

# The relationship between vendor managed inventory and operational performance

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## Abstract

**Purpose** – For the supply chain to be responsive in the age of globalization, the firm needs to adopt strategies to enable them to meet the changing market needs. Thus, it is essential to adopt automatic replenishment programmes such as vendor-managed inventory (VMI). This study sought to examine the relationship between VMI and operational performance (OP) and the moderation roles of leadership and digitization in the mining sector.

**Design/methodology/approach** – A quantitative approach was used, including primary data collected from industry players in the mining sector in Ghana. A total of 97 industry players were included in the study. Data gathered was analysed using SPSS and LISREL (8.5).

**Findings** – The results indicate that VMI significantly affects OP. However, both digitization and leadership failed to moderate the relationship between VMI and OP.

**Practical implications** – The study offers mining companies an understanding of VMI applications in their industry. The knowledge will stimulate and improve inventory management practices in the mining industry.

**Originality/value** – This study is among the first few attempts to understand VMI in the mining industry, especially in the Sub-Saharan Africa context. It presents a detailed understanding of VMI and opportunities for future research.

**Keywords** Vendor managed inventory (VMI), Mining industry, Digitization, Leadership, Operational performance, Structural equation modelling

**Paper type** Research paper

## Introduction

Supply chain management (SCM) ensures that supply chains continuously function effectively and efficiently. It facilitates the operations of organizations along a supply chain to deliver the needed products to consumers at the right time and place needed (Hammer and Bernasconi, 2016; Wettasinghe and Luong, 2020; Sari, 2007). Supply chains (SC) are complex systems involving suppliers, manufacturers, distributors and retailers and how they interact with each other (Wettasinghe and Luong, 2020). It has become a major area of interest. Zachariassen *et al.* (2014) explain that the intensity of SCs to improve each aspect to facilitate the flow of material and information across the supply chain has exposed it to risks. These include short product life-cycle (Zachariassen *et al.*, 2014), vulnerability to supply disruptions (Mishra *et al.*, 2021), customer demand uncertainty (Wettasinghe and Luong, 2020) and lack of demand visibility (Marques *et al.*, 2008). For supply chain to be responsive in the age of globalization, the firms need to adopt strategies to enable them to meet the



changing market needs (Joseph *et al.*, 2010). Firms need to take advantage of information and material control platforms in the chains (Borade and Bansod, 2010). Actors at both ends must commit to their common goal and enjoy the benefits of improved flow of data, material and services. Manufacturers need to understand their suppliers and inculcate their needs into the design of new products or services. Organizations around the globe have realized that they can only compete and sustain their momentum on the global market by gaining a competitive edge only by adopting a comprehensive and reliable supply chains and networks (Borade and Bansod, 2010).

A viable solution to this emerging challenge is the adoption of automatic replenishment programmes such as material requirement planning, just-in-time and vendor managed inventory (VMI) (Zachariassen *et al.*, 2014; Khalid and Lim, 2018). Due to demand uncertainty and the existence of lead times of members, it is essential to maintain a minimum stock sufficient to meet demand. Automatic replenishment programmes such as VMI (Borade and Bansod, 2010) are, therefore, used in exchange relationships between buyers and suppliers to serve customer needs appropriately, where there is the need to adopt an appropriate inventory policy. VMI has become a key SC management strategy for organizations across the world (Borade and Bansod, 2010). With its inception earlier as collaboration between Wal-Mart and Procter and Gamble (Sumrit, 2019), VMI gradually has been popularized in various industries, both large and small for their supply chains. VMI is an SCM practice where the vendor is given the sole responsibility to monitor and manage the inventory of the retailer (Joseph *et al.*, 2010). VMI is giving a competitive advantage to vendors which results in timely availability of stock (Sari, 2007; Sumrit, 2019). The platform also offers retailers lower inventory cost, limited to higher selling space productivity and improved control on bullwhip effect and better stock replenishment plan (Zachariassen *et al.*, 2014).

In spite of the benefits associated with VMI, firms in Africa place less emphasis on such logistics and SCM practices. Despite the significant benefits of VMI in assisting major organizations such as retaining required stock as much as possible and reducing bullwhip effect for retailers, the concept has not gained enough attention in research in Africa and Ghana. Few studies that have been undertaken have proved that VMI positively affects organizational performance (Dadzie *et al.*, 2015; Mwangi and Kitheka, 2018), although, it may be negative in the initial stages (Elsayed and Wahba, 2016). VMI provides nearly the same level of performance for both the vendor and retailer provided the ratio lead time of the latter to the former remains constant (Borade and Bansod, 2010). Borade and Bansod (2010) presented the usefulness of digitization in the success of VMI in the manufacturing sector. The VMI concept is very wide; meanwhile, only few empirical studies have validated its effect on organizational outcomes especially in developing regions like Sub-Saharan Africa, of which Ghana is not an exception. Apart from the limited literature on the association of VMI and organizational performance, past studies have certain drawbacks. First, prior research has been limited to manufacturing (Mwangi and Kitheka, 2018; Masudin *et al.*, 2018; Ru *et al.*, 2018; Radzuan *et al.*, 2018; Khalid *et al.*, 2018; De Giovanni, 2021; Hashmi *et al.*, 2021) and healthcare (Weraikat *et al.*, 2019; Sumrit, 2020; Hossain and Parvez, 2020) settings in developed economies. Therefore, this study was undertaken in Ghana with a distinct cultural context to determine whether the analysed context may yield significantly different findings. Hence, this study attempts to address the question:

*RQ1.* Does VMI significantly enhance operational performance (OP) of mining firms?

Second, in addition to the variables listed above, other variables may play important roles in understanding the relationship between VMI and OP. These variables can be investigated based on a particular theory, more than just resource-based view. Therefore, classic contingency configuration (CCC) theory is implemented to solve this research gap by providing novel concepts, leadership and digitization, to bridge the gap between VMI and OP.

