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Implications of the Internet-of-Things on the components of business models of mining companies

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ABSTRACT

Purpose of study: The Internet-of-Things (IoT) has ramifications for how companies operate. To remain competitive, companies have had to adapt to the exigencies of the business environment, some of which are dictated by the IoT, possibly by modifying their business model (BM). However, specific IoT influences on BM components remain largely unexplored in academic discourse, especially with respect to mining companies in developing economies. This study therefore examines IoT influences on the BM components of mining companies and the resultant modifications to the BM deemed necessary for improved 'IoT-savviness'.

Design/Methodology/Approach: This empirical study utilised a qualitative methodological approach and its target population was South African mining companies. Participants were selected by using a purposive sampling method along with the key-informant technique. Primary data was collected through semi-structured interviews and then subjected to a thematic analysis.

Results/Findings: Findings of this study signal that the IoT has mostly influenced the BM components of key resources, key activities and key partners; aspects that constitute the 'structure' theme of the study. In comparison, IoT's influences are subdued for the other BM components. Consequently, to improve competitiveness, modifications to the BM of mining companies are necessary and should focus predominantly on the aspects of key resources, key activities and key partners.

Managerial implications: Mining companies have to modify key resources, key partners and key activities to improve their competitiveness. Particularly, investments in up-skilling employees, to counteract job losses that may arise from the shift to the use of autonomous mining systems that leverage on the IoT is crucial. Increased transparency and collaboration with key partners, as dictated by the IoT, has to permeate mining operations. Additionally, better integration of mining operations into a 'well-oiled machine' connected through the IoT and utilising data sharing networks will enhance the value propositions of mining companies.

Key phrases

Business model; internet-of-things; mining companies; operations; strategy.

JEL Classification: L72, M10, L20

1. Introduction

The internet, along with interconnected physical objects and devices (known as '*things*') and their virtual representation, has been a growing trend in recent years. This practice has occurred because of the constant pace of change and disruption that makes the adoption of new technologies appealing (Haaker *et al*., 2021). Consequently, the reality of a kaleidoscope of new products and services in different domains, such as in smart businesses, e-health, automations, logistics and environmental monitoring, is foreseeable (Barnaghi *et al.,* 2012). The IoT is actually concerned with interconnected objects that provide anyone, wherever situated, live access to information (Westerlund *et al.*, 2014). In other words, it is the 'blaze' of digitalisation, resulting from the utilisation of a wide range of smart devices that can be bundled together through sensors and networking, that is referred to as the IoT (Leminen *et al.*, 2018). Invariably, this digitalisation process generates opportunities for innovative functionality, improved reliability and business process optimisation (Burmeister *et al.*, 2016). In this way, smart, connected devices have effectively disrupted value chains and have significantly blurred traditional boundaries in businesses (Porter & Heppelmann, 2014). In effect, technological developments have influenced current business models (Pereira & Romero, 2017) because companies have had to adapt in order to capitalise on opportunities that are crystallising with the fourth industrial revolution.

Fleisch *et al.* (2015) assert that the impact of the IoT on the management of businesses is equivalent to the influence of ultrasound devices on medical practice as well as that of the scanning electron microscope on physics. This comparison underlines the influence that IoT has had in businesses and implies that the BM, which provides the necessary framework for the various operations of companies, has inevitably been affected by the IoT. As a result, BM innovation has gained prominence as an effective approach because it delivers sustainable competitive advantage for organisations (Evans *et al.*, 2017). Regardless of this situation, Osterwalder and Pigneur (2010) observe that so called 'disruptive' BMs remain poorly understood, even though they transform competitive landscapes across industries and are emblematic of the current generation. This position is supported by Arnold (2017) who argues that though the influence of the IoT on businesses is immense, there is a paucity of research focusing on the IoT from a management perspective. Indeed, in the specific case of a

developing country such as South Africa and its mining industry, there are barely any studies of this nature, despite the fact that companies within the South African mining industry are critical players in the country's economy (Statistics South Africa, 2019). Against this background, it seemed necessary to locate the current study within the context of South African mining companies in order to seek answers to two questions:

1. How has the IoT influenced components of the BM of mining companies?
2. What specific components of the BM of mining companies require modification in response to the effects of the IoT?

