and Ethiopia. It creates jobs for many South Africans (Du Toit 2014). Steelmaking remains a key strategic industry, contributing to the fiscus and job creation (Department of Trade and Industry 2019). Each tonne of steel produced, creates jobs and provides value by beneficiating natural resources. Steel is fundamental to manufacturing in South Africa and adds significant value, representing more than 190 000 jobs in the direct iron ore, steelmaking and fabrication industries. The steel manufacturers have the prospect of employing many in the nation's labour force (Ocheri et al. 2017; Trollip, McCall & Bataille 2022). For example, ArcelorMittal employed more than 10 000 employees directly, while it will create employment for millions of South Africans indirectly through the upstream and downstream industries (ArcelorMittal South Africa 2019). This will further help to alleviate the persistent unemployment problem of the nation. As an essential element of industrialisation, the steel industries are vital for developing linkages with all other sectors of the economy.

### Lean supply chain management practices

The first objective of lean management is to eliminate every kind of waste in the company to make the business more competitive, through good results about innovation, flexibility, cost, quality, and service (Kumar Singh & Modgil 2020; Rocha 2017). The seven forms of waste addressed by lean production include defects, overproduction, delays, transport, over-processing, inventory, and motion. Based on this, Henderson and Larco (2000) defined eight fundamentals of lean manufacturing to guide the implementation. These fundamentals are environmentally safe, orderly, clean, JIT, six sigma quality, empowerment, visual management and seeking perfection. These are the bases of lean thinking. Since then, many factors have been identified as lean manufacturing practices. However, this study focuses on JIT, TQM, SP, WE and HR as the lean practices influencing lean culture and ultimately leading to SCC. These practices contribute to SCC in various manufacturing sectors, especially within the steel industries. These practices are discussed in the sub-sections below.

#### Just-in-time

The concept of JIT is defined as an inventory management philosophy, aimed at reducing waste and redundant inventory by delivering products, components, or materials just when an organisation needs them (Sharma, Dixit &

Qadri 2015). Just-in-time ensures that only what is required is produced, when necessary, at the right time and in the correct quantity (Khuluse 2015). Just-in-time is fundamentally the reduction of excess inventory (Khuluse 2015). It uses the pull system, and according to Simona and Cristina (2015), the pull system is the centre of any synchronised factory; it works by working backwards, using signals or cards to trigger or start production. Given the tight competition in the steel manufacturing industry, customers' demands must be incorporated efficiently and in a way that cost effectiveness is recognised. Firms effectively implementing JIT principles have substantial competitive advantages over competitors that have not (Garcia-Buendia et al. 2021; Madanhire & Mbohwa 2016). Lastly, organisations that have applied JIT, have managed to gain a competitive edge, improve the quality of the products, and reduce waste (Juárez, Perez & Useche 2017; Mukwakungu et al. 2019; Wyk & Naidoo 2016).

#### Total quality management

Total quality management is defined as the sequential development of a product's quality (Anvari, Ismail & Hojjati 2011). It is an approach in which all the employees work together to improve a product, process, and working environment. Its main aim is to ensure customer satisfaction (García-Alcaraz et al. 2021; Soni et al. 2013). Total quality management is required to conduct successful continual improvement programmes in the workplace or 'Gemba Kaizen', in Japanese lean terms, and embodies the concept of lean culture (Panuwatwanich & Nguyen 2017). Furthermore, it refers to management that can be characterised by its set of principles, practices, and techniques. These comprise customer focus, continual improvement, and teamwork, to name a few (Siva et al. 2016). Each principle is implemented through a set of practices or simple activities such as collecting customer information and analysing processes (Luburić 2013). Total quality management focuses on exceeding customers' expectations, identifying problems, building commitment, and promoting open decision-making among workers (Cherrafi et al. 2016; Slack & Singh 2020). Besides, Abd-Elwahed and El-Baz (2018) found TQM to correlate with lean culture positively.

#### Strategic partnership

An SP is an arrangement between two companies or organisations to help each other, or work together, to make it easier for them to achieve the things they want to attain (Caspar-Terizakis & Yu 2016). Besides, a critical partnership with suppliers has organised efforts to create and maintain a network of qualified suppliers. This effort includes all activities needed to improve the current performance of suppliers (Mohanty & Gahan 2012; Tarigan & Siagian 2021). Also, SP with suppliers has been designed to link the strategic and operational capabilities of separate organisations with suppliers to help them achieve significant benefits (Elms & Low 2013). The main objective of this concept is to increase the functional capability desired supplier (Cacciolatti et al. 2020; Mohanty & Gahan 2012). A good relationship with business partners, including key customers, plays a vital role

in the success of supply chain management practised by an organisation (Mumassabba et al. 2015). Information sharing with business partners enables organisations to make better decisions and act because of greater visibility (Elms & Low 2013). Well-managed strategic alliances and consolidation are essential to long-term sustainability, growth, and SCC (Cacciolatti et al. 2020; Mráček & Mucha 2011).

### Waste elimination

In terms of the industry, waste is defined as anything that does not add any value to the end product from the customer's perspective (Demeter & Matyusz 2011). Wastes are activities that add cost or time, but do not add value, consuming more resources (time, money, space, etc.) necessary to produce the goods or services that the customer wants (Pal & Kachhwaha 2013). Waste includes activities that add cost or time, but do not add value, consuming more resources (time, money, space, etc.) necessary to produce the goods or services that the customer wants (Panuwatwanich & Nguyen 2017). Also, Rocha (2017) posited that the first objective of lean is eliminating every kind of waste in the company to change the business into more competitive through good results in innovation, flexibility, cost, quality, and service. The primary work strategy opted for process improvement is applying lean principles in material handling in steel plants. This optimises operational performance (Kumar et al. 2014).

