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ORIGINAL PAPER

Perceptions of supplier impacts on sustainable development in the mining and minerals sector: a survey analysing opportunities and barriers from an Australian perspective

Turlough F. Guerin[1]

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Abstract
Suppliers have an important role in enabling the mining and minerals industry to achieve their goals for sustainable development and demonstrating corporate responsibility. Barriers that are limiting their business' ability to maximise the contribution of suppliers to business outcomes were a limited understanding of their client's business' (by suppliers), insufficient time, and resources to dedicate to managing suppliers effectively (from the mining company's perspective), and preferred vendor status. When mining companies had successfully engaged with suppliers, the supplier understood the needs of the business and tailored its approach accordingly. The supplier could demonstrate how its own commitment to environmental management and sustainable development would benefit the mining operation so understood the needs of their client. The supplier created value for the mining operation by reducing costs and providing an improved solution (compared with existing solutions). The supplier also knew the life-cycle impacts of its own goods and/or services on the mining operation's business. Recommendations for future research would be in understanding application of blockchain and other technologies to streamline the transactions between suppliers and mining companies. They also could include harnessing the capabilities of suppliers to de-risk supply chains in terms of modern slavery, increasing the efficiency of their supply chains (i.e. reduce time, cost, maintaining quality), and eliminating waste in the broadest sense across mining operations.

Keywords Suppliers · Supply chain · Sustainable development · Barriers · Adoption · Survey · Australia · Survey · Minerals processing

JEL classification L70

Introduction

As companies compete for market share, they are increasingly focussing on their core competencies to become customer-centric. This involves, among many other elements of a business transformation, reducing costs, which inevitably involves looking to the supply chain to increase efficiencies and enhance the value created. Companies in all sectors of industry are increasingly being required by their stakeholder groups to state where their raw materials are coming from, and take action over and above this recognition and disclosure, to influence the supply chain to improve business as well as environmental and social performance (Martins and Pato 2019). Mining companies, which are the origin of many of the materials that we use day to day, are and will increasingly come under scrutiny to manage their suppliers and supply chains at the highest levels of performance to meet triple bottom line objectives.

Strategic supply chain management has been recognised in the business and management literature for many years as a critical element of any business planning process. However, it is only in the past two to three decades that environmental and social performance has been recognised, alongside financial, to be of strategic importance in the supply chain (Anonymous 1997; Anonymous 1999; Baatartogtokh et al. 2018;

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✉ Turlough F. Guerin
AustSecretary@bioregional.com; turlough.guerin@hotmail.com

[1] Bioregional Australia Foundation, Melbourne, Victoria 3001, Australia

Christensen 2002; Fiksel 1995; Hagelaar et al. 2004; Lamming and Hampson 1996; Lloyd 1994; Lutz 2005; Mehta 1994; Tyler 1997).

Retailers and manufacturers, particularly in the automotive and electronics industries, have been leading progress in the greening of supply chains (Anonymous 1997; Anonymous 1999; Barton 2006; Christensen 2002; Ellinor 2007; Eskew 1999; Lamming and Hampson 1996; Lutz 2005; Rao and Holt 2005; Ryu and Eyuboglu 2007; Simpson et al. 2007). Business's awareness of cleaner production (or eco-efficiency) and its uptake has helped drive this change (Altham and Guerin 2005). However, there are fewer published studies that explicitly describe the role of suppliers to the mining and minerals processing industry in enhancing sustainable development in its supply chain (Bubicz et al. 2019; Enever and Robertson 1998; Guerin 2006b; Guerin et al. 2004; Martins and Pato 2019; Moktadir et al. 2019; Ntabe et al. 2015; Robinson et al. 1995).

As illustrated in a survey of Canadian-owned mining companies (Baatartogtokh et al. 2018), outsourcing has evolved from a cost cutting strategy (vanilla outsourcing) through to late twentieth century "strategic outsourcing" of activities for which a company has neither a critical need nor special capabilities, to the present day "transformational outsourcing" which is about creating a flexible and adaptive organisation consisting of loosely coupled networks of suppliers. These researchers go on to postulate that there is the possibility that the mining industry could undergo "extreme outsourcing" where "all the productive and economic processes have been outsourced through the formation of a stable but flexible network" of suppliers (Baatartogtokh et al. 2018). They concluded that in their survey, the majority of miners where undertaking strategic outsourcing, lagging behind other sectors that have embraced more progressing approaches to supplier engagement.

Purpose and scope

This paper describes ways in which suppliers to the mining and minerals processing industry can support its move towards sustainable development with a short literature review and survey. It describes the perceived barriers within mining companies to harnessing the opportunities presented by their suppliers, and how these barriers may be overcome. Specifically, it was anticipated that the survey, the first empirical study of its kind addressing barriers to sustainable development, would generate data and anecdotal evidence that suppliers do contribute to the sustainable development of the minerals supply chain, as well as how they make this contribution.

Literature review

Definition of sustainable development

A challenge for mining companies is defining what sustainable development means at an operational level (Azapagic 2004; Guerin 2000; Guerin 2005; Guerin et al. 2004). This includes the extent to which the minerals value chain is included within the scope of a mining and minerals processing business, and therefore to what extent suppliers are "within scope". There are many stakeholders for any one mining operation, and also numerous approaches available to a mining operation for assessing the impact of suppliers, one of their major stakeholder groups.

More recently, the concept of weak sustainability (human capital substitute natural capital) and strong sustainability (build-up of human capital is not completely interchangeable with, but limited by natural capital) has been reviewed and discussed in the literature (Tost et al. 2018). These authors go on to state that the mining sector is at risk of falling behind societal expectations on climate change and behind the leaders from other peer group industries on natural capital (biodiversity) considerations, hence the need for a greater focus on "strong sustainability". The mining industry can improve by considering the Paris Agreement in its approach to climate change, considering natural capital as an industry e.g. through working with the Natural Capital Coalition, and more broadly by pro-actively thinking about what the consequences of "strong sustainability" would mean for their business models (Tost et al. 2018). They concluded that almost all companies use definitions based on the three pillar (or triple bottom line) model and a "weak sustainability" position.