Notably, previous studies on BMs and the IoT have indicated that the areas mainly influenced by IoT are a company's value propositions, infrastructure management and customer relationships (Arnold *et al.*, 2016; Kiel *et al.*, 2017; Metallo *et al.*, 2018). For instance, Metallo *et al.* (2018) found that within automotive and media companies, the IoT has led to changes to key activities, key resources and value propositions. Similarly, Kiel *et al.* (2017) found that in the manufacturing industry, the IoT mainly affected the BM components of value proposition, key resources, key activities and customer relationships. The lack of absolute congruence in these findings signals the possible role that contextual nuances may be playing in the way that IoT influences companies' BM components. Consequently, the exact details of the situation within companies in the mining industry in South Africa remain unknown because these cannot be accurately inferred from the findings of previous studies conducted in different contexts (see Lee, 2017; Hodapp *et al.*, 2019; Leminen *et al.*, 2020; Haaker *et al.*, 2021). Though literature on BMs seems to be gaining traction, the analysis of BMs vis-à-vis the IoT remains grossly inadequate (Burmeister *et al.,* 2016; Suppatvech *et al.*, 2019). This situation has resulted in the call for more studies to be undertaken in order to improve the understanding of the influence of the IoT on BM components (Arnold, 2017) and it this knowledge gap that this study seeks to address. In succinct terms, this study contributes to the scholarly discourse on the IoT from a management perspective, by explicating the influence of the IoT on BM components, as well as the consequential modifications deemed necessary, within mining companies in South Africa, in a bid to enhance understanding of the IoT and BM nexus.

2. Literature review

The first three stages of global industrialisation are mechanisation, electrification and information while 'Industry 4.0' is the term associated with the fourth industrial revolution (Zhou *et al.*, 2015). Industry 4.0, riding on the crest of IoT, involves digital manufacturing, network communication and automation among other aspects which are all based on a high-tech strategy that catalyses technological innovation (Pereira & Romero, 2017). Currently, in many

well-established companies, there is an inclination towards the integrated use of the technologies of intelligent ecosystems (Santos *et al.*, 2017), largely due to the advent of the IoT. According to Vermesan *et al.* (2013), the IoT describes the global information technology (IT) infrastructure, which provides a veritable platform for the seamless integration of the physical and digital world. This infrastructure has the ability to connect sensors and other smart technologies (Langley *et al.*, 2020) for the identification, tracking and monitoring of entities in a way that helps businesses resolve a catalogue of IT and business-related challenges, thereby improving overall company performance (Scuotto *et al.*, 2016).

In the specific case of the mining industry, Gackowiec and Podobińska-Staniec (2019) observe that IoT solutions are being employed by companies to improve process effectiveness which, in turn, enables the realisation of better technical and economic results. Furthermore, the application of the IoT in mining, according to Sishi and Telukdarie (2020) has led to increased visibility of shop floor processes that enhanced quality management and optimised decision-making in real time. Notably, IoT technology is also enabling mining companies achieve cost-effective intelligent machine-monitoring that contributes to worker safety (McNinch *et al.*, 2019). Moreover, evidence of the IoT influence in the mining industry can also be found in environmental sensing and disaster warning mechanisms (Zhou *et al.*, 2017) as well as in safety-helmet systems (Eldemerdash *et al.*, 2020), among others.

All these improvements have been made possible because the IoT utilises technology to enable communication between systems that are connected through networks, thereby allowing the monitoring, co-ordination and integration of operations (Barreto *et al.*, 2017). Therefore, the IoT provides a simulated world of IT that, through virtual representation and accessibility, makes it possible for remote operations with real time data/information to take place (Ng & Wakenshaw, 2017). This practice is likely to be beneficial to companies, possibly including those in South Africa's mining industry. Owing to its effectiveness, Chui *et al.* (2010) argue that the benefits of IoT for companies are immense and some of these advantages are evident in the improvements achieved in internal operations and final products. Juxtaposed against the reality that the IoT can be applied across the entire spectrum of industries (Kim & Kim, 2016), its implications for the manner in which companies operate, as dictated by their BMs, cannot be over-emphasised. Yet, according to Kiel *et al.* (2016), studies on IoT continue to focus mainly on its technical aspects, while ignoring the managerial benefits that may be reflected in BMs. However, the BM concept has enjoyed more extensive usage in scholarly discourse since the start of the new millennium, coincidental with the increasing growth of both the internet and electronic businesses (Günzel & Holm, 2013).

Essentially, a BM prescribes a framework for how the organisation intends to create, deliver and capture value in the course of business (Osterwalder & Pigneur, 2010). Similarly, Dijkman *et al.* (2015) describe a BM as an overview of the way that a company has elected to carry out its entire business operations. According to McGrath (2010), BM decisions are part of the strategic managerial choices that have to be made in order to advance a company's prospects. To this end, an inclination towards experimentation and discovery in the development of BMs may prove useful because the business environment cannot always be accurately predicted. The Business Model Canvas (BMC) is one of the best-known frameworks for the development of BMs in practice (Burmeister *et al.,* 2016). While there are various ways to analyse and present a BM, the BMC is the most extensively used in theory and practice environments (Sun *et al.*, 2012). This is possibly because the BMC is based on a meta-analysis of BM frameworks in literature and it also provides a visual approach that has been proven as useful, even for digital business applications (Dijkman *et al.*, 2015) that are enabled by the IoT. Consequently, the BMC, as shown in Figure 1, is the adopted BM framework of this study and is made up of nine components.

Figure 1: The Business Model Canvas

<table>
<tr><td rowspan="2">Key Partners</td><td>Key activities</td><td rowspan="2">Value proposition</td><td>Customer relationships</td><td rowspan="2">Customer segments</td></tr>
<tr><td>Key resources</td><td>Channels</td></tr>
<tr><td colspan="3">Cost structure</td><td colspan="2">Revenue streams</td></tr>
</table>

Source: Adapted from Osterwalder and Pigneur (2010).