### Human resources

Lean in HR is defined as driving waste out of organisations' human resource function operation processes (Khan et al. 2013). Lean as enabled by human resources, refers to how the human-resource processes and functions help create lean success throughout the organisation. Adopting lean principles well beyond core manufacturing has dramatically changed many other corporate internal functions, including product development, supply chain management, and accounting (Brown et al. 2016). Past research suggests that an organisation's employees can be a source of sustained competitive advantage and determine their organisations' ultimate success (Njeri & Thuo 2014). Given the importance of people in organisations, most strategic HR departments consider the management of the competencies and capabilities of these human assets the primary goal (Karuoya 2014). It is generally accepted that firms can create a competitive advantage from HR and their management practices. Effective HR management generates a higher capacity to attract and motivate employees for good performance, and the benefits of having adequate and qualified employees are numerous (Carvalho, Alves & Lopes 2011; Mijatović, Uzelac & Stoiljković 2020).

Some examples are higher profitability, less rotation, higher product quality, lower costs in manufacturing and a faster acceptance and implementation of the organisational strategy. Organisational resources lead to a sustained competitive advantage when valuable, rare, and inimitable and have no substitute (Fahmi & Abdelwahab 2012; Tran & Vo 2020).

### Lean culture

The concept of a lean culture is regarded as the inclusion and engagement of every employee in continual improvement (Miller 2011). Pakdil and Leonard (2014) described it as one of the four components of a successful lean implementation. They explained that lean implementation consists of four components: lean planning, lean concepts, lean tools, and lean culture. Organisations using traditional manufacturing methodologies have struggled to compete successfully with those adopting lean practices (Van der Merwe, Pieterse & Lourens 2014). However, lean success is mainly dependent on attaining a lean culture. Companies that utilise mass-production systems controlled by top-down management approaches find that the change to a lean system is dependent on a significant shift in organisational culture (Imre, Jenei & Losonci 2013; Miller 2011). Besides, Mann (2014) described the concept as one of the four components of a successful lean implementation and explained that it consists of four components, namely lean planning, lean concepts, lean tools, and lean culture. Moreover, organisations or manufacturing industries that have successfully instilled a lean culture within the organisation and workforce will consistently realise SCC, more innovative, team-directed solutions, lower employee turnover and more success at sustaining improvements (Jekiel 2020; Van der Merwe 2014).

### Supply-chain competitiveness

The competitiveness of a firm's value chain refers to the capability of the supply chain to deliver value to the customer to competitive advantage. Also, it is regarded as the ability of the supply chain to gain a competitive advantage compared to other competing supply chain/s (Antai 2011; Shang, Zhou & Van Houtum 2010). Furthermore, Segarra-Moliner, Moliner-Tena and Sánchez-García (2013) assert that competition and rivalry currently exist between one supply chain and the other supply chain, rather than between two firms based on value delivered to the customer. Supply-chain competitiveness is considered an important tool in gaining a competitive advantage. Due to speedy technological innovations, globalisation, and widely-used information technology, SCC is necessary for firms to focus strategically (Deng et al. 2020; Rajagopal 2010).

Furthermore, SCC can be achieved by efficient delivery, customer satisfaction, a better quality of products, profitability, more responsiveness, shorter lead times, demand fulfilment, optimal facilities, etc. (Naqvi, Asim & Manzoor 2020; Verma & Seth 2011). Verma and Seth (2011) proposed a conceptual framework for SCC. It is described that effective competitiveness requires some input elements, and then SCC yields outcomes out of a supply chain. Furthermore, SCC requires agility, coordination, collaboration, cooperation, synergy among partners, mass customisation, customer orientation, process orientation, demand management, and strategic alliances (Sakuramoto, Di Serio & Bittar 2018). While SCC will yield outcomes like customer value, customer satisfaction, quickness in response to changes, innovation,

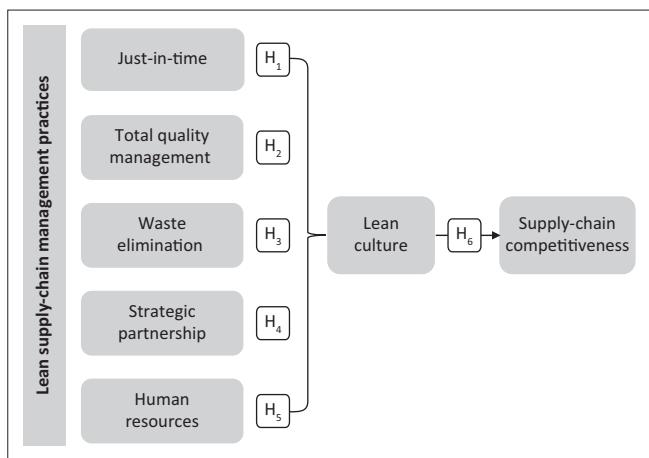


FIGURE 1: Conceptual framework.

improvement, profitability, and ultimately competitive advantage.

## Conceptual framework

The study tested the conceptual framework presented in Figure 1.

