Gordon Institute of Business Science
University of Pretoria

Exploring the role of dynamic capabilities as internal drivers of business model innovation within the critical metals mining sector

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A research project submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of Philosophy (Corporate Strategy).

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ABSTRACT

This research is intended to deepen the understanding of the role of an organisations dynamic capabilities as internal drivers impacting and influencing business model innovation within the organisation.

As a business problem, this study investigated and described the dynamic capabilities required by small and medium-sized enterprise companies in the critical metals mining sector to innovate their business models, focusing on dynamic capabilities as internal drivers influencing change.

Supply disruptions to metals markets brought about by the Covid pandemic, coupled with the accelerated societal shift to renewable energy and battery electric solutions, have created an opportunity for critical metals mining companies to create and innovate their business models to identify, optimise and capture new value.

This need to innovate is not unique to mining companies, and holds across capital and asset intensive ecosystems at the intersection of the transition to renewable energy, including capital markets, mining, automotive, and manufacturing sectors. Organisations in this ecosystem are embracing innovation at an ever increasing rate to reduce capital and operating costs, and to extract further efficiencies through uptake of new technology and greater digital integration across the value chain.

The dynamic capabilities theory provides a useful framework to analyse the drivers of business model innovation in the critical metals sector.

Keywords

Business model innovation, dynamic capabilities, environmental uncertainty, SME, critical metals, mining

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in Corporate Strategy at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

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Name and Surname Signature

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ABBREVIATIONS

BFS: Bankable Feasibility Study
BM: Business Model
BMI: Business Model Innovation
DC: Dynamic Capability
DFS: Definitive Feasibility Study
ESIA: Environmental and Social Impact Assessment
ESG: Environmental and Social Governance
M&A: Mergers and Acquisitions
MNC: Multi-National Corporation
OBFS: Optimised Bankable Feasibility Study
PEA: Preliminary Economic Assessment
PFS: Pre-Feasibility Study
R&D: Research and Development
RBV: Resource-Based View
SME: Small to Medium-scale Enterprise
TMT: Top Management Team
VRIN: Valuable, Rare, Inimitable and Non-substitutable

CHAPTER 1. INTRODUCTION

1.1. Business relevance of the research

As the world transitions to a post-Covid new normal with society's renewed focus on the urgency to transition from fossil fuels to a renewable energy future, existing business models employed by multinational corporations (MNCs) and small to medium-scale enterprises (SMEs) are being questioned.

Ernst and Young Global Limited (EY) completed a survey amongst global mining and metals industry executives in 2021 titled "Top 10 business risks and opportunities within the mining industry in 2022" (Mitchell, 2021). "Environment and Social", "Decarbonisation" and "Licence to Operate" were the top 3 risks identified within the industry. New to the survey at 9th place, was the recognition that supply disruptions to metals markets have compelled global mining and metals businesses to create and innovate business models to identify, optimise and capture new value (Mitchell, 2021; (Dunbar, Fraser, Reynolds, & Kunz, 2020).

Commodity supply and demand forecasts indicate a step change in demand for critical metals, specifically copper, nickel, cobalt, tin, lithium, rare earth elements (REE) and platinum group metals (PGMs) required for this transition from as early as 2024 / 2025. Both supply and demand side strategies will need to be modified to deliver these metals in the volumes required for the energy transition, and without immediate intervention and innovation, it is increasingly likely that the Net Zero 2030 objectives will not be met due to inelastic supply constraints of these key metals (Mitchell, 2021).

This need to innovate is not unique to mining companies, and holds across capital and asset intensive ecosystems at the intersection of the transition to renewable energy (namely, capital markets, mining, automotive, and manufacturing sectors). Organisations in this ecosystem are embracing new technologies at an ever increasing rate to reduce capital and operating costs, and to extract further efficiencies through greater digital integration across the value chain.

Company Boards and CEO's of companies within the mining ecosystem are awakening to the need to innovate before climate change, societal values, external technologies and the business environment in general make their current business models obsolete (Bryant, 2015).

1.2. Background to the research problem

Use of the business model (BM) and business model innovation (BMI) constructs have become progressively more prominent in the academic literature since 2010, indicating wide adoption across industries and sectors.

Early theorising in the BM literature viewed business models as static. As the extant literature has expanded, the role of the top management team and its unique transformational (or dynamic) capabilities, have come to be seen as crucial internal drivers to change or innovation (Demil & Lecocq, 2010). These authors view changes to the business model as an evolutionary process between deliberate, evolving changes influenced by both external and internal factors, and stable components at the core of the BM.

Research is increasingly lending support to the view that a company's success is influenced by the underlying foundations of its business model. A comprehensive literature review of the BMI literature looking at 150 peer-reviewed articles completed between 2000 and 2015 was carried out by Foss & Saebi (2017).

Business model design views companies as an arrangement of activities that are influenced by the environment within which they operate (Foss & Saebi, 2018). The authors made a number of suggestions for further research.

1.3. Research question

Foss & Saebi (2018) position BM and BMI in three future research directions, namely, 1) "BM and BMI as independent variables", 2) "BM and BMI as dependent variables", and 3) "BM and BMI as moderating / mediating variables".

Research stream 2 conceptualises BM and BMI as dependent variables without further causal relationships. In this research stream, neither of the two constructs are viewed as moderating or mediating, and can be addressed utilising numerous relevant business theories. The authors concluded that more work needed to be carried out on the "antecedent conditions, contingencies and outcomes" of BMI, and identified a gap for the antecedent conditions to be better understood (Foss & Saebi, 2018).

Internal antecedents to BMI were identified as “dynamic capabilities, and change in strategy” with “changes in competition, technologies, network position and stakeholder demands” identified as external antecedents (Foss & Saebi, 2017, pp 215, Figure 2).

For this study, dynamic capabilities theory was selected as the appropriate theory to contribute to the theoretical advancement of the internal antecedents to BM / BMI.

The selected research question derived from the literature (Foss & Saebi, 2018, pp. 18, Table 2) was thus stated as:

- “What is the role of dynamic capabilities as internal drivers of business model innovation?”

A secondary research question was formulated to address uncertainty:

- “How is business model innovation affected by environmental uncertainty?”

The research on this topic under conditions of environmental uncertainty positioned this study as exploratory in nature, and therefore no preliminary hypotheses were formulated.

Research was carried out as a qualitative study using an interpretivist approach.

1.4. Research aims

Positioning of this research in the dynamics capability theory provided a framework to investigate and describe findings, and will add to the current literature on business model innovation. Academic research is needed to gain a more nuanced understanding of where business models come from, through a process of “origination, innovation, dissemination and adoption” (Foss & Saebi, 2018, p. 17).

A review of the literature indicated that while BMI studies have been carried out in the manufacturing and services industries in other parts of the world, no studies were located specifically in the critical metals mining sector within Africa.

This research also examined how companies within the critical metals ecosystem deal with environmental uncertainty which is a constant in the global transition to renewable energy.

This research therefore aimed to deepen the understanding of the role of an organisations dynamic capabilities and their impact / influence on business model innovation theory under conditions of environmental uncertainty.

1.5. Research scope

The scope of this research was restricted to SMEs within the critical metals mining industry. In order to address the research questions, it was necessary to first identify the microfoundations of dynamic capability theory as understood within the sample group and then establish how these influence BMI.

All participants in this research were senior mining executives and managers (with an average of 27.5 years' experience), working in the critical metals mining sector in both listed and unlisted small to medium sized mining companies. Participants in this research were predominantly involved in African projects (8 out of 11), with a minority representing North and South America (2 out of 11) and Australia (1 out of 11). The majority of companies represented (6 out of 7) were listed on global stock exchanges, with one unlisted company.

1.6. Research contribution

Chapter 5 consolidates findings from the sample group on the role of internal dynamic capabilities and their impact on BMI, within the critical metals mining sector. Environmental uncertainty as an external antecedent to BMI was addressed in lesser depth. The findings are compared with the academic literature in Chapter 6.

Conclusions are drawn in Chapter 7 with regards to the academic literature, and limitations of this study are given together with recommendations for future academic research directions. Recommendations are provided for management and stakeholders of critical metals companies.

CHAPTER 2. LITERATURE REVIEW

2.1. Introduction

This research study is grounded in the business model (BM), business model innovation (BMI), and dynamic capability (DC) fields of study.

Teece (2018) highlighted the interdependence between “business models, dynamic capabilities and strategy”, pointing out the influence a business model has on an organisations dynamic capabilities, and the limits it places on the viability of a specific strategy. By contrast, an organisation’s skill at modifying its business model is mediated by the strength of its dynamic capabilities.

2.2. Literature search review

The research question for this study explicitely sets out to understand the process role innovation of business models at an organisational level using an organisations dynamic capabilities. Foss and Saebi (2017) describe business model innovation as an extension of the business model field of study, with a number of research streams now becoming evident in the literature.

As the base construct, the *business model* term has been used extensively in the general literature since 2000, and has gained momentum in the business literature in the decade since 2010. An unfiltered search of the Scopus database with the term “business model” and related variants in the “abstract, title, keyword” search field from 2000 to 2022, across all subject areas and document types yielded 41,048 results. Limiting this search to peer reviewed, English language journal articles in the Business, Management and Accounting (BUSI) and Social Sciences (SOCI) subject areas using the key words “business model” and “business models” restricted the outcome to 2,825 results (approximately 7% of total results).

It has been suggested that the large difference between the use of the business model term in the non-academic literature as opposed to its usage in the academic business literature indicates a reluctance by business science researchers to use it as a unit of analysis (certainly in the period before 2010), possibly as a result of a lack of consistency in meaning and common understanding as a business science term (Foss & Saebi, 2017).

An analysis of an unfiltered Scopus search for *business model innovation* (total 4,695 results) across all subject areas indicated that the construct is most frequently used in the Business Management (31.4%) subject area followed by its usage in the Engineering (12.5%), Computer Science (11.7%), Social Sciences (8.8%) and Economics (8%) subject areas.

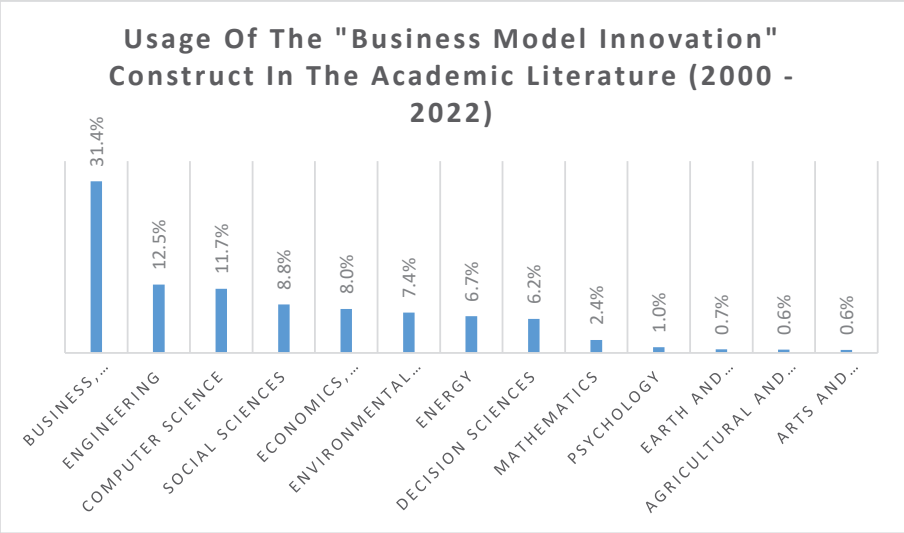

Figure 1. Scopus literature search for “Business Model Innovation” showing distribution of usage by subject areas.

Keeping the focus on the research question, the *dynamic capabilities* construct is used to define and understand the internal drivers of business model innovation. A fourth construct, *environmental uncertainty* is used to examine business model innovation under conditions of uncertainty within the business environment.

A Scopus search was undertaken to compare the usage of these related constructs using a more restrictive search limiting results to only include English language, peer reviewed, open source journals specifically in the “Business, Management and Accounting” and “Social Sciences” subject areas. This search was carried at as four separate, independent searches using one construct at a time. The results over the period 2000 – 2022 are shown in Figure 2 indicating a steady year-on-year increase in the use of the constructs in the academic literature.