The BMC components of key partners, key activities and key resources indicate what is required to realise a company's value proposition (Osterwalder & Pigneur, 2010) while the value proposition component represents the value, possibly in the form of a product/service or a hybrid of both, that the company seeks to deliver to its target market. The components of customer relationship, channel and customer segments, are collectively related to the customer for whom value is being created by the company (Silva & Maló, 2014; Gierej, 2017). The final two BMC components of cost structure and revenue streams, indicate financial flows originating from the BM (Günzel & Holm, 2013). Previous studies in this field focused on the intersection of IoT and BMs (Silva & Maló, 2014; Dijkman *et al.*, 2015; Bagheri & Movahed, 2016; Kralewski, 2016; Arnold *et al.*, 2017a; Kiel *et al.* 2017; Tesch *et al.*, 2017) have been based on the nine components of the BMC and, therefore, provide a worthy precedence for the current study.

BMs that are well suited to a company's operations and are shaped by new technological possibilities can engender improved competitiveness and overall performance (Langley *et al.,*

2020). This result occurs because, amongst others, BM innovation can serve as an important antecedent for novel products/services (Hossain, 2017). So, BM innovation, which is really about creatively modifying BMs, has become a primary way to differentiate global competitors (Amit & Zott, 2012) and this fact signals that BMs have to be adapted in accordance with environmental exigencies in order for them to remain efficacious. Essentially, BM innovation is concerned with the reconfiguration of some of the components of a company's BM through creative adaptation.

One of the reasons for BM reconfiguration may be the need to adapt to IoT technologies. The IoT lends itself to interconnectedness and real-time availability of data (Brous *et al.*, 2020) and this practice tends to change the nature of the links between business units. Consequently, some intra/inter-business interfaces are obscured by incorporated devices and machine communication, often leading to structural or process reconfigurations, where necessary. The impact of such actions implies that companies have to adjust their entire business strategy, commencing with adapting the methods they use to create, source, manufacture, operate and maintain products, based on IT considerations (Porter & Heppelmann, 2014). Attuning a BM to the IoT allows the company to offer an extended portfolio of products and services (Gerpott & May, 2016) while delivering better outputs that contribute to increased revenue (Kralewski, 2016; Rachinger *et al.*, 2018). In addition, reliance on the IoT for business operations, as dictated by a company's BM, enables the company to strengthen company-customer relationships (Hagberg *et al.*, 2016), improve resource utilisation (Bressanelli *et al.*, 2018) and reduce operating costs (Hasselblatt *et al.*, 2018). Through its effect on business operations, albeit BMs, all of these benefits lend credence to the fact that the IoT exerts a measurable influence on the entire value chain of a company. Against this background, McGrath (2010) opines that the challenge for BM innovation lies in management's ability to recognise threats to BM viability and use all available resources to mobilise for changes.

On this note, it seems obvious that the rise of the IoT has encouraged companies to adopt a philosophy of creating value through service (Breivold & Rizvanovic, 2018). In recognition of this inclination, Arnold *et al.*, (2017b), recommend that the BM should always be approached from a comprehensive perspective, considerate of subsequent changes that may become necessary due to the adjustments being made to particular components of the BM. In acknowledgement of this recommendation, Massa *et al.*, (2017) warn that companies that fail to adapt/develop their BMs may find themselves in disadvantageous positions relative to their competitors that are digitally adept. In essence, companies that do not understand or appreciate the importance and implications of the IoT on their BMs, risk moving too slowly

(O'Halloran & Kvochko, 2015) to respond to emerging opportunities arising from the IoT and this lethargy may not augur well for their overall performance.

3. Methodology

This empirical study has been executed from the philosophical perspective of interpretivism, which is linked to a constructivist epistemological orientation and seeks to understand social phenomena from the subjective experiences of individuals. This mono-method study follows a generic qualitative research approach which is deemed appropriate because, according to Bettis *et al.* (2015), this approach provides the means to identify universally applicable patterns concerning generalizable configurations in management.

The target population of the study included South African mining companies that are part of the 84-members of the Minerals Council South Africa. Further, participating mining companies have, through policy declarations and other practices, signalled that they have recognised the role of the IoT in their business operations. While the participating mining companies were the units of analysis in this study, the units of observation were selected employees of these companies. Ten companies in the cohort of mining companies identified, accepted to participate in the study. Since it was not the intention of the researchers to reach every member of the population, a purposive sampling method based on the key-informant technique was utilised to select individual participants. This technique allowed for information-rich individuals who are knowledgeable about BMs, as well as the role of the IoT in business operations, to participate in the study. In addition, some effort was made to include a variety of companies, considerate of the dimensions of geographical location, minerals being mined and the methods of mining that the companies utilise. This disposition meant that the companies that participated in the study were different with respect to the identified dimensions so that diverse views and experiences could be garnered. Additionally, a major advantage of this selection method, according to Polit and Beck (2010), is that any commonalities identified in the diverse group of study participants, become of significant value within the study's context.