## Hypotheses development

### Impact of Just in time on lean culture

The social values and morals of the employees are major enablers of the JIT system (Sharma et al. 2015). Simplified production processes such as eliminating inventories and large lot sizes in excess, create a needless customer time-cycle delay. Masudin and Kamara (2018) investigated the links between the JIT practices, attempting, in particular, to determine how they are linked to lean culture. The results support the argument that JIT practices positively affect culture. Syed, Barlow and Syed (2018) also determined the association between JIT and culture. Finally, Li, Wu and Holsapple (2017) suggest that employees have a key role in implementing lean culture. However, the JIT processes may not be achieved without the employees' compliance. Based on the provided discussion, the following hypothesis can be stated:

**H1:** There is a significant positive relationship between JIT and lean culture in the South African steel industry

### Impact of total quality management on lean culture

The concept of TQM is one of the critical determinants in a successful lean culture (Gimenez-Espin, Jimenez-Jimenez & Martinez-Costa 2013). Many other scholars have also advocated this (Panuwatwanich & Nguyen 2017; Zairi 2013). It was also found that the failure of the TQM implementation primarily derives from the lack of integration of TQM and culture change. To nurture TQM implementation success, several researchers recommended the need for organisations to change their organisational culture (Baird, Hu & Reeve 2011; Gimenez-Espin et al. 2013). Also, Viljoen (2015) states that a favourable working environment correlates with

strong business performance and proves that organisational culture directly impacts the business. In doing so, steel manufacturing organisations must systematically define and assess their organisational culture based on a well-developed framework or model. It is against this background that this study posits the following:

**H2:** There is a significant positive relationship between TQM and lean culture in the South African steel industry

### Impact of strategic partnership on lean culture

Embedded in the theoretical 'relational view' of management, which supports the view that firms may gain and sustain competitive advantage by leveraging and accessing resources from outside the firm's boundaries (Salimova, Vatolkina & Makolov 2014). The authors propose a theoretically underpinned model whereby cultural compatibility between strategic supply-chain relationships has the potential to lead to improved performance outcomes for each participant in the chain. The linkages and interdependencies between strategic supply-chain relationships and organisational culture are evident in the literature (McFarlin 2017; McKay 2014). For example, rationalisation of the supply base should result in a deepening of relationships, which highlights the importance of shared values such as trust cooperation between each supply-chain partner organisation (Henderson & Dhanaraj 2014). In addition, the focus on strategic relationships has been shown to require compatible cultures (Bendiek & Kramer 2010). This study proposes a theoretical framework whereby it is posited that strategic supply chain relationships can only be truly successful if lean-cultural fit is achieved. Hence the following hypothesis is posited:

**H3:** There is a significant positive relationship between SP and lean culture in the South African steel industry

### Impact of waste elimination on lean culture

To achieve WE, and continual improvement, organisations need the attitude, culture, and capabilities to constantly improve and sustain themselves in the future (Puvanasvaran, Huihui & Norazlin 2014). It is an organisation that does not require a management initiative, a customer initiative, or a shareholder initiative to improve – it comes from the desire and the will of the people inside the organisation (Tang, Chen & Luo 2011). This requires a commitment throughout the organisation to improve and eliminate those obstacles that delay, prevent, or inhibit improvements (Miafodzyeva & Brandt 2013). Culture determines how people think and behave in any workplace. Establishing a WE culture within manufacturing is necessary for other WE initiatives, such as a waste management plan (Miafodzyeva & Brandt 2013). By establishing a WE culture, the firm creates an environment conducive to bright ideas, increased efficiency and reduced operating costs. Hence this study posited the following:

**H4:** There is a significant positive relationship between WE and lean culture in the South African steel industry

## Impact of human resources on lean culture

Human resources and SCM importance has been recognised as a means in gaining competitive advantage in different industries (Bhaskar & Tilak 2013). Hence, integrating HR and SCM functions enables organisations to craft a unique strategy and increase the firm's supply-chain performance. According to Jurcevic, Ivaković and Babić (2013) the primary purpose of performance management is to instil in the employees a desire for continual improvement, which is the foundation of lean transformation. Selective hiring practices for new employees allow the organisation to select individuals with the desired knowledge, skills, and values to support the organisation's long-term lean transformation strategy (Brown et al. 2016). Besides, Khan et al. (2013) found a positive impact of HR management practices on supply chain management success. Lean transformation success depends on the extent to which HR within the organisation has been embracing the concept. Active support and participation in the transformation process to leanness may lead to higher organisational-culture success rates (De Menezes, Wood & Gelade 2010). Hence, the study posited the following hypothesis:

**H5:** There is a significant positive relationship between HR and lean culture in the South African steel industry

## Impact of lean culture on supply chain competitiveness

Organisations adopt lean operations principles either as a defensive strategy to stay competitive, or as an offensive strategy to move ahead of competitors (Nordin, Deros & Wahab 2010). Irrespective of adopting a lean approach, the actions required to become lean are the same, and the implementation process may be lengthy. Badurdeen, Wijekoon and Marksberry (2011) affirm that a similar lack of attention to lean culture also prevents South African steel manufacturers from realising the potential benefits of leanness. Moreover, Punnakitikashem, Buavaraporn and Chen (2013) conclude that lean culture is vital to any lean implementation plan's success and that future research is required to create and maintain such a culture. The ill-defined nature of a lean organisational culture and time constraints caused by increased competition is exacerbated by this problem. Besides, Van der Merwe (2014) advanced that manufacturing industries must instil a lean culture in the organisation to attain an adequate level of competitiveness. In terms of innovative problem resolution, lower employee turnover and better success at sustaining improvements, amongst others. Finally, Miller (2011) and Imre et al. (2013) offered similar sentiments that lean-cultured organisations provide many benefits, including greater competitive advantages in supply chains. It is against this background that this study developed the following hypothesis:

**H6:** There is a significant positive relationship between lean culture and SCC in the South African steel industry

## Research methodology

This study employed a positivist paradigm as its underpinning philosophy, because hypotheses were posited,

and the study's results are expected to be compared to the stated hypotheses. This is consistent with the objective of this study, which investigates the relationships between LSCM practices, lean culture and SCC, based on a conceptual framework with several quantifiable variables. Statistical methods are used to ascertain whether the framework fits the data. The methodology of the study is, thus, structured as follows:

## Research sites and sampling method

The quantitative approach was selected since it facilitates results that can be generalised to other contexts. In this case, it was expected that the results of the study could be generalised to different contexts of steel-manufacturing companies throughout South Africa. This study followed a correlational research design, specifically a single cross-sectional survey, because data were collected only once from the sample elements (Burns, Veeck & Bush 2018). The cross-sectional strategy was chosen, because it provided inexpensive methods of collecting data over a large sample, and it pairs well with the quantitative method. The target population of this study comprised supply-chain and operations managers and practitioners from steel-manufacturing companies based in Gauteng Province. Confining the study to the province of Gauteng is justified by the fact that it is the most thickly populated region (12564000 habitants) and includes the most heterogeneous racial and ethnic groups (Statistics South Africa 2019). Moreover, most steel manufacturers are in Gauteng Province because of its large population. Lastly, the province is also known to be the country's economic hub, which provides opportunities for current and future research. In terms of the sample frame, the lists of the supply chain and operation practitioners were obtainable from the HR databases of the steel manufacturing companies identified for this study.

## Sampling procedure and technique

The list of steel manufacturing firms was obtained from the yellow pages and permission was sought from each of these firms. The final sample was composed of 265 respondents. This sample size was deemed acceptable based on two approaches. Firstly, the historical evidence approach was used, which focuses on previous similar studies. For example, Khuluse (2015) used a sample of  $n = 250$  while Viljoen (2015) utilised a sample size of  $n = 115$  for their quantitative studies on LSCM. The second approach was based on the sample size for multivariate studies as recommended by seminal scholars. In this regard, Pallant (2007) recommends a minimum of 150 respondents, and Tabachnick and Fidell (2007) propose a sample size of at least 200 cases for multivariate analysis. With these recommendations in mind, a total of 400 firms provided access to collect data from their supply-chain and operation managers and professionals. However, there was no sampling frame from which an accurate list of all targeted respondents could be drawn. As a result, a non-probability convenience sampling technique was applied to choosing the sample. Apart from the lack of

an accurate sample frame, the respondents were not easily accessible due to the COVID-19 pandemic, making it necessary to use the convenience sampling technique. Supply-chain and operation managers and practitioners were contacted in person to complete the questionnaire.

## Measures

All measurement instruments were anchored in a seven-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. All constructs had 43-item scales adapted from Bortolotti, Boscarini and Danese (2019) for JIT, SP, and HR. Sadikoglu and Olcay (2014) for TQM, Manzouri et al. (2014) for WE. Panuwatwanich and Nguyen (2017); Ganeshkumar and Nambirajan (2013) for lean culture and SCC, respectively. Appendix 1 provides the list of the measurement instruments in the study. All measurement scales had been validated in previous studies, having attained Cronbach alpha values above 0.7.

## Field work

Data were collected through a survey using a structured questionnaire. The decision to make use of a questionnaire is influenced by the characteristics of the respondents the study intends to collect data from; the importance of reaching each targeted respondent; the importance of respondents' answers not being contaminated or distorted; the size of the sample and the nature and the types of the questions (Saunders, Lewis & Thornhill 2016). Due to the outbreak of COVID-19, questionnaires were distributed to steel-manufacturing companies using two methods in this study. The first method was the drop-and-collect method, which involved the face-to-face distribution and collection of hard copies of the questionnaires to and from the available respondents at work. The second method involved email surveys. Emails were suitable since some respondents are geographically dispersed in the constituencies to be covered in this study. Many of the respondents worked from home, making it challenging to deliver questionnaires in the hard-copy format. Email addresses for such respondents were collected from their departments and used as a reference point for contacting them. Data collection took approximately four months and were conducted in the Vaal region between April and July 2020, in which 400 questionnaires were distributed. Upon their collection, the questionnaires were screened to determine their usability. However, some of the questionnaires were not returned, while some were incomplete due to a number of reasons. After systematically screening all questionnaires and discarding the incomplete ones, 265 were found usable, representing a 66.3% response rate.

## Data analysis

The principal researcher captured the collected data on an excel spreadsheet. The data on the excel spreadsheet were cleaned by checking for missing entries. A statistician analysed the data using the Statistical Packages for the Social Sciences (SPSS 27.0). The basic statistical techniques applied

in the study include descriptive statistics, normality tests, exploratory-factor analysis, correlations and regression analyses.

## Sample profile

The majority of respondents were male (61.4%;  $n = 163$ ). Regarding the age distribution of the sampled respondent, most respondents were aged between 34 and 41 years. Besides, 47.9% ( $n = 127$ ) of the sampled population was Black-African. Also, 41.9% ( $n = 111$ ) were holders of diploma qualifications. Regarding the respondents' experience, 30.2% ( $n = 80$ ) were employed between three to five years. Furthermore, 188 (71%) respondents were permanently employed. Lastly, 61.5% ( $n = 163$ ) of the respondents were from the supply-chain management/procurement department.

## Explanatory factor analysis

A Harman's one-factor score test was conducted by running the preliminary explanatory factor analysis (EFA) on the sample data. In contrast, the unrotated factor solution was examined to determine the number of necessary factors to account for the variance in the variables. The single factor that emerged yielded one general factor accounting for approximately 24.89% of the covariance among the measures, concluding that common method variance is not a problem.