The theory hold that an organization may be effective based on its ability to adjust to change such as inventory management. Leadership and digitization are proven essential in the management of any supply chain. In past studies, leadership has emerged as an enabler of VMI implementation (Songar and Shukla, 2017). This makes leadership critical in the success of VMI implementation, such that the higher the level of leadership support for VMI, the better is its outcome on the operations of the firm. Another aspect of the success factors of VMI is information sharing (Radzuan *et al.*, 2018) which is an integral aspect of SCM (Maskey, 2018). It is an important cross-functional driver through which organizations can enhance inter-organizational connectivity, cope with uncertainties and make well-informed decisions, reduce bullwhip effect, etc. Dadzie *et al.* (2015) identified the technological environment as one of the key SCM drivers of the African market. This is made possible through increasing access to new information technology including the Internet and mobile technology. With some evidence about the positive impact of VMI on organizational performance, this study delved into how VMI enable high-level organizations to meet OP while establishing the relationship between leadership and digitization and its success. In summary, the authors believe that the presence of leadership and digitization may serve as essential bedrock to achieve superior OP from VMI. Hence, the next set of questions addressed in this study is:

*RQ2.* Does Leadership moderate the VMI–OP direct relationship?

*RQ3.* Does Digitization moderate the VMI–OP direct relationship?

In addressing the questions above, a quantitative approach was used to gather data from 100 industry players. Data was analysed using Statistical Package for Social Sciences (SPSS) and smart partial least square structural equation modelling (SEM). The results indicate that VMI significantly affects OP. However, both digitization and leadership failed to moderate the relationship between VMI and OP. The outcome of this study offers mining companies an understanding of VMI applications in their industry. The knowledge will stimulate and improve inventory management practices in the mining industry. This study is among the first few attempts to understand VMI in the mining industry, especially in the Sub-Saharan Africa context. It presents a detailed understanding of VMI and opportunities for future research. The remaining sections provide a review of the literature, the methodology employed, results and discussion and finally the contribution of the paper as well as the conclusion of the study.

## Literature review

### *Vendor managed inventory*

“Inventory” as a term originated from two languages. The French word “*inventaire*” and the Latin word “*inventarium*” which collectively mean a list of items. Inventory, therefore, is widely used in stocktaking of raw material, finished goods, work-in-progress and consumables (Ballou, 2007). Although research on VMI has intensified, Zachariassen *et al.* (2014) discovered that the concept has not received attention aside business-related projects documents available from implementation agencies. The concept of VMI emerged on anticipation that suppliers would pose a better resource at managing the customer’s inventory from their experience in approximating lead times. Popularized by its implementation in the USA, by Wal-Mart and Procter and Gamble, VMI has been replicated in many industries all over the world (Erikshammar *et al.*, 2013; Sumrit, 2019; Marques *et al.*, 2008; Yang *et al.*, 2017). Also, referred to as “continuous replenishment” or “supplier-managed inventory” (Sari, 2016; Joseph *et al.*, 2010), VMI is a system of frequent and punctual deliveries that optimize production and transport planning (Marques *et al.*, 2008). Under VMI, accurate and effective information exchange (which includes point-of-sales data) from the customer is sent to the vendor/supplier to help in estimating lead times (Joseph *et al.*,

2010). VMI is a supply chain initiative where the vendor is given the necessary information to decide on the appropriate inventory levels of each of the products and the proper optimum levels (Sari, 2007; Alfares and Attia, 2017; Joseph *et al.*, 2010; Marques *et al.*, 2008; Yang *et al.*, 2017). The firm is no longer in charge of control and order but may set service level or space needs upon which the vendor uses to provide the customer with products (Coelho *et al.*, 2012a, b; Joseph *et al.*, 2010; Hammer and Bernasconi, 2016). The retailer under VMI is given inventory cost relief to concentrate on other areas such as space. Based on data received, the vendor is able to make intermittent resupply decisions (Hammer and Bernasconi, 2016). VMI comes with benefits to each partner at both ends of the chain (Sari, 2016). The vendor/manufacturer/supplier enjoys reduced bullwhip effect, proactive response and alignment of the production, reduction in transportation cost, lower inventory costs and ease on promotion of new products (Joseph *et al.*, 2010). The retailer also enjoys a competitive advantage from reduced lead times resulting in higher product availability, higher service level, lower inventory monitoring and ordering cost (Sari, 2016) and optimum use of space and simplified procurement process (Joseph *et al.*, 2010). The consumer or end user also benefits from the implementation of VMI through improved availability of products and reduction in switching cost (Joseph *et al.*, 2010).

#### *Industrial suitability of VMI*

Although the success of VMI has been seen in various organizations in different industries, industrial suitability is still an area of concern (Joseph *et al.*, 2010). The most cited source is the implementation by Wal-Mart and Procter and Gamble in the 1980s in the USA (Marques *et al.*, 2008; Joseph *et al.*, 2010; Coelho *et al.*, 2012a, b; Zachariassen *et al.*, 2014; Sari, 2016). Joseph *et al.* (2010) cited several examples such as Hewlett Packard and ST Microelectronics, Tesco and Nestle and Carrefour and L'Oreal. These success stories direct attention to industrial suitability of VMI. According to Joseph *et al.* (2010), VMI would be efficient in industries with large and numerous branches and outlets. These firms need optimal and accurate inventory levels in order to prevent stock outs and waste. VMI would also be efficient industries with error sensitive materials such as the pharmaceutical industries. It is important that such industries do not run out of important vital supplies that will minimize error level in their operation or existence. Industries that handle perishable goods, such as goods that loose value over time and require shorter lead times for replacement, can be managed effectively with VMI.

Another sector that was identified as appropriate for the implementation of VMI is industries with high value and unpredictable demand. These industries are highly valued and have high unpredictable material needs to meet continuous innovation. VMI helps reduce lead times to the maximum and keep the supply chain lean to promote efficiency and eliminates waste to meet their random needs. The last industry suggested by Joseph *et al.* (2010) is the one with high competition. Firms in this industry have low profit margins due to competition. VMI helps firms to gain advantage by ensuring timely availability of commodities. Our study, based on the study of Joseph *et al.* (2010), shows that the mining industry falls under the high value and unpredictable demand industries due to their unpredictable needs for advanced equipment to undertake new tasks.