Primary data for the study was collected through face-to-face, semi-structured interviews conducted at the premises of the participating companies. While in accordance with the research plan, only one employee per company was interviewed, one of the companies insisted on having four of their employees partake in the interview session. Consequently, thirteen employees in all, drawn from ten companies, participated in the study. A sample size of six to twelve participants is generally considered as adequate for several types of qualitative research (Rowley 2012; Guest *et al.*, 2013) and so the current study fulfils this requirement.

The study's interest in high-level common themes, rather than the variation range, meant that it was possible to rely on a small sample of participants to reach opinion-saturation. A discussion guide incorporating some of the questions gleaned from the study of Kiel *et al.* (2017) was used for the interviews. Despite the fact that the discussion guide had been previously utilised, it was piloted with employees of a mining company, who were then excluded from the study's final sample. The results of the pilot exercise proved satisfactory and no major changes were made, subsequently, to the discussion guide. The interview questions were open-ended and principally sought to elicit responses related to the influence of the IoT on the BM components as contained in the BMC, along with the particular components that required modifications as dictated by the IoT. All the interviews, each of which ran for approximately 63 minutes, were recorded and the data was subsequently transcribed verbatim.

A template analysis, as a form of a thematic analytical technique, was used to interrogate interview transcripts. Themes, that were expected to be relevant to the analysis, were identified through subject-specific literature (see Dijkman *et al*., 2015; Arnold *et al*., 2017a; Kiel *et al*., 2017). Initial coding was performed by identifying sections relevant to the research questions. Subsequently, 'priori' themes were attached to the questions and a preliminary template was produced. This enabled identified themes to be grouped into higher-order codes, representing main themes in the data. Thereafter, the developed template was applied to the full dataset and used to interpret the opinions shared by participants.

Credibility, transferability, dependability and confirmability are the criteria most often applied to ensure trustworthiness in qualitative research (Polit & Beck, 2010). Credibility in this study was achieved through site triangulation, choosing participants from various companies to reduce the effect of factors specific to a single organisation. The description of the research methodology adopted, together with the use of a proven interview guide, evinces that the study can be transferred and executed in a different context. The study has also been considerate of the criteria of dependability and confirmability given that its findings/recommendations are strictly hinged on the interpretation of data drawn from electronically recorded interviews.

4. Findings

The study's findings, related to the two research questions, provide insights on the influence of IoT on the BMs of the participating companies and the consequent modifications to BMs that are required. The codes, main and sub-themes, used for data analysis are presented in Table 1.

Table 1: Interconnectedness of codes, sub-themes and main themes of the study

Codes	Sub-themes	Main themes
Supplier	Key partners	Structure
Service provider		
Assets	Key resources	
People		
Leadership		
Integration	Key activities	
Transparency		
Agility		
Value added	Value proposition	Value proposition
Communication		
Distribution	Channels	Customer
Buyer	Customer segments	
Customer relationships	Customer relationships	
Revenue	Revenue streams	
Cost	Cost structure	Financial

Source: Authors' own compilation

4.1. The influence of the IoT on BM components

The 'structure' theme comprises the sub-themes of key partners, key activities and key resources as reflected in the BMC. Key partners of companies in the mining industry generally include suppliers, service providers, regulatory establishments, government departments and unions. The study participants opined that the gap between key partners and the mining companies was becoming narrower with increased utilisation of the IoT. According to one of the participants:

"I particularly think that external partners have benefited significantly from the presence of the IoT in our company. This is because in the case of our suppliers, for instance, they can now monitor inventory on critical spares and plan better in order to deliver on time. So, this is beneficial to them as they have become much more relevant and closer to the business, given the ease with which they can now access and analyse copious amounts of valuable information" (P2).

In consonance with the proposition of Breivold and Rizvanovic (2018) that a company's focus should shift to value-from-service, one participant mentioned that mining companies are beginning to subscribe to the concept of 'equipment as a service' that promotes the outsourcing of the provision of equipment for work purposes. While the major reason for outsourcing is generally a lack of requisite expertise/resources within the company, the outsourcing process seems to have been further catalysed by the IoT. In support of this, a participant hinted that one of the key considerations for supplier-selection is the ability to

seamlessly slot into the mining company's existing work systems, almost akin to a 'plug-and-play' algorithm and the IoT often aids this.

The BM component of key activities was identified as one that has been significantly influenced by the IoT. Participants averred that IoT lends itself to increased automation of activities in mining companies and this process necessarily influences the effectiveness of management styles and the pace of integration of activities at any point in time. Within the studied mining companies, therefore, there is a shift from the use of a reactive approach to a proactive approach, for purposes of execution of key activities. Participants suggested that the IoT has removed some redundant activities from schedules thereby 'freeing-up' time for management and employees to focus on other important aspects of the work that need to be performed. According to a participant:

"As a team leader, when I am having a conversation with a member of my team, the thrust of the conversation currently is totally different, compared to what it was five years ago. For instance, I no longer bother about asking what happened as the IoT has enabled me stay abreast of occurrences. Rather, I probe for what the team member has done to improve the situation. It's a different conversation altogether arising from a new kind of mind-set. So there has been a big influence/change in aspects of leadership-related activities." (P9).