In the context of this survey, sustainable development is defined in relation to the wider business impacts of mining within the mining and minerals processing supply chain. Sustainable development, should, by its implication, encompass impacts throughout the supply chain both from a product and an input perspective (Monteiro et al. 2019; Ntabe et al. 2015). As referred to previously, this has not been extensively studied in the literature. An explanation for this is the emphasis on the direct impacts of the mining industry, which are material in and of itself, even without considering the wider supply chain impacts. As the focus on the triple bottom line performance of mining and minerals processing companies improves, it could be expected that there will be a refocus of attention on the inputs into the industry. This survey focuses on this input side of the supply chain.

Sustainable development, in this paper, is based on the triple bottom line, or the "weak sustianbility" which refers to the approach of measuring the success of an organisation's activities according to its social and environmental performance in addition to the traditional financial performance. On the economic dimension, an increasingly competitive, global market

imposes strong pressure over costs, productivity, and delivered value. On the environmental dimension, mining ventures must deal with ever-stricter requirements involving the efficient consumption of energy, water and natural resources, the reduction of carbon emissions and process wastes, and effective land rehabilitation upon closure. On the societal dimension, although mining projects are, by definition, temporary ventures, the economic impact they generate should be able to induce long-term sustainable social development for the communities along the value chain. In fact, by often being located in remote areas, mining can provide a unique means for stimulating significant economic development. However, local cultural and environmental implications can result in major socioeconomic challenges and successful mining and minerals processing companies are doing this internationally, such as the recent study in Chile (Bravo-Ortega and Muñoz 2018), and in Australia (Guerin 2006a; Guerin 2006b). In their recent literature review, Que et al. (2018) highlight that while mineral products provide essential fuels and raw materials for industrialisation and in our daily life, their influences on other aspects of life need to be taken into consideration. These authors point out that while the whole world benefits from mining's contributions, most of the resulting detrimental impacts on the environment and society fall on the local communities in which mining occurs. The participation of the local community is one solution to decrease the risks from community-related problems, and subsequently, they claim the requirements of mining sustainable development can be met (Que et al. 2018). While the theory of mine owners and local communities being engaged in any new mining project, the practise of finding the balance is considerably more challenging.

The working definition of sustainable development in a resources and extractive industries context is framed in the concept of stewardship. Stewardship is to hold something in trust for another (Block 1996). This concept has been embedded in the mining industry's approach to sustainable development since the Bruntland Report (WCED 1987). So sustainable development, in this context, is implementing the industry's commitment to taking direct responsibility for its production, including inputs and processes, and a shared responsibility with customers, suppliers, and end users to ensure that all outputs are produced, consumed, and disposed of (or repurposed) in an environmentally and socially responsible way. Stewardship, which is a core principle of sustainable development, has become part of the language of the industry, in particular, in the mining companies themselves. Suppliers can therefore contribute to the stewardship displayed by a mining company or it can hinder it.

High level drivers for sustainable development in mining

Globally, sustainable development principles relevant to the mining industry were adopted by the International Council for Mining and Metallurgy (ICMM) in May 2003. ICMM member companies, which include the world's largest mining and minerals processing companies, have pledged to report on their progress in implementing these principles, and these are being adopted internationally (Table 1).

In Australia, the Minerals Council of Australia (MCA) has developed a framework for sustainable development for member companies, which is based on these principles. The MCA's framework, which is called Enduring Value, was first released in October 2004. This framework recognises the role that suppliers play in the transition of mining companies to a sustainable future (Anonymous 2008). This framework has undergone revision and was re-issued in 2015 (Table 2). Three of the elements of this framework focus explicitly on how mining and minerals processing companies who commit to the framework (referred to as Signatories) are to work with suppliers.

In terms of the UN SDGs (sustainable development goals), unlike many other sectors, there is no primary point of connection between mining and one single SDG. Instead, mining operations have the potential to contribute to several different SDGs at any one time. This is due to the multifaceted impacts (both positive and negative) that companies and operations can have on communities, ecosystems, and economies. Coupled with the fundamental importance of metals and minerals to modern life, the influence of mining on all of the SDGs becomes apparent (Monteiro et al. 2019; UNDP 2016). The mining industry can impact positively and negatively across the SDGs. Mining can foster economic development by providing opportunities for decent employment, business development, increased revenues, and infrastructure linkages. Many of the minerals produced by mining are also essential building blocks to technologies, infrastructure, energy and agriculture (UNDP 2016). However, mining has contributed to many of the challenges that the SDGs are trying to address including environmental degradation, displacement of populations, worsening economic and social inequality, armed conflicts, gender-based violence, tax evasion and corruption, increased risk for many health problems, and the violation of human rights. The industry has made significant advances in mitigating and managing such impacts and risks, by improving how companies manage their environmental and social impacts, protect the health of their workers, achieve energy efficiencies, report on financial flows, and respect and support human rights (UNDP 2016).