#### *Vendor managed inventory in Africa's mining sector*

The previous era that was intensively regulated by state apparatus only worsened access to goods and services by the ordinary citizen. A new environment created through consumer demands and competition is causing the possibilities for firms to compete on the basis of their supply chains (Chironga *et al.*, 2011). Effective supply chain strategy helps firms to offer vast range of services at a reduced comparative cost. The presence of some international retailers, such as Wal-Mart on the African continent including Ghana, attests to this changing

environment. However, the transition would not be an easy task for most local firms, given the past history. Effective SCM is recognized to offer much competitive advantage than traditional logistics and strategies (Dadzie *et al.*, 2015). Inventory management, consequently, offers greater competitive advantage than other SCM strategies. The adoption of such improved strategies will give Africa a notch in the international market. Organizations achieve significant growth as a result of the implementation of market-driven development policies. However, the possibility of SCM failure questions the success of other strategies. This potency has been created from the legacy strong state control. Also, previous studies have failed to give attention to the applicability of SCM relative to another concept (Dadzie *et al.*, 2015).

Three inventory location arrangements exist under VMI installation (Joseph *et al.*, 2010). Radzuan *et al.* (2018) sampled out appropriate VMI location arrangement that will fit the African economic landscape and proposes that with such a VMI practice, the inventory can also be located at the customer's premises in a distributed manner. In this arrangement the vendor replenishes the inventories at all the consumption area, which includes store, production line and machine. One of the success factors for VMI is reduced downtimes. The mining sector can leverage on such advancement to achieve efficiency amid their unpredictable demands. A positive benefit of digitization for businesses is that, they are open to the global market (Dadzie *et al.*, 2015). Firms always have access to alternative cheaper options to meet their customers' demands. They leverage on the availability of the Internet to source alternatively affordable supplies globally.

### Theoretical review

#### *Classic contingency configuration theory*

Africa's supply chain is unique (Wanyonyi, 2017). To effectively manage their inventory, Dadzie *et al.* (2015) proposed that the CCC theory would help firms to compete successfully through effective inventory management. The theory hold that an organization may be effective based on its ability to adjust to change such as inventory management (Burns and Stalker, 1961). An organization, therefore, may try as much as possible to fit into its changing environment in order to achieve high performance. Strategic policies by firms in Africa offer contingency approaches that are relevant to logistic management. Thus, firms can improve their performance by adopting emerging technologies such as VMI as required by its economic environment. Co-aligning SCs of firms with changing economic or business environment helps them to improve on operational effectiveness (Erikshammar *et al.*, 2013). Thus, as the demand for improved inventory management calls, firms should adopt emergent technologies that can improve on the existing situation effectively. The CCC theory supports the existence of a positive relationship between firm inventory management and performance (Wanyonyi, 2017). While existing studies have focused on the use of resource-based view (RBV) and economic order quantity (EOQ) Model to understand the effect of inventory management on firm performance, this study employs the CCC theory. The choice of the theory is justified by the fact that the link between VMI and OP may not be just a direct one, but rather contingent on the presence of certain factor. Through the lens of the CCCT, the authors argue that leadership and technology forms important contingent or boundary factors necessary to enhance the connection between VMI and OP in the mining sector in emerging economies.

#### *Conceptual framework*

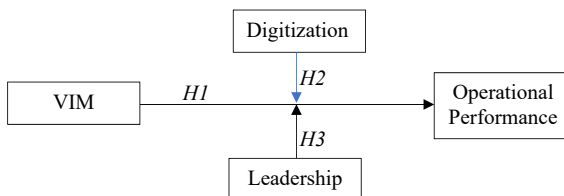
The review has revealed a framework that connects all the independent variables and the dependent variable as a unit. The initial relationship that will be established is between VMI and OP, as a SCM strategy with performance. However, the review has shown that not only

the adoption of VMI transmutes into OP, but there are also other factors. [Jermittiparsert and Srihirun \(2019\)](#) suggest that leadership plays an integral role in the success of every organization and its SCM strategies. Implementation, coordination and facilitation of VMI requires top management commitment ([Sumrit, 2019](#)) to be effective. [Sen et al. \(2014\)](#) and [Zachariassen et al. \(2014\)](#) also defend the impact of digitization on VMI. The impact of digitization on firm performance is not direct, but grossly contributes to organizational performance through VMI ([Magutu et al., 2015](#)). This is represented by [Figure 1](#). The diagram shows the main variables under study. The independent variables are VIM, leadership and digitization while the dependent variable is performance. VMI is an SCM strategy which serves as an inventory management between the vendor and a retailer, which in this case a customer, since most mining firms are customers instead of the popular retailer relationship in the commerce sector.

*Hypothesis development*

*Relationship between VMI and OP.* The goal of SCM is to enhance competitive performance by linking the internal activities of the organization with the external operations of suppliers, customers, etc. ([Agyei et al., 2013](#)). The increasing competitive nature of the global business environment influences each industry including the mining sector. SCM then becomes important to respond and compete favourably in both local and international markets. Effective SCM should aid a firm to attain coordination in the supply network and alignment with customer satisfaction to ensure efficient and effective performance ([Agyei et al., 2013](#)). VMI implementation differs among countries and sectors. [Shen et al. \(2013\)](#) discovered that there were differences between VMI adoption in the manufacturing and service sector industries in India, albeit, similarities; among countries, developed countries tend to have complex and improved form of the technology installations while developing countries were in the early stages of adoption. VMI equally seeks to achieve efficiency. Information exchange in the chain is greatly enhanced that can lead to reduced bullwhip effects arising from errors in demand forecasting ([Zachariassen et al., 2014](#)). Efficient management of inventory systems is crucial to improving business performance as inventory management often accounts for a large proportion of SCM costs and drives service levels ([Hou and Trappey, 2002](#); [Yang et al., 2017](#)). In OP, [Gitau \(2016\)](#) revealed that quality inventory management reduce loses from low quality products and unsatisfied customers.