In the opinion of the participants, the BM component that has been most impacted by the IoT in the mining industry, is key resources. This element can be broadly decomposed into physical assets and human assets. Participants feel that improved access to information has increased employees' ability to exploit physical assets to maximise return on investment and collaterally minimise operating costs. According to the participants, in practice, the IoT has not required mining companies to procure different (new) assets, but rather, information technology solutions are being acquired as 'add-ons' to equipment currently in use. In the opinion of a participant:

"We don't necessarily procure a lot anymore because we already have most of what is required. However, increasingly we are going out and acquiring technological solutions and also collaborating with other mining companies to leverage strengths and articulate ideas to overcome common challenges, with the use of the IoT." (P4).

With respect to human assets in mining companies, some participants contend that heightened concerns about how the IoT would affect this BM component have impeded the increased adoption of the IoT in the mining industry. Participants noted that IoT influences the well-being of employees through its role in decisions that border on empowerment and disempowerment, resource (re)allocation and job losses. Furthermore, participants argued

that even in the future, the IoT will continue to affect all jobs beyond merely those at operational levels, and this may be why Brous *et al.* (2020) contend that companies will require their employees to have a different set of skills. Instructively, according to participants, the general idea associated with the IoT in the mining industry is that it pivots around automation, which inevitably leads to job losses. With respect to the human assets' aspect of the BM component of key resources, opinions obtained at the interviews signalled that:

"With the IoT, there is certainly a change in the type of people required to do the work. Employees now have to think differently about how they use data to optimise the value chain." (P1).

Additionally:

"What companies require of employees, in terms of skill levels, even at the operators' level has changed; making it imperative to train personnel to use all IoT-inspired provisions in mining equipment. Critically though, the IoT definitely reduces the number of employees required to execute a specific mining operation." (P3).

It is perturbing to note that participants argued that the country is not preparing the next generation's workforce for Industry 4.0 because South African educational institutions have not adjusted their curricula to adequately provide for work-related IoT consequences. Furthermore, participants also opined that there is no palpable and coordinated effort being made to upskill the workforce in their mining companies and this is a matter of grave concern.

As is the case with other businesses, for the mining companies, the value proposition to the customer stems from the company's ability to meet pre-set product/service requirements. In the specific context of mining business, providing the customer with the product they need and expect, on time, reduces the penalties paid for incorrect specification and this fact generally helps the income stream of the company. The preponderant opinion of participants is captured by the declaration that:

"Reliance on the IoT throughout the value chain, has enabled concerned parties determine with precision, what exactly is required by a customer. In our case, sometimes we can actually forewarn the customers about the quality of coal that is to be delivered and this helps the company-client relationship." (P1).

This position highlights one of the ways in which the mining companies are riding on the crest of the wave of the IoT to improve their value proposition to clients. Notably, the companies that participated in the study have very rigid customer requirements that are generally locked-in through fixed long-term contracts. Nevertheless, the degree of work transparency and

speed of communication that crystallise with the recourse to a widespread use of different aspects of the IoT, in the opinion of the participants, enable the mining companies to improve their value proposition, mostly along the efficiency and effectiveness dimensions. Invariably, this improvement heightens the appeal of mining companies' value propositions to their clients. This outcome aligns with the view of Metallo *et al.* (2018) that a major drive in designing IoT-oriented BMs is to anticipate customer needs so as to improve value propositions.

The BM components of customer segments, customer relationships and channels form part of the 'customer' theme of this study. None of the participants indicated that the IoT has had any noticeable influence on their customer segments. With respect to customer relationships, all participants indicated that they either had no direct interaction with the company's end-customer, or that relationships have been based on very little interaction with the end-customer, and this lack of contact weakened their ability to determine the nature and extent of influences that the IoT has had on the BM components in the 'customer' theme of the study. However, this finding does not align with that of Blythe's (2014) study that found that the application of the IoT has enabled companies to continuously discover and, thus, better satisfy customer needs.

The component of 'channels' in the BMC, includes all communication interfaces and distribution channels. Participants conceded that information-sharing has become a necessity for day-to-day mining operations. According to them, communication in general is quicker and information is more accessible and accurate. A participant (P7) opined that distribution channels have not changed as such, but information on work and products in the distribution process now allows for real-time monitoring of the location of products by both suppliers and customers. Further, some of the participants also confirmed that the IoT has enabled better understanding of processes and opportunity areas, among employees. Nevertheless, a few of the participants suggested that there are still many opportunities for improvement in communication and the IoT will play a more significant role in this regard in the future. In the words of one of the study's participants:

"I really think that a critical influence of IoT is that a lot of channels-related processes that were previously manually-driven have now become automated……. for instance, the IoT has made it easier to engage with a lot of people concurrently while empowering companies to react speedily to unfolding events." (P13).