There are also links between the ICMM 10 Principles and the SDGs (Endl et al. 2019) many of which have relevance to suppliers. Each of the 17 SDGs in some way connect with or can be directly influenced by the work of ICMM, and these have been mapped to the ICMM 10 Principles against the SDGs to gain a better understanding of where the mining sector can best add value and support universal progress towards sustainable development. Suppliers can cut across all

Table 1 International guiding principles of sustainable development in the mining and minerals processing industry directly relevant to the supply chain

Organisation	Principles and/or signatory commitments	Source
The International Council on Mining and Minerals (ICMM)	ICMM has developed and published ten principles in relation to sustainable development in the mining and minerals processing industry. The following sub-set of seven principles have relevance to improving environmental performance in the supply chain: • Implement/maintain ethical business practises and sound systems of corporate governance. • Integrate sustainable development considerations within the corporate decision-making process. • Implement risk management strategies based on valid data and sound science. • Seek continual improvement of environmental performance. • Facilitate/encourage responsible product design, use, re--use, recycling, and disposal of products. • Contribute to the social, economic, and institutional development of the communities in which the industry operates. • Implement effective and transparent engagement, communication, and independently verified reporting arrangements with stakeholders.	www.icmm.com
The Global Mining Initiative (GMI)	The GMI has set out the following principles from the Mining Minerals and Sustainable Development (MMSD) study: • Minimise waste and environmental damage along the whole of the supply chain. • Ensure transparency through providing all stakeholders with access to relevant and accurate information.	www.iied.org

these SDG areas, as does the mining sector itself. While the SDGs identify 16 distinct goals for sustainable development, and a seventeenth that encourages partnership approaches, in practise, the goals are strongly interrelated. Poverty alleviation will, to varying degrees, touch on the goals of decent work and economic growth (SDG8), quality education (SDG4), good health and well-being (SDG3), and gender equality (SDG5). Similarly, progress to conserve biodiversity (the focus of SDG15, life on land) will not be possible without complementary action on food security (SDG2), climate change (SDG13), improved stewardship of water (SDG6), stronger institutions (SDG16), and progress on sustainable consumption and production (SDG12) (Monteiro et al. 2019). SDG17 is therefore of key relevance in terms of the role of suppliers in achieving more sustainable mining outcomes.

Importance of the Australian mining sector

Australia is a major player in the global mining industry. The expansion of the industry over the past two decades has led to a large investment to support this growth, particularly in Western Australia, the nation's richest source of minerals. The flow-on effect from this expansion has been widespread across the Australian economy and society, with large increases in wages (in the mining sector) and house prices in Western Australia. In 2006/7, mining contributed to 8% of Australia's GDP, employed 127,500 people directly, and 200,000 people indirectly (including suppliers). It also represented 26% of Australia's total capital investment, and contributed exports totalling A$91.3 Bn. Suppliers have been major stakeholders in and beneficiaries of this industry's wealth, and therefore have had an important role in influencing and shaping the Australian industry's transition to sustainable development. In 2018/19, the proportion of national GDP provided by mining had increased to 10% since 2006/07, and to 251,000 people employed directly. One recent announcement states that during the financial year 2019/20, mining's total contribution to Australia's GDP will be as high as 35% (Canavan 2019).

With this high level of economic and social importance also comes a great responsibility for the environment if this sector is to remain as a core pillar of the economy and society in future generations. In particular, mining in Australia is a large user of water and with much of Australia facing drought conditions, the mining sector is seen to be benefiting in an unequal manner, compared with environmental, agricultural, or community uses of water. The sector is also a large emitter of carbon emissions and in particular the coal sector is

Table 2 The Australian adaptation and development of guiding principles of sustainable development in the mining and minerals processing industry directly relevant to the supply chain[a]

Minerals Council of Australia (MCA) *Enduring Value* Framework–Overview	*Enduring Value* will apply to all exploration, mining and minerals processing activities of Signatories, wherever they operate. It will also apply to the relevant activities of contractors engaged by the Signatories to undertake such activities. In addition, signatory companies will strongly encourage application of *Enduring Value* to operations in which they hold a non-controlling interest and to other supply chain partnerships. When referring to *Enduring Value*, Signatories will be transparent in identifying those aspects of their business that are covered by their Signature. For mining companies, this may entail identifying relevant operations. Commitment to *Enduring Value* brings with it a number of obligations. In summary, these are: • Progressive implementation of the International Council on Mining and Metals (ICMM) Principles and Elements; • Public reporting of site level performance, on a minimum annual basis, with reporting metrics self-selected from the Global Reporting Initiative (GRI), the GRI Mining and Metals Sector Supplement, or self-developed; and • Assessment of the systems used to manage key operational risks (using either internal or external assessment as appropriate).
Minerals Council of Australia (MCA) Enduring Value Framework–Implementation Guidance for Element 2.4	Element 2.4: "Encourage customers, business partners and suppliers of goods and services to adopt principles and practises that are comparable to our own". • Implement a procurement policy that includes sustainable development performance outcomes in key contracts; • Promote product stewardship initiatives throughout the supply chain through partnerships with contractors, suppliers, and customers; • Encourage customers, contractors, suppliers, and business partners to adopt sustainable development policies and practises; • Establish "suppliers of choice" which include sustainable development criteria, s uch as the role of local employment, service, and supply to foster local economies.
Minerals Council of Australia (MCA) Enduring Value Framework–Implementation Guidance for Element 5.1	Element 5.1: "Implement a management system focused on continual improvement of all aspects of operations that could have a significant impact on the health and safety of our own employees, those of contractors, and communities where we operate". Implement an occupational and community health management system consistent with recognised quality standards that includes: • Control of hazards/risks of activities, products, and services over which the organisation has control, including the activities, products, and services of contractors and suppliers; • Identified management structures, responsibilities, resources, training, awareness, and competencies; • A communication system that includes employees and other interested parties, and provides for the relevant and timely reporting of performance; • Involve employees and other relevant stakeholders in auditing management systems and in management reviews.
Minerals Council of Australia (MCA) Enduring Value Framework–Implementation Guidance for Element 8.2	Element 8.2: "Conduct or support research and innovation that promotes the use of products and technologies that are safe and efficient in their use of energy, natural resources, and other materials". • Where appropriate support research to improve eco-efficiency of production processes and products; • Review and innovate to reduce waste through cleaner production processes recycling and re-use of materials; • Review usage and innovate to improve efficiency in the use of energy and water; • Take other users' present and future requirements into account, including air and water quality and environmental flows of water; • Involve suppliers in identifying opportunities to reduce energy consumption or use renewable sources to reduce production of greenhouse gases and other emissions; • Where feasible, collaborate in industrial ecology activities to develop synergies in resource usage.