Table 2 presents the EFA results, performed using principal components analysis by applying Varimax rotation, which helped evaluate construct validity. The suitability of data for factorability was ascertained after examining the significant Kaiser-Meyer Olkin test statistic ( $KMO = 0.819$ ) and the Bartlett sphericity test, which showed a significant result with a considerable chi-square value ( $\chi^2 = 8105.213$ ;  $p < 0.01$ ). Most of the items loaded as expected with their factors, except for items SP3 and SP6 and HR5, which were discarded since they yielded weak and insignificant loadings on any of the extracted factors (below 0.50;  $p > 0.001$ ). Table 1 presents the EFA's results.

The six lean principles remained unchanged, and the labelling remained the same (i.e. JIT, TQM, SP, HR, WE). Just-in-time had a KMO of 0.873, and all items explained 63.2% of the variance, while TQM had a KMO of 0.934 and explained 86.6% of the variance. Strategic partnership had a KMO of 0.786, explaining 79.5% of the variance. Waste elimination had a KMO of 0.895, with 78.4% of variance explained. Human resources had a KMO of 0.830, explaining 73.3% of the variance. Lean culture and SCC had KMO of 0.909 and 0.939 with 73.7 and 76.5 percentage of variance, respectively. All factor loadings were higher than 0.5, and commonalities were higher than the 0.3 minimum cut-off value.

## Normality and common method bias assessment

In measuring normality, Field (2013) points out that the central limit theorem stipulates that the assumption of

**TABLE 1:** Exploratory factor analysis results.

Construct	Items	Communalities	Factor loadings	KMO sampling adequacy	Bartlett's test of sphericity	Eigenvalue	Percentage variance explained
JIT	JIT1	0.636	0.797	0.873	$\chi^2 = 782.389$ df = 15 $P = 0.000$	3.794	63.229%
	JIT2	0.674	0.821	-	-	-	-
	JIT3	0.552	0.743	-	-	-	-
	JIT4	0.745	0.863	-	-	-	-
	JIT5	0.609	0.780	-	-	-	-
	JIT6	0.579	0.761	-	-	-	-
TQM	TQM1	0.853	0.924	0.934	$\chi^2 = 2014.720$ df = 15 $P = 0.000$	5.202	86.693%
	TQM2	0.893	0.945	-	-	-	-
	TQM3	0.886	0.941	-	-	-	-
	TQM4	0.883	0.940	-	-	-	-
	TQM5	0.860	0.927	-	-	-	-
	TQM6	0.827	0.909	-	-	-	-
SP	SP1	0.877	0.725	0.786	$\chi^2 = 980.750$ df = 15 $P = 0.000$	3.741	62.353%
	SP2	0.903	0.879	-	-	-	-
	SP3	0.588	0.864	-	-	-	-
	SP4	0.794	0.834	-	-	-	-
WE	WE1	0.762	0.725	0.895	$\chi^2 = 1041.492$ df = 10 $P = 0.000$	3.922	78.430%
	WE2	0.821	0.873	-	-	-	-
	WE3	0.816	0.906	-	-	-	-
	WE4	0.756	0.903	-	-	-	-
	WE5	0.767	0.869	-	-	-	-
HR	HR1	0.719	0.876	0.830	$\chi^2 = 699.409$ df = 15 $P = 0.000$	3.356	55.929%
	HR2	0.818	0.845	-	-	-	-
	HR3	0.756	0.903	-	-	-	-
	HR4	0.622	0.866	-	-	-	-
LC	LC1	0.754	0.868	0.939	$\chi^2 = 1165.635$ df = 15 $P = 0.000$	4.424	73.733
	LC2	0.789	0.888	-	-	-	-
	LC3	0.720	0.849	-	-	-	-
	LC4	0.728	0.853	-	-	-	-
	LC5	0.725	0.851	-	-	-	-
	LC6	0.708	0.841	-	-	-	-
SCC	SCC1	0.626	0.791	0.939	$\chi^2 = 2067.766$ df = 28 $P = 0.000$	6.118	76.479
	SCC2	0.801	0.895	-	-	-	-
	SCC3	0.787	0.887	-	-	-	-
	SCC4	0.768	0.876	-	-	-	-
	SCC5	0.818	0.904	-	-	-	-
	SCC6	0.764	0.874	-	-	-	-
	SCC7	0.767	0.876	-	-	-	-
	SCC8	0.788	0.888	-	-	-	-

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; LC, lean culture; SCC, supply-chain competitiveness; KMO, Kaiser-Meyer Olkin.

**TABLE 2:** Assessment of data normalcy.

Research construct	Sample size ( <i>n</i> )	Skewness		Kurtosis	
		statistic	Std. error	statistic	Std. error
JIT	265	-1.052	0.150	1.426	0.298
TQM	265	-1.120	0.150	0.497	0.298
SP	265	-0.849	0.150	0.658	0.298
WE	265	-1.390	0.150	2.088	0.298
HR	265	-1.157	0.150	2.226	0.298
LC	265	-1.089	0.150	1.780	0.298
SCC	265	-1.711	0.150	4.470	0.298

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; LC, lean culture; SCC, supply chain competitiveness.

normality has little effect on data analysis for a large sample. Although the central theorem provides a studied theoretical background for the issue of normality in this study, the skewness and kurtosis of each construct and item are presented in Table 3. The value for skewness and kurtosis between -2 and +2 is considered acceptable to

**TABLE 3:** Correlation analysis of the constructs.

Research constructs	JIT	TQM	SP	WE	HR	LC	SCC
JIT	1	-	-	-	-	-	-
TQM	0.639**	1	-	-	-	-	-
SP	0.537**	0.639**	1	-	-	-	-
WE	0.554**	0.538**	0.564**	1	-	-	-
HR	0.430**	0.388**	0.442**	0.479**	1	-	-
LC	0.513**	0.614**	0.561**	0.591**	0.413**	1	-
SCC	0.451**	0.446**	0.491**	0.540**	0.420**	0.712**	1

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; LC, lean culture; SCC, supply chain competitiveness.