A study by [John et al. \(2015\)](#) found that there is significant impact between effective management of inventory and OP in Nigeria. However, they revealed that such adoption should be based on scientific backing since their study found vast difference in effects on performance between companies with scientific inventory management and those without. [Obura \(2015\)](#) also found that VMI explains more than 90% of variations in organizational performance in the manufacturing industry in Kenya. For VMI to effectively influence organizational performance, the firm/warehouse should focus on creating improvements by streamlining the flow of material and information across the supply chain ([Obura, 2015](#)). Supply chains depend on not only internal resources but also external support provided by



**Figure 1.** Conceptual framework

suppliers or partners. Effective suppliers support ensures that each partner at the end of the chain has compatible information system that supports inter-firm processes which can be linked to the framework. Increase efficiency in SC enhances performance (Dong *et al.*, 2009 cited by Hermansson and Moller, 2016). From this review, the study proposes the following hypothesis:

H1. VMI has a significant positive effect on the OP of mining firms.

*Moderating role of leadership on the relationship between VMI and performance.* Albeit the available literature, available data on the moderation role of leadership on VMI and SC performance fall short. The role of leadership on inventory management cannot be left out in efficiency discussions. Leaders bring improvement and change within an organization which affects organizational performance. The study revealed that the leader of the supply chain brings the improvement and change within the organization (Jermisittiparsert and Srihirun, 2019). Therefore, to achieve high performance, leadership is important. A study by Jermisittiparsert and Srihirun (2019) found that there is a significant relationship between leadership and SCM. The presence of leadership in SCM such as VMI is seen as effective. The study revealed the fact that the leader of the supply chain brings the improvement and the change within the organization. As a result, the productivity and the performance of the organization is increased. In order to achieve high performance, it is important to change every aspect of the supply chain, including processes design, which requires the support of leadership (Jermisittiparsert *et al.*, 2019). In line with the above, this study sees leadership as a necessary condition or requirement to strengthen the effect of VMI on OP, such that the more the firms' leadership supports the implementation of VMI, the more they reap the full benefit. Thus, the study proposes this hypothesis:

H2. Leadership positively moderates the relationship between VMI and performance of mining firms.

*Moderating role of digitization on the effects of VMI on performance.* Neuschel (1987) observed that computers' role in digitization does not replace the role of management, albeit, it serves as an important asset in extending problem solving and management horizons after problem identification. Managers are also advised to add the existence of digitization as a management function which requires their attention and control. Thus, computers should be applied at the right level of complexity. One visible evidence of the benefit of digitization to logistics is that the computer should be able to assist or improve the delivery of products in an effective and efficient manner that otherwise could not be done without computers. The adoption of VMI, basically a computerized platform to control inventory taking for firms, should effectively and efficiently enhance performance of such businesses. For example, adopting a VMI for the mining sector in Ghana should help store managers to meet unprojected demands by reducing leads times and ensure that supplies are made available when needed. Continuous innovation is required to attain such profitability in the mining sector.

The moderation role of technology on supply chain and performance, although has not gained much attention in literature, has been established through an expanded study by Magutu *et al.* (2015). The study used expanded strategies in SC (16 categories under mid-range and long range) and technologies (25 categories as integrative and functional). Their study found a significant connection among supply chain technology and its strategies with performance. The study continued to establish that the adoption of technology in SCM moderates the relationship between the impacts of SC strategy on firm performance. Technology gives a gross moderation effect on SC strategies and performance than directly on performance (Magutu *et al.*, 2015). This means that employing technology may not directly transmute into direct sale or revenue generation but eventually corroborate performance

improvement of the firm. Drawing from the contingency perspective, digitization cannot be downplayed if firms envisage reaping the full benefit of VMI. VMI may not be beneficial to firms if their technology base is weak. Thus, for effective VMI, technological innovations must allow the vendor to have real time information of the firms' inventory, production and even sales to decide replenishment levels. Digital VMI, according to [Dirnberger et al. \(2017\)](#), is an efficient method to develop lean replenishment warehouse procedures in a supply chain, while simultaneously improving customer and vendor service standards. In VMI, inventory management and replenishment are no longer the customer's responsibilities. As a result, these tasks fall on the vendor. It is the responsibility of the client to provide the vendor with up-to-date sales and inventory data on a regular basis ([Zsifkovits et al., 2017](#); [Dirnberger et al., 2017](#)). The new digital technologies especially provide innovative potentials in data collection, provision and analysis ([Vogel-Heuser, 2014](#), p. 36f). The benefits of VMI to improve OP are therefore dependent on digitalization. Thus, the study proposes this hypothesis:

*H3.* Digitization positively moderates the relationship between VMI and performance of mining firms in Ghana.

## Data and methodology

### *Target sample and data collection*

Procurement officers, supply chain officers and warehouse managers in the mining industry were recruited for the study. These people are more experienced in managing the mining supply chains and are familiar with new development and trends in the sector. Thus, choosing the officers as the target population is not out of place. A total of 156 officers were included in the sample. But 107 responses were received and 97 was used for the analyses. The responses which were not included in the analyses were mainly incomplete. All the officers identified themselves as full-time workers of the mining companies and are involved in supply chain issues. The sample included 65 (67%) males and 32 (33%) females. With regard to age, 30–39 and 40–49 formed the majority age group [30.9% ( $N = 30$ ) and 27.8% ( $N = 27$ ) of respondents respectively]. The age group with the least representation is 60+ and 50–59 years [6.2% ( $N = 6$ ) and 10.3% ( $N = 10$ ) respectively]. The online survey method was used to collect the data. This method is seen as a novel and fast-growing technique for data collection ([Marjanovic et al., 2007](#)). The incidence of the COVID-19 pandemic made it a very useful data collection technique which assisted the researcher to reach out to the respondents easily at a comparatively cheaper cost ([Buchanan and Smith, 1999](#); [Kraut et al., 2004](#)). Online questionnaires are believed to have the same reliability and validity as paper-based questionnaires ([Buchanan and Smith, 1999](#); [Kraut et al., 2004](#)). Online survey may be biased because it is self-selective ([Kraut et al., 2004](#)). This study did not suffer this bias because the respondents are procurement officers, supply chain officers and warehouse managers who are involved in supply chain activities of their respective firms. This restriction ensured that only appropriate respondents participate in the study. The beginning of the questionnaire requested respondents to indicate whether they consent to participate in the survey before having access to the main questionnaire. The respondents were assured of their anonymity and confidentiality of the responses. The respondents used approximately 15 min to complete the questionnaire.