[a] These were obtained from the Enduring Value framework documents available at www.minerals.org.au

increasingly being put under pressure to transition away from coal exporting, and to invest in new areas to enable a just transition to lower carbon emissions activities.

Suppliers play a key role in this prosperity and carry a similar responsibility and shared liability (for risks).

Method

Survey rationale

A survey was conducted of the Australian mining industry to identify views, opinions, and examples of the types of suppliers providing products and services to the mining industry. The purposes of the survey were to investigate what mining companies perceive the role of suppliers to be in their supply chain, and to identify any barriers that suppliers should be aware of that could negatively affect the role that they play. It was also conducted to understand the potential leverage that exists among suppliers to help meet its own objectives for environmental performance, and to work towards sustainable development goals.

Survey method

A series of questions were developed based on the author's first-hand experience working with suppliers to the mineral's industry, as well as a senior sustainable development professional in the mining and resource construction sector directly. A series of questions with Likert-style (multiple choice) answer options were provided to several colleagues and other industry experts known to the author, for peer review prior to making survey available to potential respondents. Open-ended questions were also asked. Details of the survey method and descriptive statistics are provided in Table 3.

Results

Descriptive statistics

The overall survey response rate was 50%. The response rates from individual Likert-scale questions varied from as low as 40% to up to 95%, and for the open ended response, 23%. The number of respondents conducting the survey were relatively low at 22, they did represent a wide range of professionals, mining subsectors, and mineral types. Given these limitations, care has been taken in extrapolating the findings of the survey too far, nevertheless, the results offer insights into the mining sector and the perceptions of important suppliers to the sector.

Recognition and expectations of suppliers

Energy, equipment, and telecommunications were, not surprisingly, the most important supplied products and services to the mining industry (Fig. 1), representing 69, 65, and 63% of respondents, respectively. The majority of respondents identified these supplier groups as extremely important to their mining businesses. This response provides insights into the relative importance of various supplier types for the mining sector in Australia. Further findings revealed interesting results on the importance of suppliers. The majority of mining companies indicated that it was important for its suppliers to provide goods and/or services on time where they are required at competitive prices and that suppliers understand their mining businesses (Fig. 1).

When mining company respondents were asked how they would rate those barriers that are currently limiting their business' ability to maximise the contribution of suppliers to business outcomes, they indicated it was a limited understanding of their client's business', and insufficient time and resources to dedicate to managing suppliers effectively (from the mining company's perspective). Preferred vendor status was also given as a reason. These can work well, although less so when prices start to increase (without corresponding value increase). Such programmes can also promote the status quo and limit innovation (such as increasing environmental and social performance) in contracts.

Furthermore, respondents indicated that an important action a supplier could take to improve a mining company's drive or shift towards a more sustainable future was demonstrating the supplier's own commitment in these areas. These are described in Fig. 2 and the open-ended responses were provided in Table 4.

These findings reflect the largely cultural issues of maximising the value obtained from supplier relationships and in particular resistance to change. These findings underscore the importance of effective relationships between suppliers and mining companies such that there is fruitful exchange of ideas, innovations, and relevant information to address problems or to identify opportunities for improvement.

These findings also show the high expectations that mining operations have of their suppliers, and they provide useful guidance for suppliers aspiring to work for the mining industry. These characteristics provide useful criteria for how to select suppliers or supply chain partners. They are aspirational attributes for any supplier to the minerals industry.

Suppliers' role and sustainable development

Suppliers have traditionally been viewed as integral to the normal operation of mining companies (Enever and Robertson 1998). With the advent of heightened stakeholder awareness of environmental and social impacts of a mine, the

Table 3 Details of survey and summary statistics

Attribute	Description
Sample selection	Twenty two (22) professionals in the Australian mining industry and their suppliers, were surveyed using an online survey delivery programme. Although sample size was relatively small, the major industry sectors were represented in the survey and included diversified mining and minerals processing companies, metal producers, exploration, and energy supply companies (51% of respondents).
Business' size	A range of mining businesses (in terms of production output) were included in the sample from < 2 to > 50 Mt. Although the study was confidential and all data were aggregated, the study asked for the respondents' contact details for reference purposes and for future contact to obtain additional information. The details requested included name of respondent, name of employer, department and position, and phone number for future contact. Response was not necessary or required for these questions.
Sector representation	The majority of the respondents (65%) were mining and minerals processing and consulting companies. The majority of mineral classes were included in the sample. Suppliers and other support organisations to the mining sector were also represented.
Roles of respondents	The majority of individual roles represented were consultants, contracting and procurement, and community engagement staff. Other respondents included researchers, academics, government organisations, and suppliers to the mining and minerals processing companies.
Survey questions	Twenty three (23) in total. These addressed current suppliers used, barriers to them enabling the respondents to engage in sustainable development, how the barriers to more meaningful engagement [with their suppliers] could be overcome.
Survey administration	The twenty two professionals in the Australian mining industry and their suppliers were surveyed using an online survey delivery programme. The survey was sent to 50 professionals in the mining and minerals sector working Australia thereby giving a response rate of just under 50%. The responses for individual questions varied from 8 to 21 where there were Likert-style/multiple choice answers available. Open ended questions had the lowest responses rates with some receiving less than 5 responses out of the possible 22.

role of suppliers is coming into sharper focus as an important contributor to both a mine's liability and opportunity for contributing to sustainable development. There are several specific drivers emerging both from within and external to the mining industry, which are influencing suppliers to recognise and embrace their role in assisting the minerals