With respect to the 'financials' theme of the study, the only IoT influence mentioned in the interviews, relates to the acquisition of technologies associated with the IoT. The participants argued that IoT technologies come with some ancillary costs that affect the BM. According to

them, subscription fees, upgrade charges and service-support expenses are common examples of these costs. One of the participants observed that:

"With the IoT……what you tend to see, initially, is a cost-jump without an equivalent return on investment, because you just don't get desired results straight away. There is always a lag period before you start reaping some results and even then, the high cost of monthly contracts for supporting services can be concerning." (P2).

Participants suggested that the reality in South Africa is that mining companies are in the embryonic stage of implementing IoT technologies and so they are applying them on an experimental basis. In spite of this situation, there was consensus among the participants that this process has capital investment ramifications. According to a participant:

"I think that it is a difficult thing to actually motivate for a reasonable portion of capital budgets to be allocated for the purpose of the IoT. This is because many of the IoT-matters do not directly contribute to more minerals on the belt. However, companies are becoming more reliant on the IoT as it aids better decision-making." (P11).

Of significant interest is the fact that some participants argued that while it is becoming less burdensome to acquire capital for experimental technologies, technology-adoption would be much faster, with lower prices and enhanced performance of these technologies.

In general, the opinions of the interviewees signal that the IoT in the mining industry mainly influences the BM components under the 'structure' theme of the study. Within the 'structure' theme, the opinions of the participants make it evident that the IoT has a substantial influence on the 'key resources' component of the BMC. Comparatively, study findings reveal that the IoT influences the BM components under the study themes of 'customer', 'financials' and 'value proposition' to a lesser extent. This finding contradicts those of similar studies by Arnold *et al.* (2016) and Kiel *et al.* (2017) which were conducted in different contexts and, consequently, feeds the proposition that there are context-specific factors that may dictate how, and which specific BM components are influenced by the IoT.

4.2. IoT-inspired modifications to BM components

The second research question sought to determine components of the BM that require modifications so as to better position the studied mining companies to take advantage of the IoT. As part of the semi-structured interviews, participants were requested to specify the exact BM components that required modification by their companies to improve IoT-savviness. The components that were identified in each company are shown in Table 2. As reflected in the table, all participants suggested that modifications were imperative for the 'key resources'

component of the BM as part of the effort to improve the potential of their companies to exploit IoT for improved organisational performance.

Furthermore, with respect to other BM components that are deserving of modifications for increased exploitation of the IoT, the majority of the participants identified the 'key activities' component while a few of them pointed to the component of 'key partners'. Interestingly, these results suggest that modifications to components under the 'structure' theme of the study are paramount because only one participant suggested that IoT-inspired modifications should be considered for the 'channels' BM component under the 'customer' theme of the study. Surprisingly, none of the participants indicated that any modifications were necessary for the BM components under the 'value proposition' and 'financial' themes of the study.

Table 2: BM components identified for modification due to the IoT

	Respondents									
BM components	**P1**	**P2**	**P3**	**P4**	**P5**	**P6, P11, P12, P13**	**P7**	**P8**	**P9**	**P10**
Key resources	X	X	X	X	X	X	X	X	X	X
Key activities	X	X	X	X	X	X		X		X
Key partners	X	X					X			X
Channels									X	

Source: Author's own compilation

With respect to the 'structure' theme, for instance, participants suggested that the key resources component of the BM, ought to be modified the most in order to enhance IoT-savviness of the mining companies. Accordingly, there is a need for substantial investment in the training of human resources as well for the acquisition of technologically-current solutions for work purposes. In the opinion of one of the participants:

"I think as it concerns the IoT, our most critical game-changer has to be our resourcing of humans, equipment and ancillary technological solutions. If we do not resource correctly by making adequate provisions now, for what we are going to need in the future, we would fall behind in the business. Certainly, it would be too late to do so in a couple of years' time when we realise that we are grossly deficient in the types and quantities of resources necessary to undertake the mining business operations in the IoT age." (P11).

According to participants, the IoT-inspired modifications to key activities require a shift in the focus of companies, towards value creation, based upon the extraction of information from existing data. Participants confirmed that in the mining companies, IoT-influenced projects related to the installation of a variety of sensors for data gathering and subsequent data storage that were either being considered or are underway. These projects are tantamount to modifications to the 'key activities' component of the BM of the studied companies. The interviews also revealed that another aspect of key activities that is worthy of some modification, is the integration of systems and departments. Indeed, there was consensus among the participants, that in the age of the IoT, the key activities of mining companies should be integrated across the entire operating model and information should be made accessible and visible to all role players. A participant suggested that:

"With the IoT, proper integration of activities will be the 'make it' or 'break it' of the future. There is instant value in this as it lends itself to a business model, which encourages the development of different solutions across the value chain. This is really going to be key, going into the future because of its potential to add much more value to mining processes." (P2).