### *Measures*

A survey questionnaire was used to collect the data for the study. With this method the outcome of the study can be replicated and generalized as well as could concurrently examine various factors ([Pinsonneault and Kraemer, 1993](#)). In extant literature, the procedure is recognized as a robust conduit to identify relationships in a sample with a predictive theory

for the purpose of generalization of the outcomes (Straub *et al.*, 2004). The questionnaire development guidelines propounded by Churchill (1979) and Recker and Rosemann (2010) were used as the basis for the design of the questionnaire while the construct measurement followed the recommendation of MacKenzie *et al.* (2011). Again, the procedures and recommendations (including anonymity, consent screening and personalization) by Cychota and Harrison (2006) was employed to improve the response rate. With regard to the questionnaire design, a literature review was conducted to find suitable indicators whose latent variables have been published with psychometric properties to support their validity. After this a draft questionnaire was designed and shared with experts in the field of supply chain to review and modify (where necessary) the questions, indicators and wording. The measurement instrument for VMI was adapted from Dadzie *et al.* (2015); leadership (LEAD) construct was adapted from Panday and Panday (2018); digitization (DIG) construct was adapted from Dadzie *et al.* (2015) and performance (PERF) construct was adapted from Acquah and Agyapong (2015), Dadzie *et al.* (2015) and Agyapong *et al.* (2017). The questionnaire included close-ended and scaled questions for capturing data based on the objective of the study. The form was divided into four sections. Section A asked questions about the respondent's background such as gender, educational level and age. The questions from sections B, C and D were used to assess the main objective of this study. Section B was used to measure the independent variable, VMI, which was measured with six items. Sections C and D also sort to measure the moderators, LEAD and DIG with seven and five items respectively. The last section, E, measured the dependent variable, performance (PERF) with ten (10) items. The questions were structured on a Likert scale of 1–5, where 1 = strongly disagreed, 2 = disagreed, 3 = neutral, 4 = agreed and 5 = strongly agreed. The respondents were tasked to indicate the extent to which they agree or disagree with the measures.

*Data analysis*

With regard to data assessment and statistical methods, first SPSS 21 was used to assess the data and the SEM method via LISREL (8.5) was used for the empirical test. The SEM was used to test the theoretically proposed relationships between latent and observed variables in the study. To begin with, the confirmatory factor analysis (CFA, via maximum likelihood estimation procedure) was used to check for the overall validity of the measures. The outcome of the analysis with the maximum likelihood estimation and maximum likelihood replacement of missing values indicates acceptable model fit indices. All the values were found to be acceptable. The overall fits i.e. the relative chi-square over the degrees of freedom, were all lower than 3. The model fit indices are: Root-Mean Square Error Approximation (RMSEA) = 0.057, Non-Normed Fit Index (NNFI) = 0.959 and Root Mean Square Residual (RMSR) = 0.0682. The others include  $\chi^2/df = 1.31$ ;  $\chi^2 = 169.47$ ;  $df = 129$  and  $p = 0.0097$  (see Table 1).

Constructs	$\chi^2$	df	$\chi^2/df$	RMSEA	NNFI	CFI	RMSR	PV
VMI	9.34	5	1.87	0.065	0.992	0.995	0.0354	0.09625
Digitization	1.32	2	0.66	0.000	1.015	1.000	0.0185	0.51689
Leadership	0.06	2	0.03	0.000	0.974	0.991	0.0351	0.1987
Performance	9.07	5	1.81	0.077	0.955	0.973	0.0501	0.11968
Overall FIT	169.47	129	1.31	0.057	0.959	0.966	0.0682	0.00974

**Note(s):** NNFI, non-normed fit index; RMSEA, root-mean square error approximation; RMSR, root mean square residual; VMI, vendor managed inventory; CFI, comparative fit index; PV, *p*-value; df, degrees of freedom

**Table 1.**  
Goodness of fit indices

## Results and discussion

### Confirmatory factor analysis

SEM was used to estimate the linear relationships between the study constructs using LISREL (8.5). One main limitation of SEM is that it cannot make up for errors made in research design. Structural model does not improve model fit, therefore, if adequate fit was not found in the CFA model, the focus should be on improving that model before moving on to the structural model (Hair *et al.*, 2014). Main issues of validity and reliability in SEM are item structure, metric measure, theory testing, etc. (Babin and Svensson, 2012). According to Hulland (1999), the quality of measurement model can be obtained based on three indicators: reliability of measures and items, convergent validity and discriminant validity. An approach of discarding items has received various suggestions. For example, Hulland (1999) advised that factor loading must be 0.4 or higher for an item to be considered as reliable. Any item that does not satisfy this condition, should be laid aside from the research procedure and model must be analysed without that. In the factor analysis, each variable was treated at the construct level since they were measured with single indicator items. Albeit some items were deleted, all variables obtained required fit indices recommended by Hair *et al.* (2014). The first item, VMI, had one item deleted, leadership on the other hand had three items deleted while one item was deleted from digitization and four items from performance. The results confirmed both convergent and discriminant validity. Various items adopted in assessing the study variables, the standardized loadings and fit indices are displayed in Table 2.