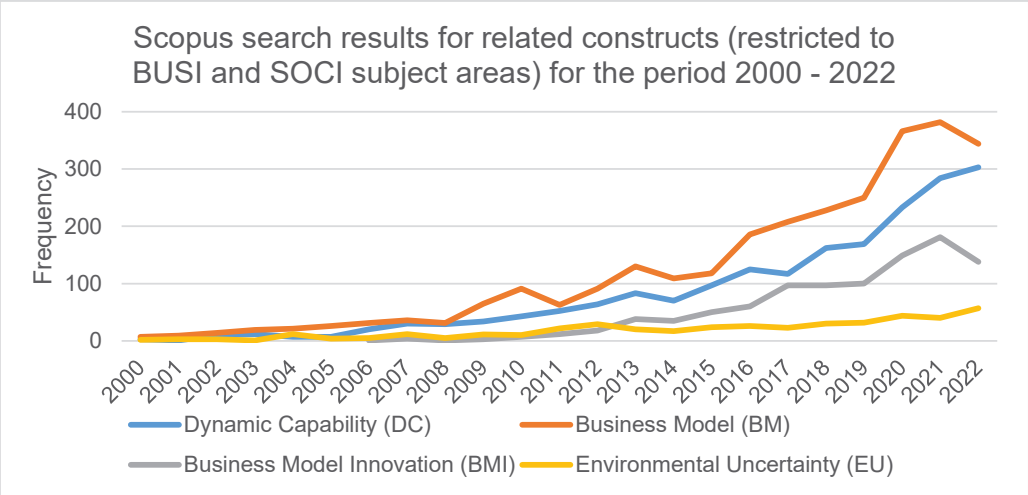

Figure 2. Separate Scopus search results for related macro-constructs ("Business Model", "Business Model Innovation", "Dynamic Capabilities", "Environmental Uncertainty") for the period from 2000-2022 limiting results to peer reviewed, English language, journal articles in the "Business, Management and Accounting" and "Social Sciences" subject areas.

It is evident from Figure 2 that the *business model* and *dynamic capabilities* academic literature is an advanced field of study with the addition of more than 300 journal publications per year. *Business model innovation* as a field of study is relatively less developed compared to the former two constructs with the trajectory of annual journal publications only increasing above 30 per annum from 2013. By comparison, the *environmental uncertainty* field of study is the least well developed with publications only increasing above 30 per annum from 2018.

The relative immaturity of the intersection of the business model innovation literature with dynamic capabilities and environmental uncertainty is presented in Figure 3, showing the low frequency of peer reviewed journal publications investigating the relationships between these key constructs.

The low frequency of journal publications investigating the intersection of business model innovation, dynamic capabilities and environmental uncertainty positions this research in a developing field of study, and lends support to the decision to carry out this research using an interpretivist approach consisting of semi-structured interviews and qualitative thematic analysis. The results of this approach are not expected to define a solution, but will highlight the personal experience of a small group of participants and organisations.

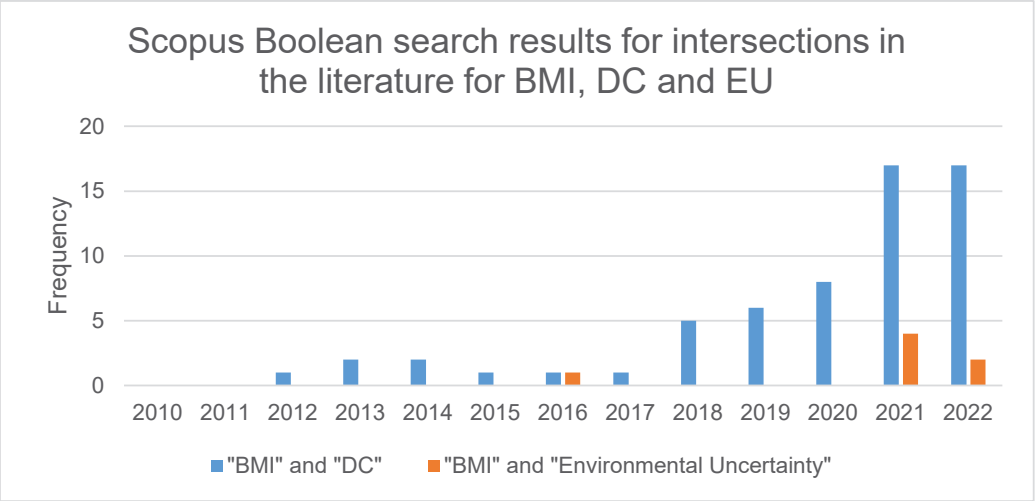

Figure 3. Scopus search results for intersections of related macro-constructs ("Business Model Innovation" with "Dynamic Capabilit*" and "Environmental Uncertainty" respectively) for the period from 2010. Results were limited to peer reviewed, English language, journal articles in the "Business, Management and Accounting" and "Social Sciences" subject areas.

2.3. The relationship between business strategy and business models

Early theorising on business models and business model innovation grappled with the relationship between business strategy and business models (Teece, 2010).

A commonly held definition of a business strategy is that it is a "plan of action to achieve the vision and set objectives of an organization, and guides the decision-making processes to improve the company's financial stability in a competing market" (Heubel , 2022, p. 1).

Michael Porter described strategy as central to "the reason companies succeed or fail" (Porter, 1991, p. 95). This belief has driven theory over the last 3 decades, and numerous theories have evolved to explain differences in the competitive success of companies through an understanding of "competitive advantage" (Porter, 1991), "resource based view" (Barney, Ketchen, & Wright, 2011), "core competencies" (Prahalad & Hamel, 1990) and "dynamic capabilities" (Teece, Pisano, & Shuen, 1997) to name a few.

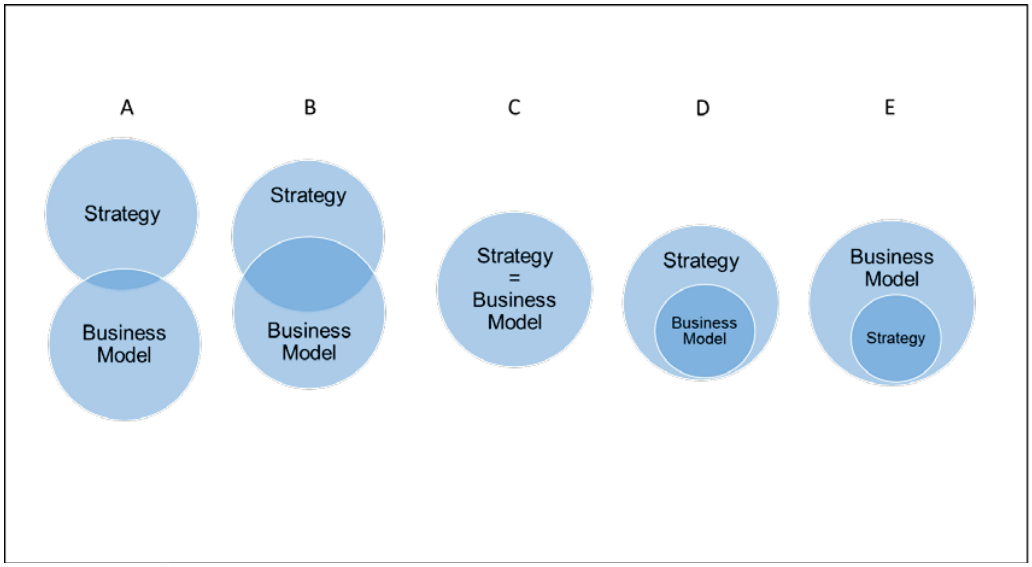

Figure 4. Conjectural overlap between "Strategy" and "Business Model" concepts (modified from Seddon, Lewis, Freeman and Shanks, 2004, p. 428).

Seddon, Lewis, Freeman and Shanks (2004) posited multiple possible overlaps between business models and strategy as illustrated in Figure 4. They argued that a business model should be seen as an "abstraction of a company's strategy", and is more generic, applying to many companies within a specific industry or ecosystem.

Seddon et al., (2004) proposed the relationship between strategy and business model as similar to model E in Figure 4. The business model includes a company's "value proposition for its various stakeholders" and the "activity system the company uses to create and deliver value to its customers", but not its unique "competitive positioning" (Seddon, Lewis, Freeman, & Shanks, 2004, p. 427). Restated more simplistically, this incorporates the logic of an organisation, how it works, what it does and how it creates value for its shareholders at an industry, sector or sub-sector level (Casadesus-Masanell & Ricart, 2010).

Teece (2010) expanded this view that a business model is less specific than a business strategy, and that more detail is required when designing a strategy. A strategy is viewed as a unique and economically distinctive roadmap or plan for how a company will outcompete against its competition. For Teece, a business model needs to be subjected to further strategic filters in order to be validated and competitively viable.

Casadesus-Masanell and Ricart (2010) presented a framework (the "*two-stage competitive process framework*", Figure 5) that views strategy as the selection of a

business model, which feeds into a tactics stage defining short term choices and behaviours.

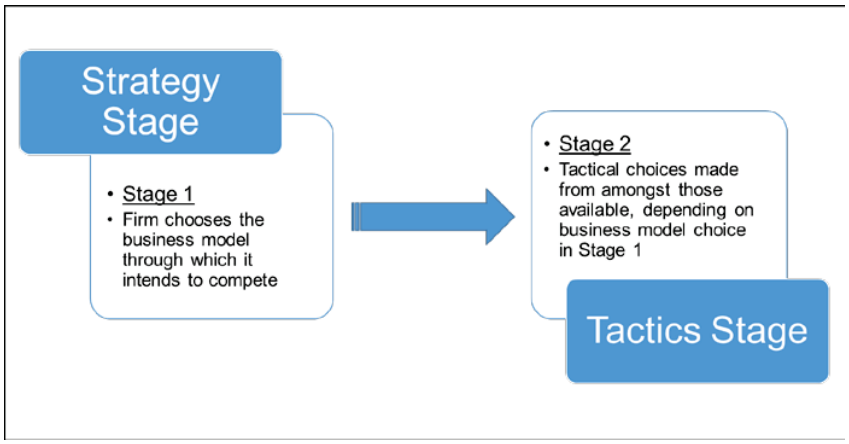

Figure 5. Generic two-stage competitive process framework (modified from Casadesus-Masanell and Ricart, 2010, p. 196).

Strategy is shaped by the business model which restricts certain activities and frees up others by pulling on the levers of costs and profits. For Teece, an organisations top management must constantly monitor for clashes between strategy and the business model, and make decisions on which to change (Teece, 2018).

This relationship between the strategic and tactical stages has relevance to the research question of this study, framed in the language of dynamic capability theory which is seen to operate at two levels. At the lower tactical level, operational (or ordinary) capabilities facilitate normal production activities, while higher order (or dynamic) capabilities are needed to define, adjust and implement changes to an organisations business model (Teece, 2018).

2.4. The Business Model (BM) construct

Baden-Fuller & Morgan (2010) view business models as a taxonomy, or as "descriptions of kinds", where individual companies all act, and are organised, differently in their pursuit of profits. Each business model is in effect a scale or role model, established to demonstrate some inimitable characteristic that separates it from its peers. There are however generic behaviours between companies that allow scholars to classify individual

companies into groups based on observed or perceived behaviours, allowing the construct of a *scale model* that can be replicated to achieve a similar outcome (Baden-Fuller & Morgan, 2010).

Foss & Saebi (2017) conducted an extensive review of the macro-management business literature, noting that by 2017 many researchers in the business model / business model innovation field had converged on the definition offered by David Teece that a business model is a conceptual construct that consists of 3 elements defining "the manner by which the enterprise delivers value to customers, entices customers to pay for that value, and converts those payments to profit" (Teece, 2010, p. 172).

Teece simplifies the business model as "expressing the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers". It provides an "outline of the architecture of revenues, costs, and profits associated with the business enterprise delivering that value" (Teece, 2010, p. 173). In its most fundamental form, the business model defines the offering to the customer, and provides details on "how money is made" (Teece, 2018).

The circularity of this definition is elegantly illustrated in Figure 6.