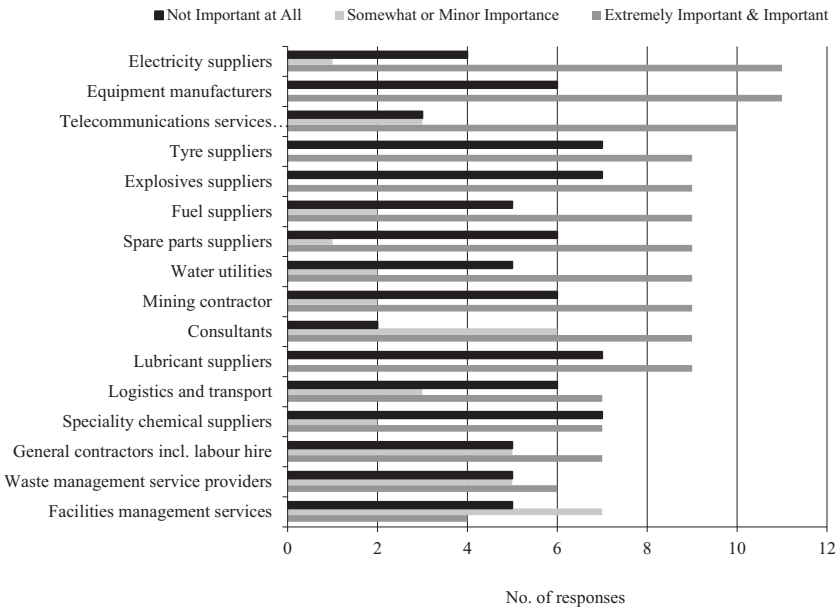

Fig. 1 Importance of supplier types to the normal running of business

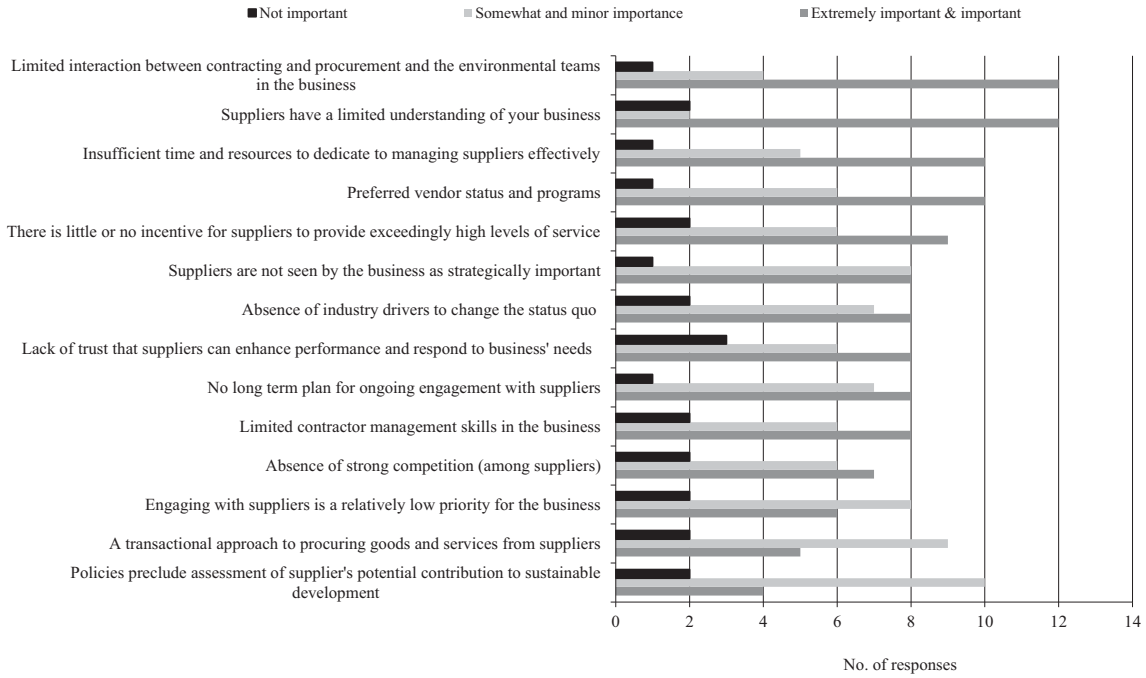

Fig. 2 Barriers to maximising suppliers' influence

industry to work towards sustainable development (Blowfield 2000; Enever and Robertson 1998; Halme et al. 2007). These include the following:

- Formal recognition by the industry of a supplier's role in assisting mining companies in working towards sustainable development (e.g. ICMM Principles, and MCA Framework for Sustainable Development (Tables 1 and 2);
- Enhanced recognition by the industry that extended producer responsibility applies to products supplied to industry as raw materials, as well as the mineral products purchased as a result of mining (i.e. product stewardship);
- The business need for suppliers themselves to be more competitive. This is driving product and service differentiation in the mining industry marketplace through social, environmental, and financial performance;
- Recognition by responsible corporations, including both suppliers and mining companies, that their activities, products, and services interact with and affect the broader environment and the communities in which they do business; and
- The business needs of the mining industry to identify materially important eco-efficiency gains across their business and their recognition that suppliers can help drive these types of improvements.

Table 4 Open responses to the most important action that a supplier to your business could do to improve your organisation's commitment and transition to more sustainable development

Improve their own sustainability performance
Understand the business of their customers
Make sustainable development part of the selling proposition and ensure the proposition is cast at the customer audience as they may not be experts in the field
Provide products that are: energy efficient, have a limited impact on the environment, and are socially responsible
Be proactive in promoting to customers the sustainability aspects of their products and services as awareness is a key issue
Demonstrate their commitment to customers and an understanding and alignment with customer's needs and aspirations.

There are two main mechanisms by which suppliers can affect a mining customer's operations. These are through indirect or direct supply chain leverage. Indirect mechanisms include engaging with industry groups (common to supplier and customer) to assist in moving the entire industry forward, such as by development of industry and professional standards, frameworks, or codes of practise, and direct mechanisms through the supplier's unique understanding of their product and/or service, their life-cycle, and nature of risks and opportunities in relation to their customer's business. Suppliers can enable adoption of innovations in the mining sector because of their unique position and influence (Gruenhagen and Parker 2020).