Standardized loadings cut-off of 0.5 was set for items that were included in the CFA (Hongyun *et al.*, 2019; Hair *et al.*, 2014) to ensure the significance and relative importance of

Item	Standardized loadings	T-stats
<i>Vendor Managed Inventory (CA = 0.724; CR = 0.851; AVE = 0.538)</i>		
To establish distribution centres	0.728	Fixed
To formulate and implement procedures for efficient product (service handling)	0.732	7.59
To minimize total distribution cost	0.551	7.52
Use advanced logistics technology to update inventory	0.624	7.08
<i>Leadership (CA = 0.799; CR = 0.902; AVE = 0.710)</i>		
Creates and communicates vision towards change in the chain	0.834	Fixed
Collaboration between all other actors of the chain	0.930	10.20
Experience and in-depth understanding of the organization's supply chain	0.803	9.38
Effective human resource skills	0.758	4.87
Adopts a scientific approach towards problem solving	0.737	
<i>Digitization (CA = 0.731; CR = 0.812; AVE = 0.523)</i>		
Modules best practices	0.734	Fixed
Knowledge of supply chain and automation	0.750	6.31
VMI is fully delivered with the support of technology	0.772	6.54
It is very difficult to forecast where the technology in our industry will be in the next two or three years	0.648	5.45
<i>Performance (CA = 0.781; CR = 0.910; AVE = 0.631)</i>		
The time it takes to restock	0.709	Fixed
The ability to handle different requests	0.50	4.30
Sales volume	0.684	6.34
Return on equity	0.744	4.13
<b>Note(s):</b> VMI, vendor managed inventory; CA, Cronbach alpha; CR, composite reliability; AVE, average variance extracted		

**Table 2.**  
Standardized loadings

variables adopted. All items that had loadings lower than the cut-off were deleted as advised by [Hair et al. \(2011\)](#). Also, [Hair et al. \(2020\)](#) recommend that, in SEM analysis, loading of 0.55 or above are acceptable. Four items were deleted due to their inability to meet the minimum loading requirement. The data proved reliable as Cronbach alpha for all constructs exceeded 0.7 indicating internal consistency ([Agyapong et al., 2017](#); [Hair et al., 2011](#)). Additionally, constructs' composite reliability index was 0.7. For the average variance extracted, [Asad et al. \(2016\)](#) advised that a variable with a threshold of 0.50 is okay to be included in the analysis which was attained in the CFA. Common method variance is a source of systematic measurement errors and therefore, threatens the validity of study findings ([Podsakoff et al., 2011](#)). Various approaches can help limit the effect of method bias. Method bias was controlled onset through data collection. [Podsakoff et al. \(2012\)](#) proposed that improving scale items to eliminate ambiguity, balancing positive and negative items, adopting proximal separation between predictor and criterion and reducing social desirability bias in item wording help to reduce method bias termed as the procedural approach.

*Descriptive statistics*

The main variables were all assessed with measurement items based on existing tools by [Dadzie et al. \(2015\)](#), [Panday and Panday \(2018\)](#), [Acquaah and Agyapong \(2015\)](#) and [Agyapong et al. \(2017\)](#). The variables are described here using their minimum and maximum recordings, mean score and standard deviations ([Table 3](#)). Also, univariate normality of data was analysed using Skewness and Kurtosis in SPSS. All items were measured on a five-point Likert scale.

Mean recordings for items used in data analysis showed that all items had average reading between 2.0 and 4.1. Leadership and digitization showed higher mean recordings implying that responding perceive these too as integral in the delivery of their responsibilities. Although these, did not transmute into performance, it can be deduced that their impact is yet to be affected on mining firms that do not have the needed technological requirement and leadership to effectively run their supply chains using vendor managed systems to improve their OP. The skewness of the data was within the recommended threshold of 3.00 as well as the kurtosis which was within 8.00. This demonstrates univariate normality of responses ([Kline, 2011](#)).

*Correlation*

The correlation between variables showed both moderate and weak correlation ([Table 4](#)). The correlation between the main variables under enquiry was moderate but highly significant. VMI had no correlation with the control variable, firm size and had a moderate and significant relation with respondents' experience. This shows that the various constructs used in this study are not strongly related to one another.

Variables	N	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Experience	97	1.00	5.00	2.2474	1.39963	0.733	-0.884
Firm size	97	1.00	3.00	2.4536	0.72199	-0.937	-0.473
Unit Size	97	1.00	5.00	3.0515	1.59015	0.073	-1.609
VMI	97	2.00	5.00	3.8825	0.69267	-0.375	-0.438
Leadership	97	2.50	5.00	4.1211	0.65462	-0.883	0.088
Digitization	97	2.25	5.00	4.1082	0.66625	-0.485	-0.182
Performance	97	2.17	5.00	3.8368	0.64496	-0.616	0.088

**Table 3.**  
Descriptive statistics

**Note(s):** VMI, vendor managed inventory

*Estimating relationships and hypothesis testing*

Using hierarchical multiple regression (HRM), each path estimated the unique effect proposed by the theory after controlling for size of firm, size of unit and employees' experience. The control variables are perceived to affect OP of supply chains. Thus, the size of the firm can affect its capital, expertise, social capital and others that can directly or indirectly affect OP. Also, the number of employees within a specific department could enhance or impede the effectiveness of an organization.

Although, reliability of data has been established through the CFA, HRM additionally presents further reliability assessment. Multicollinearity was measured through the collinearity diagnostics where variance inflation factors (VIFs) were all below 5.0 in the various models performed in the regression analysis (Table 5). Multicollinearity did not reach a critical level because variance inflation factors (VIFs) for all the models were all below 5.0 (Hongyun *et al.*, 2019). The regression results have been reported using the unstandardized coefficients and their resultants *t-values*, VIF and significance indicators and other model fit indices are obtained. Moderation assesses the interaction effect between a predictor and a moderator on a predicting variable. Moderation is then concluded based on the significance of the interaction effect. According to Baron and Kenny's (1981) simple mediation, for a third variable to moderate the relationship between a dependent and an independent variable, it must show that the nature of this relationship changes as the value of the moderating variable changes. Thus, the interaction effect to the model was added. In the first model, the control variables were run against performance. In the second model, the control variables (firm and unit size and employees' experience) and the predictor were run against performance. The

Variables	1	2	3	4	5	6	7
Experience	1						
Firm size	0.125	1					
Unit Size	0.181	0.106	1				
VMI	0.308**	0.004	0.223*	1			
Leadership	0.257**	0.141	0.142	0.406**	1		
Digitization	0.270**	0.162	0.127	0.521**	0.501**	1	
Performance	0.126	0.148	-0.085	0.419**	0.327**	0.568**	1