\*\*, Correlation is significant at the 0.01 level (two-tailed).

prove normal univariate distribution (Field 2013). Table 1 indicates that overall, the items of the scales have satisfactory skewness and kurtosis values. The Skewness values ranged from -0.848 to -1.711, while kurtosis ranged from 0.658 to 4.470. It can, therefore, be said confidently that the assumption of normality is met. Mardia (1974)

suggests that the data is non-normal if about 80% of the data presented skewness and kurtosis above the recommended threshold of -3 to +3. The data were distributed normally in this study, and the conceptual model was not complex. This thus required the use-regression model to test the proposed relationships. Table 2 presents the assessment of data Normalcy.

## Correlation analysis

In this study, Pearson correlations were applied to test the strength and direction of relationships between the research constructs. The results are presented in Table 3.

Table 3 shows significant positive correlations between all research constructs. The strongest correlation occurred between lean culture and SCC ( $r = 0.712$ ;  $p = 0.000$ ). In contrast, the lowest correlation was found between HR and TQM ( $r = 0.388$ ;  $p = 0.000$ ). This indicates that a change increase in one construct will change the other constructs, either positively or negatively.

## Regression analysis

In the current study, tolerance and the variance inflation factor (VIF), both regarded as measures of the impact of collinearity amongst the constructs in a regression model, were assessed, and should ideally be  $\text{Tolerance} > 0.1$  and  $\text{VIF} < 10$  (O'Brien, 2017:673). The values for all independent variables were within recommended limits and did not indicate any serious multicollinearity threat. The first multiple regression analysis tested JIT, TQM, SP, WE, and HR to determine if attitudes towards lean culture were predictors. It was found that JIT ( $\text{Tol} = 0.511$ ,  $\text{VIF} = 1.958$ ), TQM ( $\text{Tol} = 0.460$ ,  $\text{VIF} = 2.175$ ), SP ( $\text{Tol} = 0.503$ ,  $\text{VIF} = 1.990$ ) and WE ( $\text{Tol} = 0.549$   $\text{VIF} = 1.822$ ) were significant predictors of lean practices towards lean culture. However, HR ( $\text{Tol} = 0.708$ ,  $\text{VIF} = 1.412$ ) did not predict lean practices toward lean culture. Table 4 reports the regression analysis between lean practices and lean culture.

The predictor variables were the five lean practices (JIT, TQM, SP, WE, HR) (independent variable). The dependent variable that was entered into the prediction model was lean culture. Examining the relationship between lean practices

TABLE 4: Regression analysis of lean practices and lean culture.

Constructs; independent variables – lean practices	Adjusted $R^2$	Beta ( $\beta$ )	$t$	$p$ -level	Collinearity statistics	
					Tol	VIF
(Constant):	0.483	-	3.255	0.001	-	-
JIT	-	0.050	0.089	0.419	0.511	1.958
TQM	-	0.309	4.740	0.000	0.460	2.175
SP	-	0.147	2.360	0.019	0.503	1.990
WE	-	0.279	4.677	0.000	0.549	1.822
HR	-	0.073	1.383	0.168	0.708	1.412

$R = 0.702$ ;  $R^2 = 0.493$ ;  $F = 50.413$ ; mean = 5.6541; Mean square = 23.429; standard deviation = 0.66613; Eigenvalue = 5.927;  $n = 265$ ;  $p < 0.000$ .

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; LC, lean culture; SCC, supply chain competitiveness.

and lean culture rating, the adjusted  $R^2 = 0.483$  indicates that lean practices combined, explained 48.3% of the variance in lean culture. Table 5 reports the regression analysis between lean culture and SCC.

The predictor and independent variable held constant was lean culture, and the dependent variable was SCC. The rating (adjusted) of the relationship between the constructs was  $R^2 = 0.507$ , indicating that lean culture explained 50.7% of the variance in SCC.

## Assessment of measurement instruments (Reliability and validity results)

Table 6 presents the reliability results of the study, as indicated by the Cronbach alpha.

All scales attained Cronbach alpha values above the recommended 0.7 minimum threshold, which confirms that the scales were internally consistent.

To test for face and content validity of the measurement instrument, the questionnaire was reviewed by the research supervisors. Additionally, a pilot study was conducted, involving a convenient sample of 50 respondents. Feedback from the review and the pilot study was used to improve the questionnaire to make it more suitable for the final survey. The EFA procedure was used to test for construct validity (refer to Table 1), where factor loadings were higher than the 0.5 lower cut-off value, indicating that construct validity was adequate. Additionally, the positive correlation values (refer to Table 3) further confirmed that construct validity was acceptable. Figure 2 shows the conceptual model of the study incorporating the results of the hypotheses testing.

TABLE 5: Regression analysis of lean culture and supply-chain competitiveness.

Constructs	Adjusted $R^2$	Beta ( $\beta$ )	$t$	$p$ -level
Dependent: Supply-chain competitiveness	0.505	0.712	16.343	0.000*
Predictors: (Constant): Lean culture				

$R = 0.712$ ;  $R^2 = 0.507$ ;  $B = 0.739$ ;  $F = 270.065$ ; mean = 5.8877; Mean square = 129.556; standard deviation = 0.70053; Eigenvalue = 1.986 (greater than 1);  $n = 265$ ;  $p < 0.000$ .  $p = 0.000^*$  indicates the highest level of significance at 0.01% point.