There are numerous suppliers for any mining company or mining operation. These include product, service, and people suppliers covering every aspect of the minerals value chain.

Table 5 provides examples of generic supplier groups, suppliers active in the industry, and the types of products and services they can provide. Table 5 also provides a description of the niche leverage that each supplier grouping can exert in support of their mining customer's sustainable development performance.

In a recent Canadian study on outsourcing in the mining sector (Baatartogtokh et al. 2018), although not focused on sustainable development as a driver, it illustrated what the perceived needs of outsourcing were and included access to specialised competencies, including skilled labour, flexibility (of operations), which includes adapting to seasonality, changes in geology and commodity prices and short-term needs and life of mine, avoiding investment in fixed assets as a significant reason for outsourcing.

Barriers to optimising the contribution of suppliers

While there is a willingness of suppliers to work with mining companies to drive innovation in the sector, there are barriers

Table 5 Role of suppliers in influencing environmental performance of the mining value chain

Supplier's industry	Services or product provided	Niche value-add to mining customer	Example of supplier[a]
Electricity supplier	Electricity (and commonly natural gas) supply	Provide carbon-offset programmes for customers; renewable energy offerings	Origin Energy; AGL (in Australia)
Explosives	Explosives and related services	Technologies to increase blast efficiency and reduce environmental impacts; provide expertise in engaging with and managing neighbour relationship	Orica, Akzo Nobel
Facility managers	Building and facility management	Identify and incorporate environment-related key performance indicators into mining contracts; identify and drive initiatives to reduce water and energy use	Transfield, Spotless and United Group Services (UGS) (all operating in Australia)
Fuel supplier	Fuel supply, distribution, and related services	Provide biofuels, carbon-offset fuels, and low particulate/low emissions fuels; advice on fuel efficient driving	Shell, BP, ExxonMobil, Caltex
Labour hire	Temporary staff hire services	Providing staff with environmental skills, awareness training programmes for staff	Skilled Group (Australia); local indigenous labour hirers
Lubricant supplier	Lubricant supply, distribution, and related services	Biodegradable lubricants alternatives; advice and services on lubricant life extension; life-cycle management of lubricants	Fuchs, Shell, Castrol
Mining contractors	Mining operations services	Identify and incorporate environment-related key performance indicators into mining contracts	Thiess (Global); Downer
Telecommunications	Voice, data, Internet access, dedicated networks for mining operations	Travel substitution such as high definition video conferencing; telemetry solutions for remote real-time monitoring	Telstra, Bell Canada, Vodaphone, Verizon
Waste management contractors	Total waste management services	Identify and incorporate environment-related key performance indicators into mining contracts; advice to mine on waste prevention strategies; implement and drive waste reduction initiatives across the mine	Thiess; Veolia; Transpacific Industries (Asia Pacific region)

[a] Providing of a supplier's name does not imply that they provide the niche value-added services, or that it is being endorsed by the author

to be overcome. There are technical barriers to implementing supplier-driven environmental improvements in the mining supply chain. However, the most difficult barriers are those relating to changing culture in both the supplier and mining customer businesses. In a previous publication, the author has identified barriers to adopting technologies for enabling sustainable development across a range of sectors, so non-adoption is not unusual and should be expected, particularly in a conservative business sector such as mining and minerals (Guerin 2001).

The current survey explored the major barriers identified to maximising the role of suppliers in, and leveraging their contribution and influence to, enhancing a mining company's strategy for working towards sustainable development (Fig. 2). As illustrated in the survey findings, there is little or no incentive for suppliers to provide exceedingly high levels of service, and there is insufficient time and resources to dedicate to managing suppliers effectively, to further involve suppliers in the achievement of more sustainable mining practises.

Overcoming barriers to supplier engagement

Another major finding identified from the survey was the barriers that limited mining companies from further engaging with their suppliers (Fig. 3). These were a lack of time (for this particular activity), absence of commitment from senior mine management to such engagement, uncertainty of outcomes from such engagement, and a lack of interest from suppliers to such an engagement. Other barriers include the perceived increase in cost from such engagement, and that such engagement is unusual (i.e. not standard business practise or part of management culture) for mining operations.

Reasons for future ongoing engagement

When mining companies were asked to rate each of a series of statements in relation to the importance of engaging with the suppliers involved, their ranking gave insights as to what aspects of the supplier relationship were most valued, it was when suppliers understood their mining businesses and suppliers could demonstrate their own commitment to sustainable development (Fig. 4). These results were consistent with the author's own perspective on the importance of advisors and consultants understanding their client businesses if they are to add value (Guerin 2018).

There are other barriers that will limit the implementation of services and products that represent value from suppliers. The lack of an understanding by suppliers that their long-term commitment to a mining operation is critical. Such commitment will require ongoing relationship management and a 2-way commitment to improve the value provided back to the supplier and through to the mining operation. Further open responses are detailed in the Supplementary Material.

The challenge is for the supplier to remain engaged and not lose margin (EBITDA or profit), while contributing social and environmental benefits. This is an important dispute or tension between the single and triple bottom line. To meet this challenge, suppliers require a clear and compelling offering (or value proposition) that is attractive to mining companies, who in turn can recognise the value the suppliers will add to their mining operations, that is, in terms of costs reduced or other tangible benefits, in addition to the social and environmental advantage over an otherwise comparable service or product.