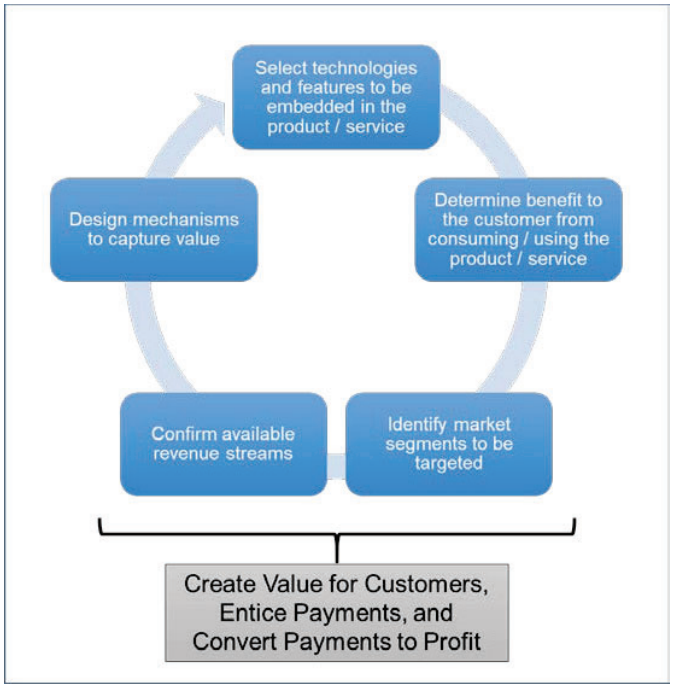

Figure 6. Foundations of business model design (modified from Teece, 2010, p. 173).

Foss & Saebi (2018, p. 9) emphasise the importance of a business model as defining the “architecture of the company's value creation, delivery and capture mechanisms”. However, without balance between these different elements, complementarity is not possible and the model would quickly collapse losing the company money (Teece, 2018).

Once a business model has been defined, it influences strategy through its impact on costs and profitability, and can lead to changes having to be made in either should they be in conflict (Teece, 2007).

2.5. Business Model Innovation (BMI) as an extension of Business Model (BM) theory

Leveraging off of the business model definition, Foss & Saebi (2018) lend crispness to the definition of business model innovation (BMI), which is more precisely defined as new and unique changes in the design and complimentary activities of the business model. Building on Teece’s definition of a business model, BMI is simplistically about innovating (modernising and transforming) the value creation process to improve company performance (Teece, 2018).

A concern raised by Foss & Saebi (2017) regarding BMI is that when considering the multiple theories put forward to understand BMI, previous research has not resulted in a “cumulative theory” and that research has not produced common units of analysis with a clear definition of independent / dependent variables and parameters of study.

Their work indicated a gap in all dimensions, and to address this, established an organising framework with four streams of BMI research becoming evident summarised as 1) conceptualisation and classification of BMI, 2) BMI as a process, 3) BMI as an outcome, and 4) BMI and organisational implications / performance. Relevant case studies and content analysis are presented in Table 1.

Foss and Saebi (2017) identified conceptualisation and classification of BMI as the first emerging research stream, which remains nascent with numerous definitions, often vaguely defined and with significant differences. Clarity of definition and articulation is still required to ensure meaningful research that can be compared and operationalised (Foss & Saebi, 2018).

The second emerging research stream described by Foss and Saebi (2017) relates successful BMI to a dynamic process of organisational change, recognising the role of

the capabilities of the organisation, its leadership and how it learns at different stages in the process. This research stream provides an academic framework and background to expand on for the research questions defined in Chapter 3.

Table 1. Streams of Business Model Innovation Research (Foss & Saebi, 2017, p. 206)

Research Focus	Method	Examples
1. Conceptualization and classification of BMI	Conceptual, case examples	Amit and Zott (2012), Johnson et al. (2008), Koen et al. (2011), Markides (2006), Santos et al. (2009), Sorescu et al. (2011)
	Survey data	Giesen et al. (2007)
2. BMI as a process (e.g., importance of capabilities, leadership, learning mechanisms)	Conceptual, case examples	Berglund and Sandström (2013), Cavalcante (2014), de Reuver et al. (2009), Deshler and Smith (2011), Evans and Johnson (2013), Girotra and Netessine (2013, 2014)
	Single/multiple case studies	Achtenhagen et al. (2013), Aspara et al. (2013), Demil and Lecocq (2010), Deshler and Smith (2011), Dmitriev et al. (2014), Doz and Kosonen (2010), Dunford et al. (2010), Enkel and Mezger (2013), Frankenberger et al. (2013), Günzel and Holm (2013), Khanaga et al. (2014), Moingeon and Lehmann-Ortega (2010), Mezger (2014), Pynnonen et al. (2012), Sosna et al. (2010)
	Content analysis	Bohnsack et al. (2014)
	Experimental	Eppler and Hoffmann (2012), Eppler et al. (2011)
3. BMI as an outcome (e.g., identifying/ describing innovative business models)	Single/multiple case studies	Abdelkafi et al. (2013), Anderson and Kupp (2008), Gambardella and McGahan (2010), Sánchez and Ricart (2010), Yunus et al. (2010), Wirtz et al. (2010), Berman (2012), Holm et al. (2013), Richter (2013), Visnjic Kastalli and Van Looy (2013)
4. BMI and organizational implications/ performance	Survey data	Zott and Amit (2007), Giesen et al. (2007), Aspara et al. (2010), Bock et al. (2012), Denicolai et al. (2014), Huang et al. (2012, 2013), Pohle and Chapman (2006), Cucculelli and Bettinelli (2015), Wei et al. (2014), Velu and Jacob (2014), Kim and Min (2015)

The third and fourth research stream are static in nature, highlighting new business models through case studies within specific industries and measuring of the financial performance as a result of business innovation respectively, but with little impact on improving the definition of BMI or providing insights into how BMI is progressed. Neither of these streams are considered viable sources of information, or of relevance to the research question of this study, and will not be dealt with in any further detail.

2.6. Drivers of BMI

Research on how BMs are formed is at an early stage, with the internal and external antecedents that initiate change requiring further study (Foss & Saebi, 2018). Successful BMI places value creation at the core of the BM, and is enabled by changing and recombining common BM elements, such as “resources, processes, capabilities and revenue” to improve the value propositiion (Filser, Kraus, Breier, Nenova, & Puumalainen, 2021).

Internal drivers including entrepreneurial decision-making, research and development (R&D), experimentation, implementation and other forms of knowledge transfer are key processes identified to date for successful business model innovation to occur (Foss, Lyngsie, & Zahra, 2013).

The top management team (TMT) within an organisation plays a central role in BM design and BMI. BMI which is new to the organisation, requires the TMT to exercise tighter control on the changes to the BM to ensure the integrity of the BM and the principal logic of the organisation. Where more complex changes to the BM are being iterated and implemented, it is likely that the TMT will be involved in both the design and day-to-day investigation and management of the BMI process (Foss & Stieglitz, 2015).

Value creation is influenced by learning within the organisation, research and a more nuanced understanding of the organisations’ business model (Filser, Kraus, Breier, Nenova, & Puumalainen, 2021). Learning through trial-and-error (or iteration) can help craft new BMs, and allow organisations to develop new insights regarding their BMs. “Experimentation and exploration” are seen as internal traits that allow an organisation to increase knowledge and improve their core BM, while “exploitation” allows scale up and implementation (Sosna, Trevinyo-Rodríguez, & Velamuri, 2010). BMI is facilitated by the TMT encouraging and instilling a culture of experimentation, openness to learning and a willingness to question traditional mind-sets (Sosna, Trevinyo-Rodríguez, & Velamuri, 2010).

BMI can also occur as a result of changes in the external business environment within which companies operate. Business models exhibit different degrees of change depending on the nature and duration of the external influences, and change can be either positive (proactive) or negative (reactive) with varying financial consequences (Saebi, 2015). In this environment, TMTs evolve, adapt or innovate the BM when faced with extreme uncertainty.

The inclusion of technology innovation within the BM has been identified as a means to create and capture new value with “experimentation, leadership and alignment” recognised as core internal managerial requirements (Chesbrough, 2010). Alignment between the BM and the technology innovation is achieved by trial-and-error, with obvious similarities to the ideas proposed by Sosna et al. (2010).

Filser et al. (2021) identified “sustainability, dynamic capabilities, and small- and medium-sized enterprises” as emerging trends within the BMI literature. All three of these emerging trends have relevance to the business case for this research study, with dynamic capabilities having direct relevance to the primary research question.

(Bocken & Geradts, 2020) provided a framework for value creation through sustainable business model innovation (SBMI) which demonstrated a strong link between BMs, dynamic capabilities and organisation design. SBMI covers a wider understanding of value creation including environmental and social governance (ESG) elements (Foss & Saebi, 2017). This is identified as an external driver of BMI, and has particular relevance in the extractive industries including mining, oil and gas and quarrying.

Organisations with well-developed dynamic capabilities are seen as being more responsive to customer’s needs, while still being able to entrench a competitive advantage (Filser et al., 2021). Changes in technology require companies to be agile in the acquiring of dynamic capabilities to adjust to new customer needs by rapidly innovating their business model (Teece, 2018). While various dynamic capabilities specific to individual companies have emerged from the literature (for example, founders entrepreneurial capabilities, organisational design, stakeholder relationships, etc), no capabilities generically applicable to BMI have been identified in the literature.

Most business model innovation theory developed for larger organisations can be applied to small and medium sized companies, even though there are limitations to the extent that expensive technology innovation can be applied to SME’s due to limited resources (Dymitrowski & Mielcarek, 2021).

2.7. Impact of Entrepreneurship on BMI

Entrepreneurs exhibit dynamic capabilities of "sensing, selecting, shaping and synchronising" and are able to reimagine their surroundings by recognising changes brought about by new trends (Vu, 2020). Entrepreneurial competencies operate in tandem with the environment, and are established through experience and reflection (Bingham, Eisenhardt, & Furr, 2007). Entrepreneurship has a strong influence on business model design, and at its most fundamental level, is a driver of BM design and a primary contributor to value creation (Filser, Kraus, Breier, Nenova, & Puumalainen, 2021).

Filser et al. (2021) proposed a framework that can be used by scholars and researchers alike in the advancement of the BMI literature (Figure 7). At the Base Level, the framework has the BM model concept at the centre, with firm links to BM design / entrepreneurship and strategy. Combined, these three elements create awareness of new opportunities, and when combined with trend information (upwards facing arrow), new value is created at the Innovation Level. "Organisational Transformation" and "Product and Technology Innovation" interact at the Innovation Level, strengthening the value creation hub.

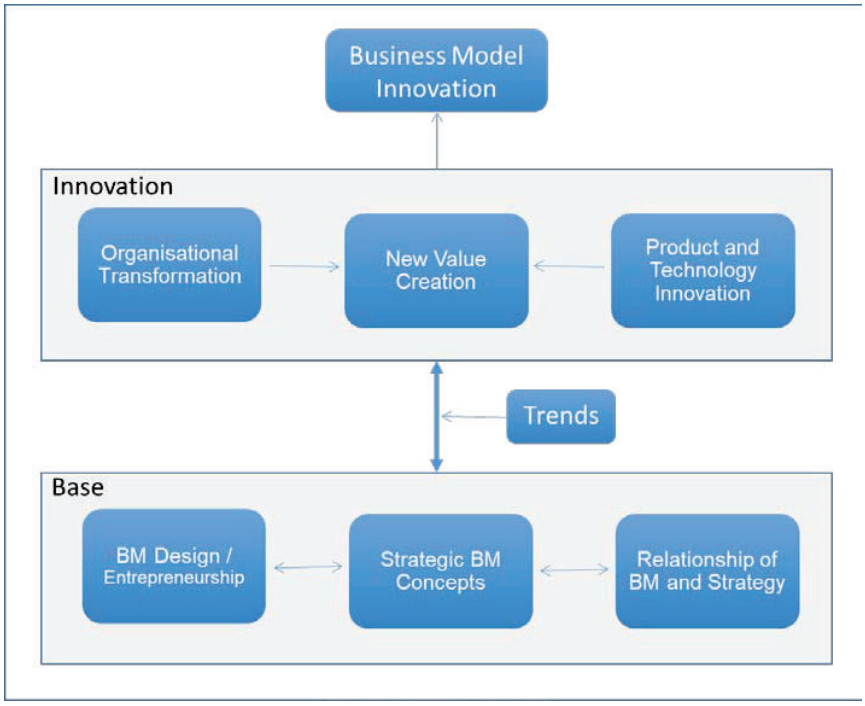

Figure 7. Business model innovation framework (modified from Filser, Kraus, Breier, Nenova, & Puumalainen, 2021, p. 902).