According to study participants, the typical gap between key partners and the mining companies is being substantially bridged. Most of the study participants contend that this improvement is due to increased outsourcing, which is believed to be an easier and cheaper solution for IoT implementation. Participants observed that outsourcing of aspects of the business owing to the efficacy of the IoT would positively influence intra-company product/process innovation. This opinion perhaps sprouts from a conviction that the act of outsourcing various support aspects of mining operations would enable the company to focus more on its core business, which would be beneficial to all role players. This belief is in alignment with the finding of the study of Rachinger *et al.* (2018) which revealed that the IoT has permitted companies to increasingly add services to existing physical products or solutions. Some of the participants, however, argued that for this process to crystallise, the need for investment and commitment on the part of all key partners cannot be over-emphasised, because such actions are likely to boost innovation and experimentation. The notion of experimentation synchronises with the opinions of all the participants that the use of a 'discovery-driven' approach in the work process will foster increased adoption of the IoT. This view may be because this particular approach is suitable for the uncertain, complex and ever-changing environments (McGrath, 2010), in which mining companies typically operate. According to a participant:

"Cognisant of the fluid environment of mining, our company is now changing its project methodologies to allow for quicker decisions about how and where we spend capital. Crucially,

the company now accepts that sometimes monies and effort spent do not automatically equate to optimal solutions, but nevertheless lessons learnt at every step of the way will take the company and its employees in the right direction, ultimately." (P1).

On a general note, with regard to the necessary modifications that ought to be made to components of the BMs of mining companies, as inspired by the IoT, a participant argued that:

"If we understand our business models, then we should be able to absorb change and redefine the way we do things so as to achieve the desired competitive edge in business. If to the contrary, we are static and insensitive to the changing times, part of which is driven by the IoT, then, it is not good enough. I really think that holistically, mining businesses need to change and become far more adaptive. We certainly don't have to be so restricted in our current ways and certainly, companies that opt to pay little attention to the IoT, are definitely at risk." (P5).

The participant's view is in tandem with the opinion of Jacobs and Webber-Youngman (2017) who assert that mining companies will have to adjust their rigid and iron-clad BMs and practices of old and rather become fluid, flexible and agile companies that are poised to exploit arising opportunities, if they are to remain competitive, going into the future.

5. Conclusion

The first research question of this study sought to determine the influence of the IoT on the components of the BMs of mining companies in South Africa. In this regard, the study found that the BM components of key resources, key partners and key activities that constitute the 'structure' theme of the study are most influenced by the IoT. This finding is in harmony with the results of Kiel's (2017) study on manufacturing companies that also found that the BM components of key partners, key activities and key resources were influenced the most by the IoT. However, contrary to the findings of Kiel (2017), this current study conducted in the context of mining companies, shows that IoT influences on the customer and value proposition components of the BM are negligible.

The second research question sought to determine the modifications to BM components required in the face of the IoT. The study findings indicate that businesses should focus modifications on the BM components of key resources, key partners and key activities to catalyse value creation in the IoT era. This result aligns with the findings of Metallo *et al.* (2018) who also found that the same BM components were most critical in companies operating in the business-to-business markets. This fact essentially implies that the real drivers of value creation in an environment in which the IoT is prevalent are the key resources, key partners and key activities that are categorised under the 'structure' theme of this study. This statement

notwithstanding, a collage of selected opinions of the participants, as it pertains to IoT ramifications for specific components of the BM of the studied mining companies in South Africa, is presented in Figure 2.

Figure 2: A BMC synopsis of participants' views of the IoT ramifications for components of the BMs of mining companies

<table>
<tr>
<td rowspan="2">Key Partners
"The gap between suppliers, service providers and mining companies has been bridged by the IoT."
"Extensive data-sharing has become the new norm, blurring boundaries that contributed to information asymmetries. This has led to quicker service times."
"Our key partners are now much closer to mining operations and have become an integral part of the company."</td>
<td rowspan="2">Key activities
"Routine jobs are starting to disappear; freeing up employees for more innovative endeavours."
"Managers are learning to think proactively instead of reactively, while adjusting management systems to adequately exploit the features of the IoT and become part of the new information-rich mining businesses."</td>
<td rowspan="2">Value proposition
"The IoT has made it easier to utilise data to make better decisions that enhance the company's value proposition."
"Increased accuracy with the description of product properties and other critical circumstances contributes to the overall value proposition of the company."
"The consistency and predictability facilitated by the IoT ensures that products are always according to specifications."</td>
<td>Customer relationships
"The IoT has enabled automated notifications to clients and this is strengthening customer relationships."</td>
<td>Customer segments
"There is no notable IoT influence on our customer segments; this has not changed."</td>
</tr>
<tr>
<td>Channels
"There is more visibility in distribution channels."</td>
<td>Key resources
"There is a need to up-skill employees so that they are able to work with new technologies".
"Machinery currently being used, needs to be replaced and updated with those equipped with current technologies."</td>
</tr>
<tr>
<td colspan="3">Cost structure
"There is increased pressure to make funds available to implement projects that allow for the exploitation of IoT-related leverages."
"Optimisation through the IoT is reducing costs in the company."</td>
<td colspan="2">Revenue streams
"Stability and quality of production, as spin-offs of the astute use of the IoT is enhancing company revenue streams while enabling the avoidance of non-conformance penalties that could arise in the course of the company's operations."</td>
</tr>
</table>