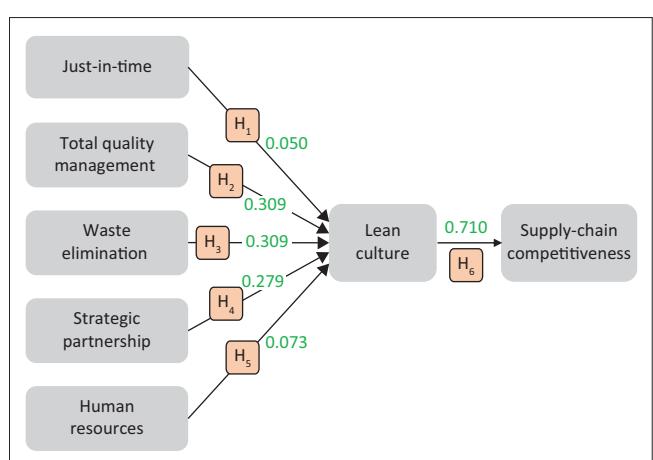


FIGURE 2: Path coefficient results.

**TABLE 6:** Reliability results.

Constructs	Cronbach alpha value
JIT	0.881
TQM	0.969
SP	0.884
WE	0.930
HR	0.928
LC	0.928
SCC	0.956

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; LC, lean culture; SCC, supply-chain competitiveness.

**TABLE 7:** Hypotheses decisions.

Hypothesis	Relationship	Beta coefficient	t	p	Supported/not supported
H1	JIT → LC	0.05	0.89	0.419	Supported
H2	TQM → LC	0.30	4.74	0.000*	Supported
H3	SP → LC	0.14	2.360	0.019	Supported
H4	WE → LC	0.27	4.677	0.000*	Supported
H5	HR → LC	0.73	1.383	0.168	Supported
H6	LC → SCC	0.71	16.343	0.000*	Supported

JIT, just in time; TQM, total quality management; SP, strategic partnership; WE, waste elimination; HR, human resource; IS, information sharing; LC, lean culture; SCC, supply-chain competitiveness.  $p = 0.000^*$  indicates the highest level of significance at 0.01% point.

## Hypotheses tests results

Table 7 shows a rundown of the results from this research and states the decision relating to the hypotheses formulated for this study.

In Table 7, H2, H3, and H4 were supported, implying that TQM, SP, and WE significantly predicted lean culture. H6 was strongly supported with a Beta-value of 0.712, indicating a positive and significant relationship between lean culture and SCC.

## Discussion of results

Regression analysis was used to test the direct causal relationships between the study constructs. The results revealed the following empirical observations. Regarding the association between JIT and lean culture, the implementation of the JIT solutions in the steel industry is not linked to establishing a lean culture or does not predict its improvement. This result contradicts previous studies by Wyk and Naidoo (2016:237) in the electronics manufacturing industry that showed that adopting JIT affects the extent to which lean thinking and the minimisation of waste become entrenched within the organisation. Sharma et al. (2015) also established the importance of JIT in lean manufacturing processes.

Furthermore, Masudin and Kamara (2018) deduced that JIT's philosophy advocates the elimination of waste by simplifying lean production processes. The empirical evidence from this research highlights that TQM is a significant predictor of lean culture. This result aligns with a previous study by Sreedharan et al. (2016) and Cherrafi et al. (2016:828), who further established that effective TQM requires a lean system among people, machines, and information, stressing a systematic approach to quality. Strategic partnership was found to be an essential predictor of lean culture. This point was supported by Mumassabba et al. (2015), who stated that

SP and lean culture yields better understanding among crucial stakeholders in supermarkets in Kenya. The significance of WE as a driver of lean culture was advocated by Demeter and Matyusz (2011). They established that WE plays a vital role in the implementation of a lean culture in the manufacturing industry. The results regarding human resources showed a positive relationship with lean culture. This was endorsed by Bhaskar and Tilak (2013), human resources do play a positive and significant role in the implementation of lean culture through employee engagement. In the study it is, therefore, deduced that employees are the most critical resource of the four resources required to bring about success in any form of organisation.

It can be concluded that employees who continually learn and enhance their skills become the organisations' critical assets. This implies that organisations in the steel industry in Gauteng need to investigate HR and align them with the learning culture to more successfully adopt a lean culture. Finally, the result demonstrated that a lean culture exerts a positive and significant influence on SCC. This, thus means that the steel manufacturing firms with lean culture are more likely to achieve SCC. These findings align with Vanichchinchai's (2019) observations in that the author established that lean practices positively influence supply-chain performance in terms of competitiveness and customer satisfaction. According to Van der Merwe (2014), manufacturing industries that have successfully instilled a lean culture in the organisation and workforce will consistently realise SCC, more innovative, team-directed solutions, lower employee turnover, and more success at sustaining improvements.

## Theoretical contributions

This study proposed and empirically tested a conceptual model that incorporated LSCM practice (JIT, TQM, HR, SP and WE) as antecedents of a lean culture in the steel manufacturing industry. In addition, SCC was also incorporated as an outcome of lean culture. This model's uniqueness is its holistic stance that posits six LSCM practices which directly impact lean culture and, ultimately, SCC. Finally, the resultant conceptual model proposed in this study would improve the supply-chain model related to the steel manufacturing industry; and researchers studying the supply chain for other industries could use the model.

## Managerial contributions

Knowing more about the factors enhancing lean culture and improving SCC would help these firms create the right strategies to strengthen, enhance, and manage their supply chains. This study provides this much-needed information and indicates the extent to which steel manufacturing's LSCM practices affect lean culture and SCC. This would guide the steel manufacturing firms to allocate their resources to improve their SCC appropriately. This study would also be helpful for businesses and decision-makers because it would provide insights into LSCM grey areas and help improve their business performance in South Africa and Africa as a whole.