2.8. Dynamic Capabilities (DC)

Rapid changes and uncertainty in the business environment mean that organisations need to constantly develop capabilities to adjust and survive in a process of continual renewal. Capabilities in this context are defined as a set of unique actions or learned practices including “skills, processes, routines, organisational structures and disciplines” enabling an organisation to produce a specific product or output to meet customer needs (Teece, Pisano, & Shuen, 1997).

Dynamic capability theory was developed from the resource based view (RBV) to address how an organisation’s resources (both tangible and intangible) need to be dynamic to respond to changes in the environment (Teece, 2007). In the RBV theory, a company’s competitive advantage comes from its internal resources and competencies that are “valuable, rare, inimitable and non-substitutable” (VRIN) allowing an organisation to grow and generate profit (Barney, 1991). A major criticism of the RBV is that it is unable to describe how organisations react to environmental uncertainty using VRIN resources as production inputs. In the RBV, a company’s competitive advantage is dependent on its tangible and intangible assets and is not created from within the organisation (Helfat & Peteraf , 2009). The RBV also fails to explain how a company would grow future resources and competencies, and how VRIN resources could be adjusted to respond to changes and uncertainty in the environment (Mousavi, Bossink, & van Vliet, 2019).

While theory on dynamic capabilities has been emerging since the late 1990’s, Teece (2007) expanded the RBV and defined dynamic capabilities as the ability of an organisation to sense and adjust to opportunities and threats as they emerge, whilst remaining competitive through a process of adaptation, using the organisation’s physical resources, unique capabilities and intellectual property. Dynamic capability theory provides an academic framework, allowing managers to rationalise why companies succeed or fail.

The capabilities of the organisation are perceived as operating on two levels, with operational and other ordinary capabilities at the base, overlain by a layer of higher order dynamic capabilities.

Ordinary capabilities are the repetitive daily activities that enable companies to produce goods or services in a semi-efficient manner, and from which they derive income. Ordinary capabilities include administration, basic governance and extend to best practices utilised across an entire industry or sector. Dynamic capabilities, on the other

hand, are idiosyncratic and unique to a specific company based on its origin and business evolution, and are anecdotally described as “signature processes” (Gratton & Ghoshal, 2005).

Dynamic capabilities are unique, not easily developed or deployed and not easily copied (Teece, 2007). Organisations that have and practice dynamic capabilities are able to change and evolve within their sector or industry, developing a clear economic moat with their competitors through an evolutionary and transformative process. The dynamic capabilities construct is split into three high level sub-constructs or themes, viz. sensing, seizing and transforming, leading to growth and competitive advantage as shown in Figure 8.

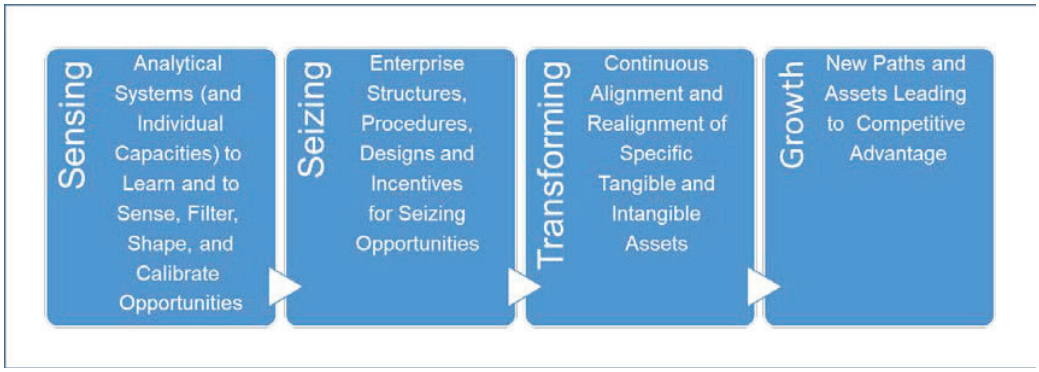

Figure 8. Foundations of dynamic capabilities and business performance (modified from Teece, 2007, pg 1342).

Organisations that demonstrate dynamic capabilities through their top management team’s innate ability to identify weak signals in their environment ahead of their competition have an edge on their competitors, and are able to innovate their business model to create processes to capture the identified future value gap (Teece, 2014). Dynamic capabilities theory requires that the opportunities for change are discovered through a process of exploration (Madsen, 2010). Entrepreneurial orientation is a necessary capability to being innovative, taking risks and exploiting the opportunity.

Eisenhardt and Martin (2000) recognised that the creation and progression of new combinations of resources are enabled by both management routines and process, and entrepreneurial actions. This recombining of resources is both a dynamic capability and a measure of an organisation’s entrepreneurship (Madsen, 2010), and willingness to try

new combinations of resources are fundamental to establishing new products, services or markets (Eisenhardt & Martin, 2000).

Teece, (2007) divides dynamic capabilities into microfoundations and higher-order capabilities. Microfoundations are the processes and routines displayed by managers or teams, and when grouped together, constitute high-order dynamic capabilities that allow a company to outperform its competitors (Bojesson & Fundin, 2021). Microfoundations are described as the modification and recombining of an organisation's ordinary capabilities as well as the development of new ones, through a process of smart decision making by the top management of an organisation (Teece, 2007). Modification and recombining activities often take place under conditions of environmental uncertainty facilitating the development of new products and opening up of new markets (Eisenhardt, Furr, & Bingham, 2010).

Higher-order dynamic capabilities are processes used by management and organisations to sense new opportunities through amplification of weak signals within the market using foresight and scenario analysis, and then generating and refining business models to seize these opportunities (Schwarz, Rohrbeck, & Wach, 2019). These higher order capabilities allow managers to reconfigure the organisation to maximise product differentiation and income presented by the opportunity (Teece, 2018).

Successful organisations with inimitable dynamic capabilities are able to embed these dynamic capabilities into the fabric of the organisation by encouraging shared value, high levels of organisation learning, tolerance for experimentation and risks (Schoemaker, Heaton, & Teece, 2018). Organisational dynamic capabilities are viewed as a competitive advantage, allowing companies to reorganise their resources to adjust to new opportunities, avoid or minimise threats and to gain market share (Mousavi, Bossink, & van Vliet, 2019).

2.8.1. Sensing

Teece (2007) defines sensing as a process whereby managers scan the environment for new opportunities and weak signals, addressing the broader geopolitical and societal backdrop, competitive market forces, changes in technology, changing customer needs and impact of new suppliers in the market.

Sensing and scanning of the environment detects opportunities that are otherwise hidden or weakly developed. The sensing capability is reliant on the ability of a manager or

team to process large volumes of external information to isolate and articulate opportunities before they are evident to competitor organisations operating in the same sector or industry (Schwarz, Rohrbeck, & Wach, 2019).

The process of building an organisations sensing ability is enhanced through leveraging networks and relationships with customers, suppliers, technology partners and research organisations who contribute new knowledge and data (Foss, Lyngsie, & Zahra, 2013).

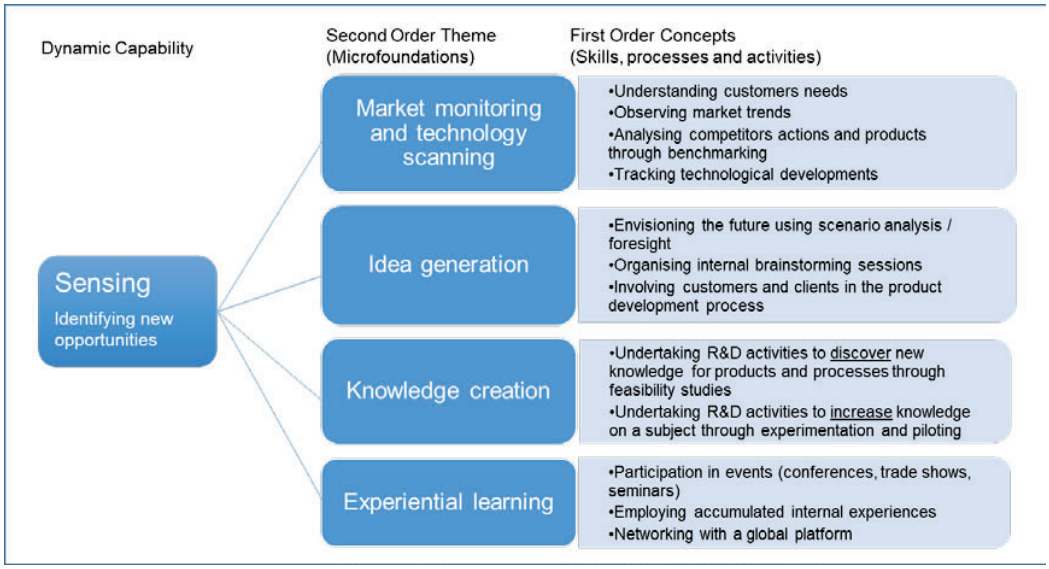

Figure 9. Microfoundations and first order concepts of the sensing dynamic capability (modified from Khan, Daddi, and Iraldo, 2020, p. 1484)

On the microfoundations of the sensing capability, Figure 9 provides a framework of how organisations use a combination of sources and activities to sense opportunities in the market including market monitoring, idea generation, knowledge creation and experiential learning (Khan, Daddi, & Iraldo, 2020)

Teece (2007) flagged the cognitive and creative differences between individuals in senior management as a differentiator in the ability of organisations to create and discover new opportunities. For Teece (2007), the organisation is however at risk if the sensing capabilities of an organisation are dependent on the perceptions and cognitive abilities of a few individuals, and routines and processes are necessary at an organisational level to capture and synthesis information. To facilitate this, organisations need to provide internal managers with the resources and incentives to create and nurture contacts within

the broader ecosystem or network. This process should include the establishing of a hypothesis that maps the development of technology, consumer requirements and market feedback and how the organisation can benefit from these changes.

Identification of opportunities is influenced by an organisations knowledge creation processes such as R&D activities, its capacity to interact with current and potential customers regarding their needs, and to classify this information. Customer engagement is seen as an essential process as often customers are the first to recognise the potential of new technology (Ibarra, Bigdeli, Igartua, & Ganzarain, 2020).

Specific processes such as foresight and scenario analysis are used alongside more organic processes such as brainstorming to generate new ideas (Haarhaus & Liening, Building dynamic capabilities to cope with environmental uncertainty: The role of strategic foresight, 2020). Accumulated experience amongst top management and a learning culture within the organisation are crucial skills and routines for sensing of opportunities (Khan, Daddi, & Iraldo, 2020).

In a volatile and uncertain environment, sensing is the primary activity required to build a company's dynamic capabilities (Eisenhardt, Furr, & Bingham, 2010).

2.8.2. Seizing

Seizing is the process whereby an organisation deploys resources in order to gain market share or competitive advantage, and in so doing exploit the opportunities identified through the sensing dynamic capability (Teece, 2007). Seizing allows managers to mobilise an organisation's resources to secure market opportunities recognised through the scanning process (Teece, 2014). Seizing is a mindful and applied process, taking many forms including dialogue and knowledge sharing within the ecosystem network, alerting partners and stakeholders of potential opportunities, and innovation and development of proprietal processes or intellectual property (Helfat & Peteraf , 2009).

Value for the organisation is created by changing existing market offerings; through innovative combinations or iterations of value creating activities external to the organisation; or by addition of innovative of new products, processes or services (Mousavi, Bossink, & van Vliet, 2019).

The microfoundations of the seizing dynamic capability are strongly influenced by strategic planning, business model innovation and changes to corporate governance structures and collaboration (Khan, Daddi, & Iraldo, 2020). Figure 10 illustrates how seizing requires unique strategy formulation capabilities, and a focus on capital budgeting for acquisition of new technology and strategic investments.

Seizing capabilities are enhanced by nurturing strong internal capabilities and best practices, and engaging with external specialists regarding processes and the market. Seizing capabilities allow organisations to develop competencies to allocate both internal and external resources in order to exploit market opportunities (Madsen, 2010).