**Note(s):** VMI, vendor managed inventory  
 \* $p < 0.05$ , \*\* $p < 0.01$

**Table 4.**  
Correlation between variables

Model		Unstandardized coefficients			Sig	VIF
		<i>B</i>	Std. error	<i>t</i>		
1	(Constant)	3.538	0.260	13.612	0.000	
	Experience	0.060	0.048	1.265	0.209	1.046
	Size of firm	0.129	0.091	1.412	0.161	1.023
	Unit size	-0.050	0.042	-1.200	0.233	1.042
2	(Constant)	2.045	0.391	5.231	0.000	
	Experience	0.005	0.045	0.001	0.999	1.137
	Size of firm	0.150	0.082	1.820	0.072	1.026
	Unit size	-0.084	0.038	-2.182	0.032	1.078
	VMI	0.432	0.091	4.768	0.000	1.144

**Note(s):** VMI, vendor managed inventory; VIF, variance inflation factor

**Table 5.**  
Direct effect

third model assessed the effect of the control variables (firm and unit size and employees' experience), the predictor and the first moderator (DIG) on performance. The interaction between VMI and digitization was added in model four. This was repeated in models five and six for leadership (see Table 5).

In model one, the control variables were regressed on the dependent variable, performance. The model result showed that none of the control variable was significant on performance; thus, the firm size, unit size and employees' experience do not have a significant effect on performance thereby affecting the outcome of this study's findings. The overall model caused a variance of 4.8% ( $F = 1.567, p > 0.05$ ) change on performance; however, it was insignificant. In model two, the direct effect of VMI on OP was assessed. When VMI was added, the model showed a significant effect ( $F = 7.142, R < 0.001$ ) on performance. The result proved that the predictor, VMI, positively affects performance ( $\beta = 0.464, t = 4.768, p < 0.01$ ). Thus, for every inventory management adopted OP increased significantly by 43.2%. Hypothesis (H1) is hereby affirmed that VMI significantly affects performance of mining supply chains.

In the third and fourth models, the moderating effect of digitization was assessed. In the initial test that included VMI and leadership, the results showed that the predictor, VMI and digitization positively and significantly affected performance [ $(\beta = 0.233, t = 2.332, p > 0.005)$  and  $(\beta = 0.469, t = 4.765, p < 0.005)$  respectively]. In the fourth model, when the interaction effect was added, the model result showed that the interaction effect was negative and insignificant ( $\beta = -0.100, t = -1.092, p > 0.005$ ). Moderation effect of leadership was assessed in models five and six (Table 6). When VMI and leadership was introduced in the

Model		B	Std. error	t	Sig	VIF
3	(Constant)	1.209	0.393	3.077	0.003	
	Experience	-0.022	0.041	-0.546	0.586	1.152
	Size of firm	0.087	0.075	1.162	0.248	1.058
	Unit size	-0.080	0.034	-2.332	0.022	1.078
	VMI	0.217	0.093	2.332	0.022	1.494
	Digitization	0.454	0.095	4.765	0.000	1.442
4	(Constant)	1.367	0.418	3.268	0.002	
	Experience	-0.006	0.043	-0.130	0.896	1.313
	Size of firm	0.068	0.077	0.880	0.381	1.118
	Unit size	-0.076	0.035	-2.202	0.030	1.091
	VMI	0.197	0.095	2.079	0.040	1.552
	Digitization	0.441	0.096	4.600	0.000	1.464
5	(Constant)	1.626	0.452	3.600	0.001	
	Experience	-0.010	0.045	-0.234	0.816	1.157
	Size of firm	0.130	0.082	1.587	0.116	1.045
	Unit size	-0.086	0.038	-2.256	0.026	1.078
	VMI	0.372	0.096	3.880	0.000	1.307
	Leadership	0.178	0.099	1.792	0.077	1.250
6	(Constant)	1.336	0.505	2.644	0.010	
	Experience	-0.022	0.045	-0.485	0.629	1.207
	Size of firm	0.149	0.083	1.789	0.077	1.079
	Unit size	-0.088	0.038	-2.322	0.022	1.081
	VMI	0.365	0.096	3.817	0.000	1.311
	Leadership	0.242	0.111	2.175	0.032	1.585
	Interaction	0.094	0.075	1.259	0.211	1.352

**Table 6.**  
Indirect effect of  
leadership and  
digitization

**Note(s):** VMI, vendor managed inventory

model, VMI proved positive and significant ( $\beta = 0.399, t = 3.880, p < 0.001$ ); leadership also showed a significant effect on performance ( $\beta = 0.180, t = 1.792, p > 0.005$ ). In the fourth model when the interaction effect was added, the model result showed that the interaction effect was negative and insignificant ( $\beta = 0.131, t = 1.259, p > 0.005$ ). According to [Baron and Kenny \(1981\)](#), for the moderation to occur, the general model ( $R^2$ ) should be significant. Also, the introduction of the interaction effect should result in a significant  $R^2$  change and a significant effect.

In models four and five, with and without the interaction terms between VMI and digitization, the general models were significant [ $F(5, 91) = 11.60, p < 0.001; F(6, 20) = 9.89, p < 0.001$ ]. However, in model five, the interaction between VMI and digitization accounted for insignificantly more change than VMI and digitization individually ( $R^2$  change = 0.008,  $p = 0.278$ ). Similarly, in model six when the interaction between VMI and leadership was introduced, it resulted in an insignificant change ( $R^2$  change = 0.13,  $p = 0.211$ ) although, the general model showed a significant effect [ $F(6, 20) = 5.709, p < 0.001$ ]. The findings failed to approve hypotheses H2 and H3, that leadership and digitization moderate the relationship between VMI and performance of mining firms in Ghana (see [Table 7](#)).