## Limitations and future research

In assessing the findings of this study, it should be noted that the study is by no means without limitations, which offers avenues for future research. Some of the main challenges that hampered the adequate completion of this investigation are that the study was confined to only steel manufacturing firms in Gauteng Province, specifically Southern Gauteng, where there is a market leader of steel producers in the country (ArcelorMittal South Africa). Studies (Mukhtar 2015) show that market leaders are more proactive in their business operations than their followers, as a result they may have been practising lean manufacturing for a more extended period. Another limitation is related to the research methodology employed. A survey using self-administrated questionnaires was employed in this study. While self-reporting may rightly gauge the LSCM practices influencing lean culture, the report on these practices may need implicit studies or experimental methods. The third limitation is that the study was cross-sectional in nature. This means that the reported results relate to only a particular point in time. Applying a cross-sectional design implies that the investigation has focused on reported lean practices, lean culture and SCC instead of emphasising observed changes in these variables over time. In future research a longitudinal survey and observation research focusing on uncovering LSCM practices affecting lean culture and SCC over a long period may be applied. For example, researchers may track SCC frequency should the firms improve their JIT, TQM, SP, WE and HR.

## Conclusion

This study aimed to investigate the relationships between LSCM practices, lean culture, and SCC in the steel industry in Gauteng Province. It tested a conceptual model that incorporated LSCM practices (predictor variables) and lean culture (mediator variable) to understand the factors influencing SCC (outcome variable). It made theoretical contributions by developing and testing the conceptual model and understanding steel manufacturing's supply chain. Practical contributions exposed areas where decision/policymakers and businesses could enhance their efforts in improving SCC in the steel manufacturing industry. The study opens avenues for future research to expand the findings obtained and deal with a few limitations. While the factors driving lean culture may help improve supply-chain performance, corresponding efforts should be made to increase the ineffective supply chains in South Africa and other parts of the globe.

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### Competing interests

The authors have declared that no competing interest exists.

### Authors' contributions

S.K. conducted the fieldwork of the study and wrote the research methodology section. C.M. performed the data

analysis and wrote the results section. Lastly, W.V.L.O. wrote the initial section of the article and performed the literature review.

## Ethical considerations

Ethical clearance to conduct the study was obtained from the Central Research Ethics Committee at a South African University of Technology. The study conformed to ethical standards regarding the minimal risk it posed and the voluntary participation and protection of respondents' identity. It was further supported by providing an ethical clearance certificate conferred by the Vaal University of Technology (FRECMS-18032020-028 25264231 [30 April 2020]).

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## Data availability

Data supporting the findings of this study are available from the corresponding author on request.

## Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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Appendix starts on the next page →

## Appendix 1

TABLE 1-A1: Measurement instruments.

Questionnaire instruments	Sources
<b>Just-in-time (JIT)</b>	
We have located our machines to support JIT production flow.	Bortolotti, Boscari and Danese (2019)
Our suppliers deliver to us on a just-in-time basis.	
We receive daily shipments from most suppliers.	
We can depend upon on-time delivery from our partners.	
Our suppliers are linked with us by a pull system.	
Continuous improvement programmes been implemented in the materials handling control function to improve JIT.	
<b>Total quality management (TQM)</b>	
Our TQM supports continuous improvement and innovations.	Sadikoglu and Olcay (2014)
Our TQM is reliable.	
Our TQM is competent and flexible.	
Our TQM is effective and competitive.	
Our TQM focuses on quality data and reporting.	
Our TQM oversee supplier quality management.	
<b>Strategic partnership</b>	
We provide a fair return to our suppliers.	Bortolotti, Boscari and Danese (2019)
Our organisation shares proprietary information with its supply chain partners.	
We include our key suppliers in our planning and goal-setting activities.	
Our key suppliers provide input into our product development projects.	
<b>Waste elimination</b>	
Waste reduction is focused on the functional areas within the company.	Manzouri et al. (2014)
This company analyses internal processes to minimise waste.	
Our supply chain partners are working together to eliminate waste.	
We understand end-to-end processes and work together to eliminate waste throughout the supply chain.	
We eliminate waste by avoiding overproduction.	
<b>Human resources</b>	
Our employees receive training to perform multiple tasks.	Bortolotti, Boscari and Danese (2019)
Employees at this plant learn how to perform a variety of tasks.	
The longer an employee has been at this plant, the more tasks they learn to perform.	
Employees are cross trained at this plant, so that they can fill in for others, if necessary.	
<b>Lean culture</b>	
Our organisation reduces process set-up time (time required to prepare or refit equipment/workstation for production).	Panuwatwanich and Nguyen (2017); Ganeshkumar and Nambirajan (2013)
A problem is viewed as an opportunity to improve.	
Our organisation produces only what is demanded by customers when needed (e.g. JIT).	
We are able to respond quickly to customers' changing demands.	
We consider the impact of decisions on the rest of the organisation.	
We believe that reducing waste makes us more competitive.	
<b>Supply-chain competitiveness</b>	
Manufacturing lead times are shorter.	Panuwatwanich and Nguyen (2017); Ganeshkumar and Nambirajan (2013)
Our deliveries are on time.	
We have fewer or no shipping errors.	
There is minimal customer complaint.	
There is an improvement in order item fill rate.	
We have a customer response time.	
Sale forecast matches the demand.	
We have improvement in inventory turns.	

JIT, just in time; TQM, total quality management.