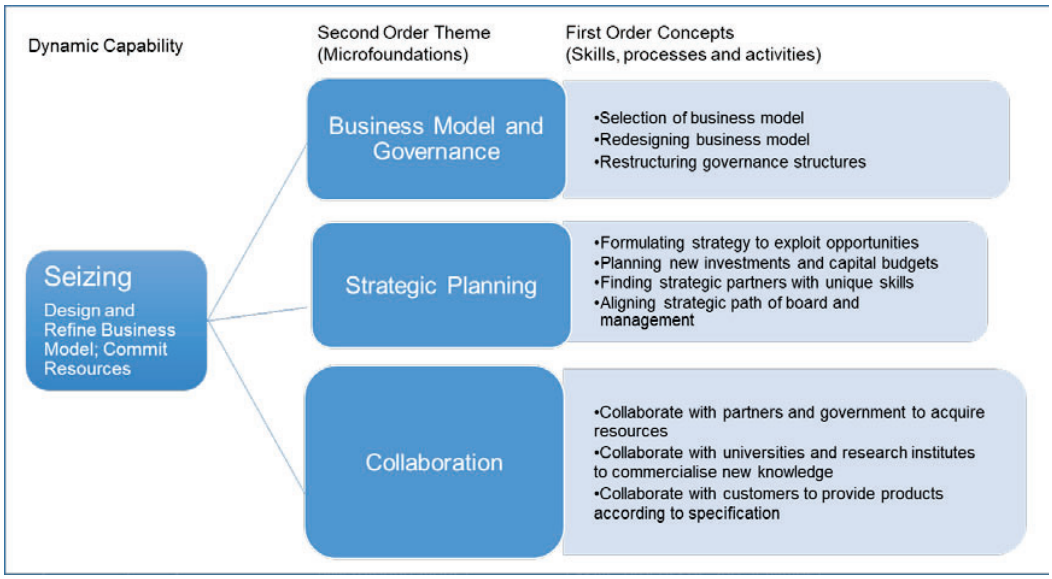

Figure 10. Microfoundations and first order concepts of the seizing dynamic capability (modified from Khan, Daddi, and Iraldo, 2020, p. 1484)

Teece (2007) highlighted the significance of business model design as a crucial seizing capability, setting out the hypothesis of what customers want, how the organisation will deliver value and how it will receive payment. The process of business model design provides detail on technologies to use, the specifications of products and services, marketing requirements and a cost / revenue model (Teece, 2018). This process is complex, and is as much an art as a science, requiring creativity, insight and judgement on how best to combine information from competitors, customers and suppliers (Teece, Peteraf, & Leih, 2016).

Mediating factors to successful business model design include scenario analysis looking at multiple alternatives, having a clear understanding of customers' needs and a deep analysis of the value chain to understand how to deliver the product to the customer on time and cost effectively (Teece, Business models and dynamic capabilities, 2018).

Organisations with well-established and disciplined decision-making processes that minimise biases are able to gain a competitive advantage. Strong and independent governance structures at a board and a top management level mediate seizing capabilities.

Collaboration and partnership is an essential seizing capability and is necessary to acquire further knowledge and resources. This is particularly relevant in technology dependent industries where organisations may not achieve this knowledge through their own R&D activities, and are able to exploit the advanced capabilities of universities, research institutes and nongovernmental organisations (Khan, Daddi, & Iraldo, 2020).

2.8.3. Transforming

Transforming is the dynamic capability allowing managers to reconfigure an organisations' intangible and tangible assets to maintain competitiveness, through orchestration of business improvement and optimisation processes, and combinations and re-alignment of business units (Teece, 2007).

Asset orchestration is an important management consideration of the transforming dynamic capability. For Teece (2007), assets that have greater value when combined are able to deliver more highly valued competitive advantage than if considered in isolation, but require dynamic capabilities to identify, manage and transform so that the whole is more valuable than the sum of the parts. Transforming as a dynamic capability has an ordinary capability spin-off, as organisations that are constantly renewing their internal processes and routines are able to respond faster to environmental uncertainty and external market stress (Teece, 2018).

Transforming microfoundations encourage renewal, and allow the organisation to adjust and position itself to take advantage of the sensed opportunities and changes (Eisenhardt, Furr, & Bingham, 2010). Organisations with well-developed dynamic capabilities are able to quickly reconfigure their business and transform ahead of their competition. The most successful organisations are those that are able to accomplish "high payoff changes at low costs" (Teece, 2007).

The microfoundations of the transforming dynamic capability include organisational restructuring, technological upgrading, knowledge integration and the adoption of best practice (Khan, Daddi, & Iraldo, 2020) as represented in Figure 11.

Organisational restructuring is a crucial dynamic capability involving M&A, internal reorganisation of business units, the addition of new specialised units or facilities and the sale or closure of non-core units (Bocken & Geradts, 2020). Decentralisation of decision making provides flexibility and quick reaction to local conditions in fast paced environments without the need to roll up decisions to a single decision maker (Teece, 2007).

The impact of decentralisation, a flatter organisational structure, a high level of internal cooperation, openness and knowledge-sharing, and incentivisation of entrepreneurial behaviour are considered fundamental dynamic capabilities (Leih, Linden, & Teece, 2015).

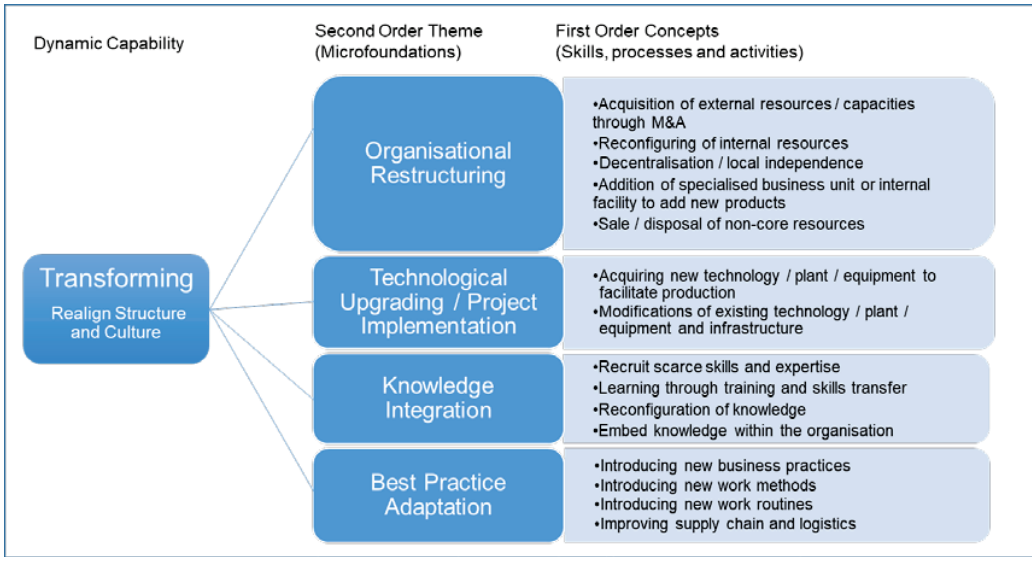

Figure 11. Microfoundations and first order concepts of the transforming dynamic capability (modified from Khan, Daddi, and Iraldo, 2020, p. 1484).

Under conditions of high environmental uncertainty, realigning of the organisation by itself may be insufficient to capture value from an innovative business model, and it may be necessary to influence and transform the entire ecosystem network within which it

operates in order to derive benefit from the realigned business model (Schoemaker, Heaton, & Teece, 2018).

2.9. The role of DC's in BMI

In analysing the dynamic capabilities literature, Filser et al (2021) noted that the dynamic capabilities of sensing, seizing, and transforming play a critical role in business model innovation. In its simplest definition, organisations need to develop an innate ability to scan or *sense* the market within which they operate for opportunities and threats. Once identified, opportunities need to be acted upon or *seized*, and in so doing innovate and *transform* their resources to respond to the identified opportunity (Teece, 2018).

Leih, Linden, & Teece (2015) noted that "collective learning", "culture of the organization" and "entrepreneurial skill of the top management team" are key dynamic capabilities that influence business model innovation and implementation. Entrepreneurial managers are identified as agents of change who recognise the need for business model change, and drive innovation and company transformation through "acceptance of new technology", by "modifying existing or inventing new business models", and by "coordinating or restructuring existing assets".

The impact of decentralisation, a flatter organisational structure, a high level of internal cooperation, openness and knowledge-sharing, and incentivisation of entrepreneurial behaviour are considered fundamental dynamic capabilities that require further analysis (Leih, Linden, & Teece, 2015). (Ibarra, Bigdeli, Igartua, & Ganzarain, 2020) recognised "sensing customer needs", "sensing technological options", "conceptualizing and experimenting", "collaborating" and "BMI strategy" as crucial dynamic capabilities for business model innovation in SMEs.

Dynamic capabilities are the means by which companies identify and are able to adopt a long term view benefiting the internal profit generating functions, and infrequently, the value chain within which the organisation is located (Ameer & Othman, 2012). Well-directed dynamic capabilities will often times have a pull effect on the sector within which a company operates, irrevocably changing the business ecosystem and network within which it operates through the introduction of a new and innovative business model (Teece, 2018).

Teece (2018) presented a framework of the relationship between dynamic capabilities, business models and strategy (Figure 12), positioning business model innovation as a seizing capability requiring design and refinement of the business model.

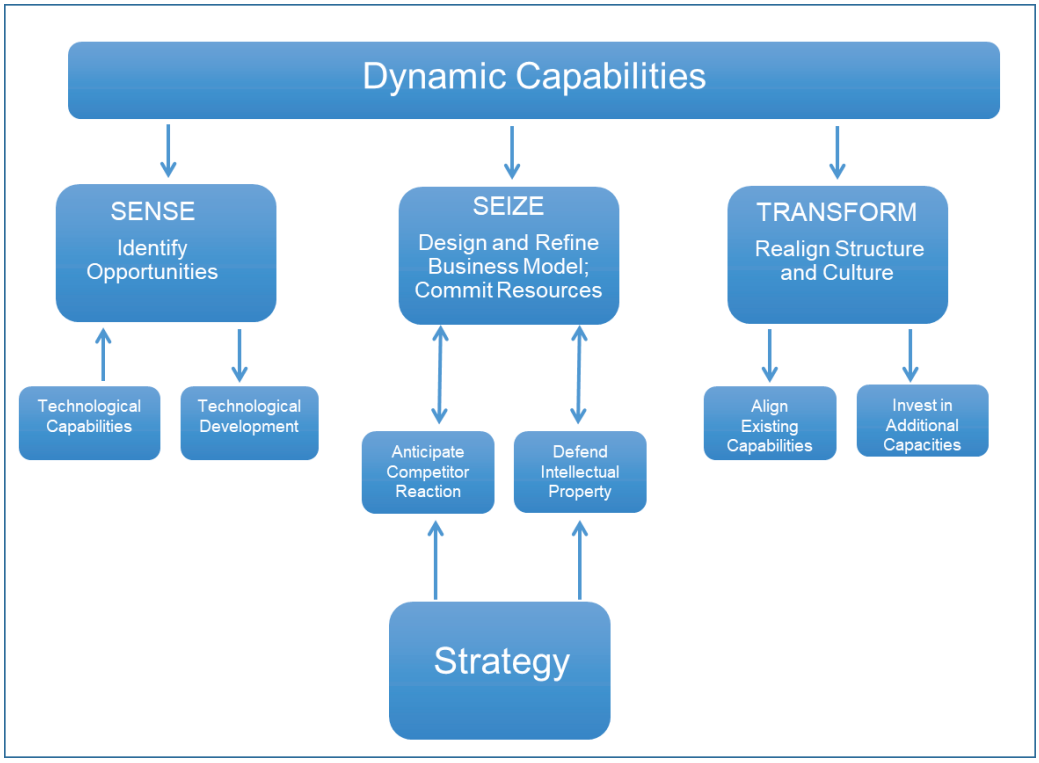

Figure 12. Simplified framework of dynamic capabilities, business models and strategy (Teece, 2018, p. 42).

2.10. Environmental uncertainty

Definitions of environmental uncertainty can be grouped into those used in a human psychology context, and those used in an economic or business context (Akpolat, Soliman, & Schweitzer, 2016). Uncertainty is experienced at an individual level as a perceived inability to forecast precisely and accurately due to insufficient data, or the ability to make sense of what data is applicable (Milliken, Three types of perceived uncertainty about the environment: State, effect, and response uncertainty, 1987).