### Discussion

The study found a significant effect of VMI on performance of mining supply chains. This is in tandem with other studies that have put SC strategies to scrutiny ([Obura, 2015; John et al., 2015; Atnafu and Balda, 2018; Mbah et al., 2019](#)). A study by [John et al. \(2015\)](#) found that there is significant impact between effective management of inventory and OP in Nigeria. This study also found that both digitization and leadership failed to moderate the effects of VMI on performance of mining supply chains which refutes studies such as [Magutu et al. \(2015\)](#) who found that technology moderates the relationship between supply chain and performance. Also, [Magutu et al. \(2015\)](#) adds that technology gives a gross moderation effect on SC strategies and performance than directly on performance. Thus, technology may not directly transmute into direct sale or revenue generation but eventually corroborate performance improvement of the firm. However, this is not the case of this study's finding. This finding, however novel, reveals the ineffectiveness of inventory management in collaborating with leadership and digitization. The role of leadership on inventory management cannot be left out in efficiency discussions. Leaders bring improvement and change within an organization which affects organization performance. Digitization is equally the platform or basis on which VMI is implemented and therefore, its presence should effectively enhance the efficiency of VMI in predicting performance.

However, this finding can be defended that there is variation between VMI implementation between developed and developing countries. According to [Shen et al. \(2013\)](#), developed countries tend to have complex and improved form of the technology installations while developing countries are in the early stages of adoption. We, therefore, cannot estimate fully the role of digitization on VMI and the resultant effect on its relationship with performance. Equally, although, leader is expected to be familiar with any organizational change, this study shows that leaders of mining SC chain are still in the

Hypotheses	Decision
H1: VMI-OP	Supported
H2: Leadership (VMI-OP)	Not supported
H3: Digitization (VMI-OP)	Not supported
<b>Note(s):</b> OP, operational performance; VMI, vendor managed inventory	

**Table 7.** Summary of hypotheses

learning process and yet to fully understand and make the needed decisions that will enhance the effect of the strategy on performance. According to Kumar (2008), digitization may not always be true because technology firms are segregated into niche markets that drive their activities. Each sector's advancement is dependent on their innovativeness. The uniqueness of supply chains in Africa is seen as a contingent aid that will transmute into performance through competitive inventory management (Dadzie *et al.*, 2015; Wanyonyi, 2017). This is dependent on its ability to adapt to change. Although, VMI presents an opportunity for firms to enhance their performance, this is subject to their ability to change (Dadzie *et al.*, 2015) which make it complex because other factors such as finance, expertise and resource becomes a concern.

### Theoretical implications

This study makes three key theoretical contributions. The first theoretical contribution of this study lies in the relationship between VMI and OP of mining supply chains in Ghana. This is among the few attempts to examine how to leverage VMI to advance OP in the mining supply chain especially in the Sub-Saharan Africa setting. This study offers a contemporary perspective of contingency configuration theory by examining the nexus between VMI and OP. Knowledge regarding the relationship between firm inventory management and OP is insufficient (Wanyonyi, 2017). Thus, this study offers empirical support to the validation of the contingency configuration theory as it has not been sufficiently tested in the SCM literature. Second, the novel contribution of this study lies in the attempt to validate the moderating role of leadership in the VMI–OP direct link. Though few studies have examined the direct link in developed economies, contingency perspective argues that direct link between two variables may be influenced by other factors. Being the first attempt to unearth the moderating role of leadership in the VMI–OP direct link, this study extends existing knowledge by demonstrating that the link between VMI and OP is bivariate. Hence, VMI does not depend on either leadership or digitization to enhance OP. Finally, this study found that digitization insignificantly moderates the VMI–OP link which is also missing in extant literature. The outcome of the moderating role of digitization in this study presents a contemporary view of how the relationship between VMI and OP can be independent of information technology from the perspective of the Ghanaian mining sector. The outcome contributes to the extant literature on VMI by presenting insights from Ghana, an emerging economy. In summary, the use of digitization and leadership to extend the VMI framework is unique as it has not been explored, especially in the African context. Wanyonyi (2017) proposed that Africa's supply chain is fairly different; capitalizing on resources available ensures its effectiveness. This expunction and operationalizing of the model add to the existing body of knowledge on SCM and subsequently benefit the academic community. The study increases the generalizability of research through the appropriate use of random sampling procedure which provide equal chances of respondents to be selected, making generalization of results more reliable (Creswell, 2015). Also, the application of LISREL (8.5) to test hypotheses in the model in a context that has been minimally used stand to gain significant contribution to the methodology. Similarly, using the moderated relations to determine the conditional effect on the dependent variable (Hair *et al.*, 2017) has been less applied in the mining industry, particularly in the Sub-Saharan Africa context.

### Managerial implications

The study is significant to organizations in general as it puts to light the contemporary inventory management practices that are being adopted by the major companies in the mining industry in Ghana. It will serve as preliminary information on the benefits and

challenges of adopting world-class inventory management technique and may be a starting point for future benchmarking and learning. The study would further promote the development of inventory management in both mining and other sector organizations and management in general. The study offers contemporary guidelines for the government, regulatory authorities, professional bodies and policy makers on how to improve and address gaps in SCM and promote governance and implementation of best practices in inventory management. The outcome of this study offers guidance to aid the mining industry in Ghana and beyond to make informed decisions to improve OP in the mining industry. Specifically, this study has proved the positive and significant effect of VMI on OP of mining supply chains in Ghana; however, leadership and digitization (technological advancement) failed to moderate this relationship. This infers that supply chains of the extractive industry in Ghana have either not yet understood the role of digital resources and leadership in the effective management of SC or has not been fully optimized. Moreover, there is the need to quantify the role of leadership and digital resources in the implementation of VMI. According to the studies by Gitau (2016) and John *et al.* (2015), inventory management affects operational and financial efficiency (Mbah *et al.*, 2019). These aspects of the organization may not directly transmute into profitability but activates performance through VMI adoption.

## Conclusion

This study proposed to investigate the relationship between VMI and OP of mining supply chains in Ghana. The research with the dearth of literature particularly in the Ghanaian contest made this study a challenge onsite. However, the study hypothesized various relationships between VMI and OP that could be established. This study has proved otherwise albeit presented interesting inferences that can influence supply chain strategies and management in the mining sector in Ghana and Africa. The findings showed a direct significant relationship between VMI and OP; however, the moderating role of digitization and leadership were found to be insignificant. This study has made managerial and theoretical implication of the above findings and the necessary research recommendations that will influence the industry development as well as future research. This study proposes that future studies may look into areas such as the variation in VMI adoption in Africa and the developed world and the role of legislation on the implementation of VMI.

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