Source: Author's own compilation

6. Theoretical and managerial implications

Extant literature focusing on the study of BM implications of the IoT is sparse and findings of studies that have investigated the intersection of both concepts are inconsistent. Moreover, there is a paucity of studies specifically examining how the IoT has influenced BM components of companies, despite an acknowledgment of the omnipresent nature of the internet through the IoT in contemporary society. From a theoretical perspective, this study, therefore, responds to this deficiency and contributes towards the body of knowledge by improving the understanding of the influence of the IoT on the components of the BMs of mining companies in South Africa. The study's findings provide enriching insights because of the revelation that that there are specific BM components that are influenced more by the IoT and, accordingly, ought to be modified to improve the IoT-savviness of the studied mining companies. While some of the findings of this study corroborate those of earlier research efforts, others are incongruent with them.

The theoretical implication of this outcome is that it amplifies the need for further studies specifically focused on interrogating the nexus of the IoT and BM components to be undertaken. The study's finding that the IoT has scant influence on customer segments, which is in alignment with that of Metallo *et al.* (2018), is curious and worthy of further investigation. This call stems from the fact that anecdotal reasoning would suggest that the IoT might have broadened customer segments, given that it eases access and facilitates interconnectivity with a broad spectrum of customers, even if they are widely dispersed geographically. The finding of an overwhelming influence of the IoT on the BM components that make up the 'structure' theme of the study, which is corroborated by previous studies in other contexts, implies that more scholarly research attention may need to be dedicated specifically to the BM components of key resources, key activities and key partners, in order to enhance scientific appreciation of the role of the IoT in BM reconfiguration across companies.

The dynamism of the environment means that the business of mining has to be agile, emergent and sensitive to an ever-changing business climate with different constraints. The results of this study highlight the importance of transparency and collaboration with key partners in the BM of mining companies, as dictated by the IoT. It is imperative, therefore, for managers of mining companies to recognise that service providers, as partners, will participate more significantly in the business of the company. For instance, the appeal of ideas such as equipment-as-a-service and the purchase of man and machine hours are creating greater value for businesses and increasing the extent to which mining companies are outsourcing different tasks. Further, the study's findings emphasise the need for the integration of mining

operations and services because this process would enable the creation of a 'well-oiled machine' connected through the IoT and leveraging off data sharing networks, to enhance a company's value proposition.

Another managerial implication of the findings of the study is that mining companies should invest in up-skilling employees now, to counteract job losses that may arise from the automation of business processes using IoT, that could result in more autonomous mining systems. This finding resonates with the position of Brous *et al.* (2018) and implies that new skills will be needed, with an emphasis on the use of data analytics for better decision-making. It would seem that going into the future, a competitive advantage might be enjoyed by companies who can create value from all the generated data. The findings of the study signal that IoT applications require substantial levels of capital investment and so companies should budget for equipment replacement and upgrading within the succeeding years, adjusting their cost structures to provide for maintenance costs and subscription fees on all devices and solutions utilised in mining. Finally, it is important to highlight that the IoT should not be considered as merely a 'fad' because the idea of simply leaning towards the IoT, in deference to a bandwagon effect, is unlikely to contribute to value-optimisation in mining companies. Consequently, mining companies should find specific aspects of their BMs through which the IoT will eliminate inefficiencies and present the greatest value, and strictly utilise IoT solutions in those areas.

7. Limitations and directions for future research

As is characteristic with all research endeavours, this study has some limitations. The participants in this study were mostly drawn from the operations sections of medium to large mining companies. This fact could have contributed to the overwhelming opinion that the BM components under the 'structure' theme of the study were the most affected by the IoT and, conversely, that the BM components under the 'customer' theme were scarcely influenced by the IoT. Seemingly, the consistent exposure of the participants to similar operations-related activities shaped their thinking and made them less considerate of the effects that the IoT could have on other BM components, under the study themes of 'financials', 'value proposition' and 'customer'. To overcome this deficiency, it is recommended that future studies should be undertaken with participants drawn from more diverse work groups across disparate companies.

Furthermore, the study relied on a non-probability sample of participants to obtain data for the study. This sampling technique implies that the findings of the current study, therefore, are not generalizable and are inapplicable to a different group of mining companies. Therefore,

future researchers can improve the generalisability of their study findings by using a probability sampling technique to determine the individuals from a defined study population who can participate in the study. Finally, a study that investigates the influence of the IoT on BM components across a supply chain, such that attention is paid to a range of companies that play different roles in the delivery of a product/service, instead of just focusing on similar companies within a single industry, could provide more enriching theoretical and practical insights.

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