Environmental uncertainty refers to the constantly changing conditions in the external business environment, and over which organisations have minimal control (Teece, Peteraf, & Leih, 2016). This perceived environmental uncertainty quite often relates to

factors external to the organisation including legislation, customers and suppliers (Akpolat, Soliman, & Schweitzer, 2016).

In the business environment, risk and uncertainty are frequently used in similar contexts although scholars in the literature make a distinction between the two terms (Teece, Peteraf, & Leih, 2016). Teece (2019) noted that much of the business literature assumes operations under foreseeable conditions, and that while "recognising risk, generally ignore deep uncertainty", assuming both can be managed in a similar manner.

Risk is defined as the unpredictable and random factors with a direct impact on corporate performance, and can generally be identified and analysed using probabilistic, risk assessment tools based on the likelihood of an event occurring and the likely impact of such an event (Miller, 1992).

C-suite, executive and middle management in well run organisations are generally aware of the primary risk factors in their industry, and are able to plan ahead and put routines and procedures (ordinary capabilities) in place to address these (Irwin, Gilstrap, & Drnevich, 2022).

Uncertainty on the other hand, is more random, less easily identified and predicted, and refers to rare events external to the company which can have a disproportionate impact on corporate performance, often referred to as "Black Swan events" or "Unknown unknowns" (Taleb, 2007). Uncertainty increases risk and reduces the ability to accurately forecast company performance (Miller, 1992).

Environmental uncertainty is the inability to determine the probability of events in the future, largely due to insufficient evidence regarding cause and effect relationships and an inability to forecast the likely impact of actions taken by managers to mitigate these (Samsami, Hosseini, Kordnaeij, & Azar, 2015).

2.11. Dealing with environmental uncertainties using DCs

Recent research on the response of organisations to Covid-19 indicates the importance of "combining dynamic capabilities with organisational agility" to rapidly adapt to environmental uncertainty (Mero & Haapio, 2022).

Companies that have internal dynamic capabilities to deal with uncertainty constantly scan and analyse the business environment, and are able to adapt to the observed uncertainty and transform their business model to play to their strengths and reduce

exposure to threats (Teece, 2018). Eisenhardt and Martin (2000) reasoned that under conditions of low to moderate uncertainty, internal capabilities required to manage these are clear and non-repetitive, and consist of predictable, all-inclusive and established processes that have evolved over time.

In a complex and highly uncertain environment, dynamic capabilities are favoured over ordinary capabilities, which are more focused on the day to day optimisation of the value adding functions of the organisation (Akpolat, Soliman, & Schweitzer, 2016). Dynamic capabilities theory defines “deep uncertainty”, recognising that what needs to be done with minimum disruption to the organisation, is more important than “how to do it efficiently” (Teece, 2019). The emphasis is on selection of a simple, agile and pragmatic process or routine that works, rather than a more complex, embedded solution (Eisenhardt & Martin, Dynamic capabilities: what are they?, 2000).

This focus on simple capabilities allows managers to remain focused on the issues within the changing environment without needing to resort to old, familiar routines and past experiences that may not address the new changing circumstances (Eisenhardt & Martin, Dynamic capabilities: what are they?, 2000). Under conditions of deep uncertainty, managing is as much an art as it is a science, requiring logic, analysis, agility and imagination to establish resilient systems (Teece, Peteraf, & Leih, 2016). Ordinary capabilities in these conditions are short lived as competitors are quick to copy and adjust their business models to outcompete against first mover organisations (Gratton & Ghoshal, 2005).

Organisations that understand the external factors that generate uncertainty (for example, changes in government regulations, financial markets, cost inflation, competitor products, changing customer needs, labour demands, etc) are able to take a strategic view and plan accordingly (Irwin, Gilstrap, & Drnevich, 2022). Opportunities to address these factors might include product differentiation and segmentation to separate them in the market and gain competitive advantage (Teece, 2018). (Schneckenberg, Velamuri, Comberg, & Spieth, 2017) documented five approaches to manage uncertainty in business model innovation, namely, “customer centricity, value co-creation, capability evolution, ecosystem growth, and adaptive pricing”.

Organisations often compensate for environmental uncertainty internally through decentralisation of management control and adaptability of employees throughout the organisational structure, increasing the chances of survival when faced with uncertainty (Leih, Linden, & Teece, 2015). Mero & Haapio (2022) identified three internally focused

strategies to assist business-to-business companies during periods of unexpected uncertainty. These are 1) make sense of the situation internally and communicate with customers and stakeholders, 2) start with a simple solution and iterate with key customers, and 3) empower internal managers to “make decisions to reorganise structures and processes”.

During periods of deep uncertainty, established organisations can benefit by injecting outside perspectives into an internal management team (Teece, Peteraf, & Leih, 2016). New perspectives and knowledge is developed through a process of dynamic tension between both internal and external team members.

2.12. Chapter Conclusion

Through the literature review and a discussion of current literature, the relationship between strategy, business models, business model innovation and dynamic capabilities has been established. Dynamic capability theory provides a viable framework to investigate business model innovation using the sensing, seizing and transforming capabilities.

Dynamic capability theory provides insight into how organisations are able to deal with environmental uncertainty through innovation of the value creation logic of the organisation, and formulation and implementation of strategies and plans to outcompete in the market place. Carried out correctly, the BMI process builds long term resilience in the organisation.

People, and the unique experience they possess, are central to successful BMI. The entrepreneurial ability of the senior team is recognised as a key driver of business model innovation and implementation. Entrepreneurial managers recognise the need for business model change and drive company transformation through a process of learning, establishing an enabling company culture, BM design and strategic planning, adoption and implementation of new technology, and reorganisation of resources.

The research question to investigate the role of dynamic capabilities as internal drivers for business model innovation is demonstrably anchored in the academic literature, and warrants further research.

CHAPTER 3: RESEARCH QUESTIONS

This chapter addresses the research questions for the study.

The research questions for this study sought to address the core internal dynamic capabilities that critical metal mining companies have developed to create and innovate their business models, and to identify how this process was affected by external drivers such as environmental uncertainty.

An interview protocol consisting of seven questions was developed to guide the interview process, and is attached in Appendix A. The interviews were not restrictive however, and allowed participants to add further to topics if they had further insights they wished to share.

3.1. Framing question

"How innovative is the mining industry in general, and do you feel your company is a leader or a follower in the creation and adoption of new technology?"

The first question was framed to establish a baseline for impressions and attitudes towards technological innovation within the mining industry, and to compare these with innovation at an organisational level. This question was intended to provide an industry background and platform for a more nuanced discussion on the dynamic capabilities of the organisations, and how these have influenced BM design and BMI. The understanding of the responses would then be used by the researcher as a basis for comparison in approaches to business model innovation, and triangulation between participants.

3.2. Research question 1

"What is the role of dynamic capabilities as internal drivers of business model innovation?" (Foss & Saebi, 2018).

This research question was positioned as four questions in the interview protocol.

Participants were first asked to describe business model innovation in the context of their company, and then asked to describe how they identify new opportunities referring specifically to the 'sensing', 'seizing' and 'transforming' dynamic capabilities.

All questions was used by the researcher to identify common abilities, processes, routines or stuctures to define the dynamic capability microfoundations of the organisations, and to establish how business model innovation was enabled and carried out using these dynamic capabilities. Participants were encouraged to discuss entrepreneurial vision, top management team culture, unique experience, company culture and values to provide the researcher with data on how BMs originate.

3.3. Research question 2

"How is business model innovation affected by environmental uncertainty?"

Participants were asked to comment on how their organisations perceived and dealt with environmental uncertainty. This question enabled the researcher to understand how uncertainty as an external antecedent would influence the choice and evolution of a BM.

Chapter 4 which follows, outlines the research methodology used in this study.

CHAPTER 4. RESEARCH METHODOLOGY

4.1. Introduction

The aim of this chapter is to provide a broad description of the research methodology selected to address the research questions defined in Chapters 1 and 3, and supported by the literature review in Chapter 2. The literature review provided context and content for the design of the data collection phase of this research.

The methodology used addressed issues of data validity and reliability, and provided the foundation for the results section in Chapter 5, and a golden thread for the analysis section in Chapter 6.

Research design was underpinned by the ethical practices of the University of Pretoria, as approved by the Masters Research Ethics Committee (MREC) of the Gordon Institute for Business Studies (GIBS).

4.2. Research methodology and design

As the research question advanced in Chapter 1 is of an exploratory nature, this research study used an interpretivist approach consisting of semi-structured interviews and qualitative thematic analysis.

Interpretivism is an appropriate research approach for studying social phenomena including the behaviour of people and institutions in their natural environment, and by definition, is fundamentally different to the positivist approach used in the study of the natural sciences (Saunders and Lewis, 2012). The outcomes of an interpretivist approach do not necessarily define a solution, but rather highlight the personal experience of people and organisations in routine business environments and are often used to pilot more extensive and scientifically rigorous research.

The research design was structured to probe for gaps in the body of knowledge taking into consideration the limited time available to access senior mining executives and to complete the study.

This research study used exploratory design to gain insight into how critical metal mining companies deal with uncertainty in the business environment, using dynamic capabilities theory to understand how they innovate their business models to align to this uncertainty.

A mono method, defined as a research design using only one data collection method (Saunders and Lewis, 2012), was used in the interests of time.

Using the interpretivist paradigm as a guide, this research study set out to identify specific organisational dynamic capabilities through an interview process, and to establish how these impact and influence high level business model and business model innovation themes at a company level when faced with environment uncertainty.

An interview guide was established to facilitate one on one semi-structured interviews with the selected participants.

In this design, conceptual themes based on the experience of the individuals interviewed were distilled through an analytical process to provide context and meaning (Saunders and Lewis, 2012). Understanding of the research question was derived from the meaning attached to events and experiences of senior executives within the industry. Using inductive reasoning, raw data was associated and merged into themes, with relationships established between themes and conclusions summarised by establishing a framework describing the processes identified in the raw data (Thomas, 2006).

4.3. Population and setting

A population is defined as a set of components, participants, organisations or places forming a data set, and to which specific research conclusions can be assigned (Leedy & Ormrod, 2001).

The population for this study was individuals within the mining ecosystem network, with specific exposure to the critical metal sector.

Research was carried out in a natural, real-life setting as a qualitative study with no experimental or control groups.

4.4. Sampling frame and / or criteria

Saunders & Lewis (2012) indicate that a sample needs to be selected on the basis that it is a representative sub-set of the selected population.

Qualitative studies can use either probability or non-probability sampling methods.

Probability sampling refers to the randomised selection of a sample from a population with subjects in the population having an equal probability of being selected, whereas

non-probability sampling is a sampling method involving non-randomised sampling where not all members of the population have an equal probability of being selected (Saunders & Lewis, 2012).

A purposive sampling technique has been selected for this research study. Purposive sampling is a non-probability sampling method relying on the sound judgement and experience of the researcher to select representative samples for the study (Saunders & Lewis, 2012).

A criticism of non-probability sampling is that it is based on subjective selection, and the researcher is not able to evaluate the representivity of the sample (Welman, Kruger, & Mitchell, 2005). Disadvantages of purposive sampling include “vulnerability to errors in judgment by the researcher”, “low level of reliability and high levels of bias” and “inability to generalise research findings” and as a result are not very popular in business studies (Saunders & Lewis, 2012).

This methodology was however deemed appropriate for this study as the literature linking environment uncertainty, dynamic capabilities and business model innovation is not well developed (Haarhaus & Liening, Building dynamic capabilities to cope with environmental uncertainty: The role of strategic foresight, 2020). While the study is positioned within the mining industry, the business case is limited to a smaller sub-set of companies with direct exposure to the metals critical for the transition from fossil fuels to renewable energy sources.

A list of potential critical metal companies to approach was compiled based on professional and social media (LinkedIn) contacts within the industry, and a sampling frame was established to monitor recruitment and eligibility / availability of participants to take part in the interview process. Company representatives approached for interviews were drawn out of the C-Suite (CEO, CFO, COO or CIO) or executive level management with responsibility for corporate development and strategy, sampling one to three top management team decision makers per company. Care was taken to approach managers with experience and knowledge of dynamic capabilities of their organisations, and how these DC’s have been deployed to innovate, modify and strengthen the business model of their organisation thus differentiating the organisation from its competitors through corporate, business unit and functional level strategies (Teece, Business models and dynamic capabilities, 2018).