Also the perceived benefits of stakeholder engagement along the supplied product life-cycle can be intangible, with

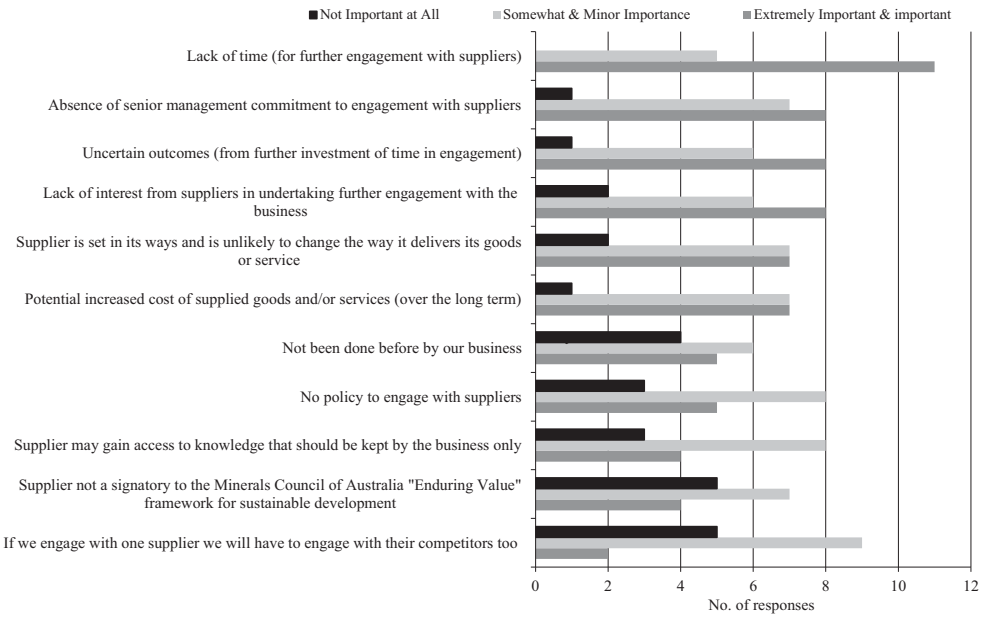

Fig. 3 Barriers to further engaging with suppliers

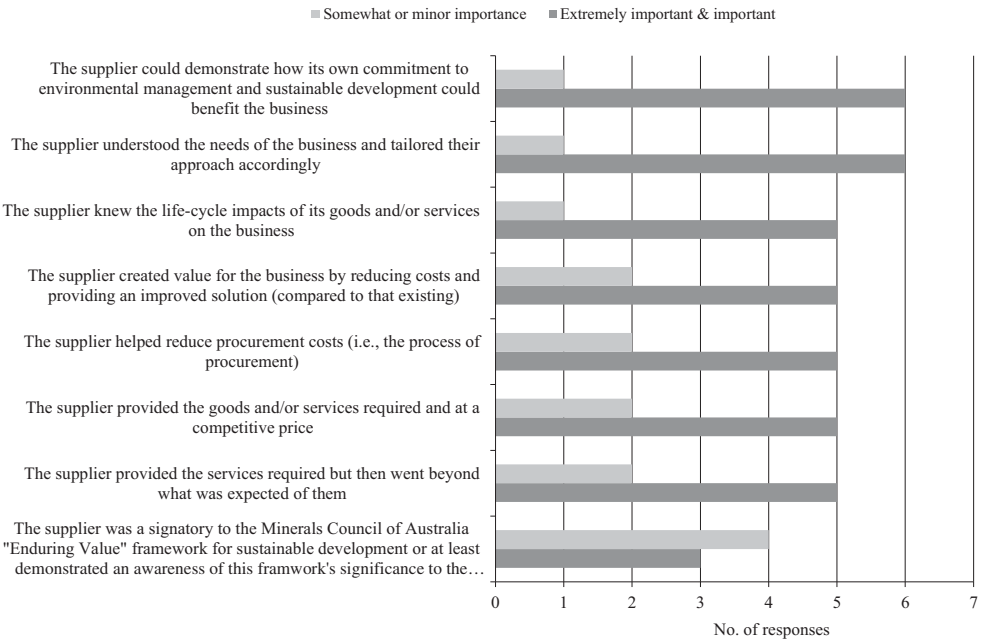

Fig. 4 Reasons for engaging with suppliers [Note: No responses were provided in the category "Not Important at All"]

only limited direct evidence of impact on financial performance. The challenge for suppliers is to demonstrate the financial value in all the offerings provided to the mining company, in addition to the benefits that help the mining company become more sustainable from a social and environmental perspective.

Integrating life-cycle considerations into the purchasing process at a mine requires a commercial decision by the supplier to provide the necessary resources and linkages with its mining customer to ensure the value of both products and services is delivered. This should involve sharing of information between environmental or sustainability managers or their equivalent between each organisation.

Discussion

An early survey of the international mining industry (Lane and Danielson 2001), although two decades old, recognised that sustainable development, in the context of suppliers to mining, included the following:

- Impact on lives of people in the local communities in which mining communities operate;
- Interaction and consultation with local communities, particularly regarding the economic and social impacts of mining; and
- Impacts on the environment where mining occurs.

The same survey demonstrated a general trend that there was a widening of an organisation's perceived area of responsibility in relation to sustainable development, and also showed that the mining and minerals processing industry has seen the emergence of many specialist contractors, for example in areas such as earth moving and maintenance, and that it is normal that business-critical activities are being outsourced. It indicated that while mining and minerals processing companies have experience in dealing with contractors, they are not familiar with using their influence over suppliers. Of the 32 companies surveyed, 78% and 59% required specific environmental standards to be met by contractors and suppliers, respectively. Respondents exhibited a strong interest in ensuring that local suppliers are used in their operations, and 90% of respondents stated that engaging with stakeholders effectively was one of the top five economic issues of concern to their company (Lane and Danielson 2001). There have been few studies since addressing the specific topic of the role of suppliers and the achievement of sustainable development in the minerals sector.

In their recent survey of Canadian miners, researchers have shown that barriers to further outsourcing of their mining activities is limited by the barriers that these miners perceive in terms of their ability of suppliers to sufficiently control quality, the potential for costly delays and mine disruptions, and the ability of suppliers to meet stringent health, safety, and environmental standards (Baatartogtokh et al. 2018).