Saunders & Townsend (2016) examined standard practice regarding the optimal number of interview participants for qualitative interviews at an organisation and workplace level from a review of 248 peer reviewed studies. They note that there are three ways of

defining the optimal number of participants explicitly, being “citing expert opinion”, “citing precedence set by similar studies” and by “demonstrating saturation”. Saturation, also refferred to as Informal Redundancy, is defined as the point at which limited or no new insights are added to the research question or variable being investigated.

For Saunders & Townsend (2016) an optimal number of between six and twelve participants is considered a minimum to reach saturation for relatively homogenous populations. For heterogenous populations implying differences in gender, experience and commodity focus as it pertains to this study, Saunders & Townsend (2016) suggest a sample size of twelve to thirty participants.

A target population of 12 participants was defined for this study using Saunders and Townshend’s lower limit.

4.5. Level and unit of analysis

Units of analysis are defined as the major entity being studied either as people, groups, companies, organisations, units of production or events (Welman, Kruger and Mitchell, 2005).

While this research targets organisation level responses, the sample unit was senior executives and managers within the critical metals mining industry with exposure to, and with in-depth knowledge of how corporate / organisation level dynamic capabilities are used to align and innovate their business models in times of uncertainty.

4.6. Data gathering process to be used and research instrument

A qualitative data gathering process was selected for this study based on completion of interviews with identified participants from within the mining industry. An interview guide with seven open ended, exploratory questions was compiled (presented in Appendix A) and used in semi-structured interviews, which were recorded and later transcribed.

Ethical clearance was applied for from the Masters Research Ethical Committee (MREC) before commencement of the interviews. Once ethical clearance approval was received (presented in Appendix B), identified participants were sent an email with information on the nature of the study and an informed consent form (presented in Appendix C), which needed to be signed by the participant as a record of their agreeing to take part in the interview process. Upon acceptance and return of the completed informed consent form, a date and time for the interview was scheduled.

The interview questions were sent to the participants prior to the interviews being conducted, allowing for the participants to understand the basis of the research in the context of their organisations.

Interviews were limited to a maximum of 60 minutes per participant and were carried out virtually using the Zoom online communication platforms. The interviews were recorded directly to the cloud, and then downloaded later as audio recordings to the researchers' PC. At the outset of the interview, the researcher described the background and objectives of the research and what was expected of the participant, who were then given an opportunity to ask questions before the start of the interview. Participants were assured anonymity and confidentiality as per the informed consent form, and that they had the right to stop the interview at any time should they not be comfortable with the questions being asked.

Interviews were transcribed into Microsoft Word documents by a third party transcription service, who signed a confidentiality agreement before commencing the work. Audio recordings and transcriptions of the interviews have been stored on a personal external hard drive device using a generic, non-specific file naming convention i.e. Transcript_Participant 01_Researcher name_Date, Audio Interview_Participant 02_Researcher name_Date, etc. Digital transcriptions have been uploaded to the GIBS server for permanent storage as per the rules of the University of Pretoria.

4.7. Data analysis approach

The two commonly used data analysis approaches used in qualitative studies are content analysis and thematic analysis (Braun & Clarke, 2006).

Content analysis is a descriptive analytical tool that uses digital word processing tools to code and categorise transcribed data into word patterns, themes or concepts allowing researchers to analyse the presence and relationships of these themes or concepts (Vaismoradi, Turunen, & Bondas , 2013). Thematic analysis is commonly used as an alternative to content analysis, and is a descriptive tool involving selection of codes and construction of themes that searches data sets to identify, analyse and interpret word patterns (Braun & Clarke, 2006).

Thematic analysis was carried out using using an Atlas.ti software licence provided by the University of Pretoria IT department. Coding was carried out through a process of inductive coding using the Braun and Clarke framework to code phrases identified as BM / BMI constructs, dynamic capabilities and environment uncertainty concepts and

themes. Codes were initially generated based on the language usage and phrasing of the initial participants, and progressively refined with subsequent transcripts. The process involved an initial iterative ("read-check-read") assigning of descriptive codes and categories (Maquire & Delahunt, 2017).

Related codes were then grouped into categories describing skills, activities and processes at an individual and an organisation level and categorised into first order concepts using a coding frame based largely on the DC microfoundations and the frameworks modified from Khan, et al., (2020) as presented in Figures 9, 10 and 11 discussed and presented in Chapter 2. This allowed the researcher to move from specific codes to a more conceptual grouping of data into themes, categories and constructs which were then used in the findings, discussion and conclusion chapters.

4.8. Research quality and rigour

Research quality relied on developing and refining an interview protocol, with exploratory questions designed to answer the research question stated in clear, unambiguous, non-academic language. The protocol was piloted in advance to test for consistency and ease of understanding as well as timing of the interview.

The validity of the research findings were tested against the five quality control questions proposed by Saunders & Lewis (2012) involving checks for 1) a logical flow / golden thread evident from the data through to the conclusion, 2) consistency between data and summarised responses, 3) compatibility between data collected and research methodology, 4) research methodology alligned to the research strategy, and 5) linkage between research strategy, research questions.

Conclusions coming out of the research were tested against the data and analysis through a process of comparison, cross interview analysis and data triangulation, and tested for validity, reliability, generalisability and objectivity.

4.9. Study limitations

Purposive sampling was used in this study as an explorative methodology to draw out themes in the study of dynamic capabilities and business model innovation, specifically under conditions of environmental uncertainty.

The nature of purposive sampling is such that the researcher is not able to validate the representivity of the sample, and the research is reliant on the judgement and experience of the researcher to select representative samples for the study. It is possible that other researchers would select their samples differently, and as a result, the research findings may not be applicable to a wider grouping of similarly positioned companies.

In order to reduce the potential for sampling bias, respondents were selected from a pool of mining companies based in South Africa, Australia, Canada and the UK with mining operations in Africa, Australia, North and South America. It was a desired outcome of this research that the insights derived from this varied sample with geographical, commodity and experiential diversity would produce an enhanced understanding of how companies transform and innovate under conditions of environmental uncertainty.

CHAPTER 5. FINDINGS

5.1. Introduction

The findings of the research study are presented in this chapter.

Constructs and key points (or microfoundations in the case of the dynamic capabilities) from the Atlas.ti analysis discussed in Chapter 4 are covered in this chapter in terms of a description, evidence and a summary. Quotes have been selected as evidence to illustrate key findings from the research questions.

Findings in this chapter have been organised into 4 sub-sections, namely, a) Framing question - Innovation in the mining sector, b) Research Question 1, c) Research Question 2, and d) Conclusion.

5.2. Detail of interview participants

All participants were senior mining executives and managers working in the critical metals mining sector in both listed and unlisted small to medium sized companies, referred to here as either junior mining companies or mid-tier mining companies respectively (see definitions in section 5.3).

Participants were primarily selected on the basis of their seniority in the critical metals sector, with the majority of participants drawn from the C-suite of their respective companies. Participants were drawn from a number of countries (Australia, Canada, South Africa, UK, and US) with projects across Southern and Central Africa, Australia, North and South America.

All participants were male, and had a minimum of a 4-year tertiary qualification in the sciences (geology, chemistry), engineering (civil, mining, metallurgy) or in business (accounting, economics). Experience ranged between 16 and 43 years, with an average of 27.5 years.

Table 2 provides an anonymised breakdown of the interview participants with detail of their experience and nature of the companies they represent.

5.3. Definitions

The following definitions are based on commonly held meanings within the mining industry.

Critical metals or *minerals*, sometimes referred to as *technology metals* (collectively referred to in this study as *critical metals*), refer to those metals used in technology that are subject to supply risks, and for which there are no easy substitutes. In this study, the term is used to describe those metals critical for the energy transition from fossil fuels to renewable energy sources and for rapidly expanding technology, and include copper, nickel, cobalt, lithium, tin, vanadium and rare earth elements. Platinum group metals (pgm's) are included in some definitions due to their extensive use as auto catalysts in the automotive industry, but were not sampled in this study.

The term *junior mining company* refers to mining companies that are primarily involved in the early prospecting or exploration stages of mining development, and are the mining equivalent of a tech start-up with high risk associated with these early activities. They are often focused on a single commodity and limited to one or two early stage development projects. Junior mining companies have a high risk / high reward profile (if successful) and are frequently viewed as potential M&A targets by larger companies. Listed junior mining companies will generally have a market capitalisation of less than US$500 million, generating revenue of less than US$50 million per annum if already mining

Mid-tier mining companies on the other hand are associated with development and producing mining assets, and can have more than one producing asset across a basket of commodities in its mineral asset portfolio. Mid-tier mining companies typically have a lower risk profile compared to junior mining companies. Mid-tier companies generate revenue through sales of mineral products with annual revenue of US$50 million to US$500 million, with a market capitalisation of between US$500 million and US$2 billion.

Major mining companies tend to operate large producing mines with multi-decade operating horizons and consistent output. They are well funded with a diversified portfolio of global assets, generating more than US$500 million revenue per annum and market capitalisations greater than US$2 billion.

A *mineral resource* refers to a naturally occurring deposit of minerals containing metals of economic value, and is discovered through a process of exploration and drilling activities. Samples are collected and analysed to establish quality and size of the

deposit, and will also be used for metallurgical bench scale and pilot test work studies to establish if the metal is economically recoverable.

Mining companies will establish a project team to take the mineral resource through a sequential stage gate process of knowledge creation and *research and development* (R&D), starting with a *preliminary economic assessment* (PEA) or *scoping study*, followed by a *preliminary feasibility study* (PFS) and a *bankable feasibility study* (BFS). It is not uncommon for studies to be further optimised, either as an *optimised bankable feasibility study* (OBFS) or as a *definitive feasibility study* (DFS).

Each stage is progressively more detailed with larger budgets and longer completion schedules resulting in greater confidence and lower risk. It is not uncommon in the mining industry for the full stage gate process to take up to 10 years from discovery to construction and start-up of mining activities, costing many millions of dollars.

A PFS typically reviews multiple scenarios consisting of alternate mining, processing and refining methods, with the selection of an optimal base case. The BFS process will develop the base case further, providing detailed design and capital / operating cost estimates, and will typically be used to raise project finance, either through a combination of a rights issue (equity) and corporate debt.

The role of top management and the board is essential in this feasibility / stage-gated process, with go / no-go decisions to proceed to the next level of study being governed through an approvals framework.

Table 2. Interview participants' information

Interviewee Name	Experience in the mining industry	Position held	Additional Information
Participant 1	32 years	Director of Operations	Participant 1 is the Director of Operations for an unlisted mining investment company providing permanent capital (as opposed to venture capital or private equity) by investing across the technology metal value chain including upstream mining production and downstream battery manufacturing. He previously worked in the cement and copper mining industry as a CEO and COO in the Southern African region, as well as in the financial services industry as a financial analyst.
Participant 2	32 years	Chief Executive Officer (CEO)	Participant 2 is the CEO of a listed mid-tier copper mining company with producing mining assets in North and South America. He is a mining engineer who previously worked for one of the majors as the CEO of one of their large divisions, before completing a management buy out / private equity deal on two of their mining assets in South America. These assets were held in a private company for 6 years before merging with a TSX listed entity with complimentary assets in South America in early 2022.
Participant 3	18 years	Senior Vice President (SVP), Corporate Development	Participant 3 works closely with Participant 2, having joined the company in 2021 prior to the merger. He has a background in economics and politics, and has worked in financial roles in the mining and renewable energy industries, focusing largely on M&A deals in the precious metals environment.