While the link has been made with role of suppliers and increased mine productivity, no clear connection has been shown with sustainable development and suppliers to the sector in the literature. For example, a recent commercial survey has linked increased mining productivity to the industry adoption of vendor-managed inventory (Mitchell et al. 2019), which has existed in the electronics manufacturing industry

for many years but is almost unknown in the mining industry. Their study has shown that by evolving relationships with key suppliers to cover activities such as maintenance, mining companies can improve productivity i.e. tonnes of mined product per employee. A further benefit is that they reduce waste when these companies become more productive. If relationships are nurtured, these can be sustained through the mining boom and bust cycle to develop new technologies that will give the mining company first-mover advantage and encourage broader mining sector productivity (Mitchell et al. 2019). Commercial-in-confidence performance is another reason why supplier and mining company outcomes are not more widely spread in the literature.

Managerial implications and recommendations

Recognising value in the supply chain

Building the case for change is important in the mining industry because it is very conservative and mining companies often stick to existing, proven technologies and thus existing, proven suppliers, rather than "experimenting" with new technologies and new suppliers.

From analysing the survey findings, it is evident that corporate and/or mine procurement groups and other critical decision makers within mining companies may not recognise their role in implementing the environmental and sustainable development goals of their company in a commercial context. This is expected from this conservative culture and reluctance to try innovations that are unproven, or potentially unproven. Procurement staff require training and awareness of these issues. Key performance indicators need to be set by senior mine management to emphasise the importance of environmental or sustainable development concerns or values in purchasing decisions.

Mining companies need to appreciate and value suppliers, products, and/or services that will or can contribute materially to the achievement of their goals for long-term, sustainable operation of their mines. Such an appreciation is reflected in collaboration between suppliers and contractors that includes joint engagement and planning sessions. While collaboration and partnering can be considered the driving force behind effective supply chain management, there is still limited evidence that companies have truly capitalised on its potential (Guerin 2006b; Guerin 2008). This is a challenge for the mining industry, which in this regard is considerably behind other industries such as the food, automotive and electronics industries. Such engagement can only be done effectively where there is trust between the parties.

Importance of supplier leadership

Suppliers need to be seen to be walking the talk if they are to convince mining companies to adopt more sustainable approaches to mining through the supply chain. They need to demonstrate commitment and be able to transfer innovation to the mining operation. These involve the supplier carrying some risk in their relationships with mining companies. Supplier leadership does not negate the need for mining company leadership which is more important for the overall sustainable development of the mining sector because it can influence more stakeholders than suppliers.

Relationships and trust

As evidenced from the survey findings, relationship levels and trust present a challenge to the conventional negotiation process, and is currently the major hurdle to mining companies obtaining potential value from suppliers. It is also this point where there are considerable opportunities for improvement. Much work is yet to be done to educate supply and procurement staff to the business value of close engagement with suppliers, as well as the first specifiers, that is, the engineers and designers which give purchasing requirements to procurement professionals. Both suppliers and mine staff need to take time to broaden the relationship between their organisations so that opportunities to improve the environmental and social performance of the supply chain can be explored more comprehensively for their particular mining operation.

Recommendations

The author's recommendations for overcoming these barriers, based on the survey findings, are primarily for mining companies to allow for time for the dedicated engagement with their suppliers. This should be linked with a focused engagement session between each major supplier and mining company to identify opportunities. In doing this, they should establish key performance indicators for supply and procurement personnel to ensure they are systematically exploring opportunities to incorporate environmental and social enhancements and improvements into purchasing decisions. Similarly, proactive engagement needs to be undertaken by suppliers to ensure that mining companies are aware of the opportunities for improving environmental and social performance of their supply chain.

A relatively minor investment in time and resources to engage with suppliers through engagement and planning sessions can provide a useful platform for identifying, discussing, and developing joint actions to address issues that directly affect a mining operation's objectives for sustainable development.

Conclusions

In relation to sustainable development in the mining industry, suppliers have a pivotal, although often poorly recognised role in enabling mining companies to achieve their goals. Suppliers can enhance sustainable mining practises by helping corporate functions and operations become more efficient in their use of supplied products and input resources, which can lead to improved business as well as environmental and social performance. Suppliers have specialised knowledge, and there are numerous examples of how they can assist mining customers throughout the life of the supplied product. The survey, while limited in its sample size, underscores the important perceived role of suppliers to the mining industry in relation to sustainable development objectives, and has provided insights into suppliers and how they can help mining companies meet their sustainable development goals.

When mining companies had successfully engaged with suppliers, the supplier understood the needs of the business and tailored its approach accordingly. The supplier could demonstrate how its own commitment to environmental management and sustainable development would benefit the mining operation so understood the business needs of their client. The supplier created value for the mining operation by reducing costs and providing an improved solution (compared with existing solutions). The supplier also knew the life-cycle impacts of its own goods and/or services on the mining operation's business.

While there are numerous opportunities for a mining operation to enhance its own move towards sustainable development, there are real barriers entrenched in the way in which suppliers are currently engaged. These barriers will need to be overcome before the benefits of closer engagement with suppliers, to sustainable development will be realised.

Recommendations for future research would be understanding the application of blockchain and other technologies to streamline the transactions between suppliers and mining companies to better enable sustainable development outcomes to be achieved. They also could include harnessing the capabilities of suppliers to de-risk supply chains in terms of modern slavery, indigenous supplier engagement, increasing the efficiency of their supply chains (i.e. reduce time, cost, maintaining quality), and eliminating waste in the broadest sense across mining operations. More productive mines are likely to be less wasteful and therefore have lower costs of operation and reduced social and environmental footprints. The adoption of such recommendations could lead to improved triple bottom line performance by mining and minerals companies.

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