Participant 4	20 years	CEO	Participant 4 is the CEO of a listed mid-tier mining company with a tin mining asset in Central Africa. He is a chartered accountant (CA) with a corporate finance background. He was previously the CFO for a mid-tier mining company with copper and cobalt assets in Central Africa.
Participant 5	23 years	Chief Operating Officer (COO)	Participant 5 is the COO of a listed junior mining company with tin and lithium mining and development assets in Southern African. He is a mining engineer who was previously a director of a mining consulting company.
Participant 6	18 years	Chief Financial Officer (CFO)	Participant 6 is the CFO for the same company as Participant 5 and is a chartered accountant. He recently joined the company but has extensive experience in the mining, metals and energy industry as a financial executive with experience in restructuring and turnaround strategy. He has also worked for copper mining and metals trading companies with a footprint in Central Africa.
Participant 7	34 years	CEO	Participant 7 is the CEO of a listed rare earth element (REE) junior mining company developing a mining resource in the Southern African region, while developing a vertically integrated rare earth refining and permanent magnet supply chain strategy in the UK. He is a metallurgist with previous experience as CEO and director of a number of diamond and gold mining companies in the Southern African region.
Participant 8	43 years	COO	Participant 8 is the COO of the same company as Participant 7. He is a veteran of the rare earth element industry and was previously CEO of a rare earth development company with a mineral resource in East Africa. He is a process engineer and is

			working closely with the feasibility and construction teams for the mine and refinery to implement the company strategy.
Participant 9	16 years	Chief Commercial Officer (CCO)	Participant 9 is the CCO of the same company as Participants 7 and 8. He is responsible for the development of the global supply chain and offtake markets for the products to be produced by the company. He is a chemistry graduate with experience in supply chain development and procurement in the UK.
Participant 10	32 years	Managing Director (MD)	Participant 10 is the MD of a listed vanadium junior mining company, and is developing a vanadium resource in Western Australia. He is a geologist with many years of executive management experience. The company has a vertical integration strategy, and has established a subsidiary focused on development of grid scale vanadium redox flow batteries.
Participant 11	36 years	Chief Geologist	Participant 11 is the chief geologist for a listed junior mining company with lithium exploration and development assets in the Southern African region that were recently sold to a Chinese company. The company has now commenced a search for new projects in the Southern African region, and an expansion into North America. He was previously technical director for a gold and base metal mining and exploration company in the Southern and Central African region.

Findings from the participants' responses during the interviews are covered in the following sections as evidence in the form of direct quotes arranged according to the research questions outlined in Chapter 3.

5.4. Framing question – Innovation in the mining industry

"How innovative is the mining industry, and do you feel your company is a leader or a follower in the creation and adoption of new technology?"

This question was framed to establish a baseline for impressions and attitudes towards technological innovation at an industry and sector level, and how this impacts on BMI.

5.4.1. Participants view of innovation in the mining industry

As a general statement, Participants 2 and 9 felt that the mining industry was historically not particularly innovative in the use of new mining and processing technology due to the high upfront capital intensive nature of the business.

> ***Participant 2****: "Historically the mining industry has been very slow to embrace technological change, and there is a bunch of reasons for that, it is a business that has a lot of risks and hazards involved, and ad hoc trying new things carries risk with it. You also typically invest a huge amount of capital upfront and so it is not that conducive to, when new technology pops up, reinvesting against the capital that has already been spent."*

> ***Participant 9****: "Comparative to some other industries I would say it [the mining industry] is behind the curve. In some arenas, I think they have the ability to innovate in certain steps but still there are risks involved in it, right – so when you are developing a mine and seeking investment, it is risky to try new technology."*

There was a sense, expressed by Participants 2 and 3, that the level of innovation within the mining industry was experiencing a shift as a result of increasing costs and the competitive landscape getting more difficult.

> ***Participant 2****: "[….] it is still an industry that is going to need quite a lot of reset in its way of thinking and operating to actually facilitate it being able to embrace innovation more quickly."*

> ***Participant 3**: "I don't think the mining industry is a standout in terms of innovation. I think that being said you know, people generally, they like to do things better with fewer resources [costs], and there has been for sure a lot of innovation over the last 100 years but not nearly as much as what would certainly stand out in other industries."*

Participants 3 and 10 recognised the technological advancement being made by larger companies with the balance sheet to fund new ideas, take risks and experiment.

> ***Participant 3**: "I think most of the useful innovation; the leadership comes from the larger companies. And I think is for easy to understand reasons – you need to have size, scale, financial capacity, the ability to cover overhead on potentially innovative projects, risk taking over a number of years to have people dedicated to stuff – that sort of thing – that is not where smaller companies stand out."*

> ***Participant 10**: "I think that the mining industry is more innovative than it gets credit for. I definitely think so – and that is not necessarily geographic – I think that maybe in our context here in Western Australia where we have a lot of examples of innovative behaviour at the larger end in particular with companies like [the iron ore majors], really using this environment as a test bed for things like automation and trucking, improving their logistical software systems, dynamic systems and so on in a very, very innovative way."*

5.4.2. Participants view of innovation in the critical metals sub-sector

Participants noted that development of new supply capacity to the niche battery metals (lithium, cobalt, vanadium) and permanent magnet metals (rare earths) end-users would likely come from mining projects that have not been developed in the past due to complexity in their basic mineralogy, mode of occurrence, geographical location or poor economics.

The major mining companies have tended to avoid investing in the niche markets, such as lithium and rare earths, due to the relatively small market size and high price volatility of these metals. Consequently, new production has been left to entrepreneurial junior

and mid-tier mining companies to develop, often requiring innovative processes to produce a product to the correct specifications for downstream customers.

Participants 8 and 9 noted that their companies are having to balance the level of novel technological innovativeness that they can apply in their processes, with the availability of capital due to conservative credit risk processes applied by lenders.

> ***Participant 8****: "It is somewhat difficult for mining companies to be too much of a leader because they have a difficult time showing what their financial outcome is going to be if they take on technology that hasn't been used in the past. So today there are a number of these people out there that are touting new technology that is going to be replacing this and replacing that. I doubt they are going to get financing for that, because nobody has demonstrated that that is going to be usable yet. So it is difficult, it is kind of like the chicken and the egg. I think they find it difficult."*

> ***Participant 9:*** *"[….] so for example there are plenty of rare earth projects out there, you are talking about different separation technologies but that, if it hasn't been proven, you won't get finance. So you have got to be very risk averse when you are developing a project and it's going to be using traditional techniques and technologies."*

5.4.3. Disconnect between upstream and downstream innovation

Three participants, succinctly summed up by Participant 5, felt that this divide in allocation of capital is partially to blame for the slow response time from mining companies to react to changes in demand from downstream users.

> ***Participant 5****: "I've given it a bit of thought and my sense is because the mining industry is at the start of the supply chain, it is somewhat removed from the end user, and it is particularly relevant for commodities like lithium where you have a fairly long value chain. So by virtue of that, the mining industry tends to be quite insensitive to changes in technological developments downstream, and it takes quite a long time for those technological developments or information to flow up the value chain, and to be translated into changes in the mining supply."*

Participant 6 noted that because of this downstream shift of innovation, mining companies have tended to focus on their ordinary or operational capabilities to provide raw materials as cheaply and efficiently as possible, with a lot of effort going into optimisation of existing mining processes, debottlenecking of metallurgical processes and managing of on-mine unit costs.

> ***Participant 6****: "I think overall, mining companies are innovative and that is in a traditional resource sense, because they needed to drive operating costs down for those traditional resources, especially if the prices of those resources are in the balance sometimes for their operations."*

This will unfortunately not address new supply requirements, and critical metal markets are likely to remain constrained for the next 5 - 10 years.

5.4.4. Summary of findings of the framing question

Participants noted that while the major mining companies were showing increased levels of innovation, the smaller mid-tier and junior mining sector has not been as innovative.

As demand for critical metals increases, supply will need to come from mining projects that have not been developed in the past due to complexity in their basic mineralogy, mode of occurrence, geographical location or poor economics. The relatively small size and price volatility of critical metals markets has kept the cash-flush major mining companies out of this sector, leaving it to the junior and mid-tier mining companies to develop.

Technological innovation that could potentially facilitate development of these new projects has been stalled by an inability of smaller companies to raise finance for complex and untested technology.

The net effect of this risk aversion and lack of investment has been to push technological innovation away from the mining process and closer to the end-product user. This has had the effect of leaving junior and mid-tier mining companies disconnected from the end customer, restricted in their ability to innovate using new technology, and unable to respond to increased demand.

This has created a 'wicked problem' for the critical metals producers and customers alike, requiring higher order thinking and dynamic capabilities to solve.

5.5. Research question 1

> "What is the role of dynamic capabilities as internal drivers of business model innovation?" (Foss & Saebi, 2018).

Research Question 1 was structured as four shorter questions in the interview protocol using BMI and dynamic capabilities (*sensing*, *seizing* and *transforming*) as the core constructs.

Participants were first asked to describe business model innovation in the context of their company, and then asked to describe how they identify and act on new opportunities, referring specifically to the sensing, seizing and transforming dynamic capabilities.

Participants were probed to comment on entrepreneurial vision and organisational culture to provide the researcher with data on how BMs originate.

5.5.1. Research question 1.1: Drivers of BMI

Participants were asked to comment on business model innovation within their companies, and the high level factors influencing selection of their business models. This section identifies some of the external drivers of BMI in the critical metals mining sector, and provides a platform to establish a more robust understanding of the internal drivers of BMI dealt with in subsequent sections as dynamic capabilities.

Divergent views were expressed on what factors were most important in BM selection and BMI. These have been grouped into five major categories from the Atlas.ti thematic analysis as illustrated in Figure 13, namely, a) context defined by the business environment, b) the VRIN nature of the resources available, c) the capabilities and processes of the organisation, d) understanding the value chain, and e) the limiting factors associated with technology, ESG and financing uncertainty.

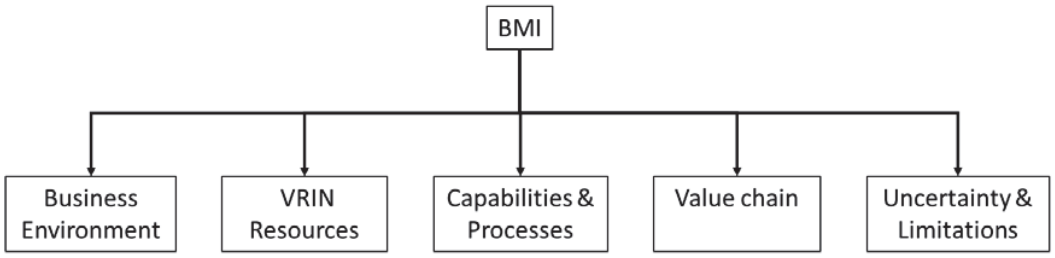

Figure 13. Key business model innovation themes identified in this study (Author's creation).

5.5.1.1. Business environment as a driver of BM and BMI

Participant 3 noted that BM creation is guided by an understanding of the core business of the organisation, where the future opportunities lie and its flexibility to make changes.

> ***Participant 3: "****But what is the core business that we are in and that we want to be in in the future, and how much room do we have to make changes there, potentially adapting to where we see opportunities and the theme around decarbonisation which no question, we are very keen on, and view as a great opportunity for us."*

Participant 2 noted the importance of context, and the business environment a company is operating in when considering business model innovation. The business environment is an external driver of BMI, with varying responses of organisations to these external stimuli.

> ***Participant 2****: "I have had the opportunity over the last sort of 30 years to be involved in multiple different business models – so 25 of those [years] were with [large major company] but in multiple different business units and what I have tried to do from that and how I have looked at things in the new company that I have set up, is to really try and distil what is effective and how it is effective in different contexts, because context is also important in terms of what business model works."*

Part of the context is understanding the unique geopolitical environment and political-economy within which the organisation operates as described by Participant 11.

***Participant 11**: "So our story is a geographic push, we are basically a team of Zimbabweans, our senior project engineer is South African [….] so we push that as our thing – that we can operate in Zimbabwe. And that has given us success, that gives us eyes and ears on the ground and the ability to operate during hyperinflation and no fuel and minor things like that – which have literally killed a couple of junior companies."*

5.5.1.2. VRIN resources as a driver of BM and BMI

Participants 8 and 10 recognised the importance of the VRIN resources of the company as a driver of BMI, including unique geographic location, regional infrastructure, and geological features of the mineral resource. These were recognised as internal drivers of BMI, and key inputs in the mining process.

***Participant 8**: "Every deposit is different, so you have to go in with your eyes wide open, you have got to find out what problems you have got, based on the impurities that are in your ore body, and kind of what the logistics are around the areas that you are doing these things. We have great logistics; you know we are around a rail line [with a direct link] to the port. We have an opportunity to do hydroelectric – so we have some really good advantages."*

***Participant 10**: "So understanding of the ore body and its limitations in a very factual way, but like right from how much metal is there, getting a really good handle on that."*

"So that is we think one of our innovations and strengths that we have inside the company, is our geo-met understanding and that extends across the metallurgical team and it is quite fundamental because it is your factory, right? So if you get the factory dynamics wrong you are going to be in trouble."

5.5.1.3. Unique processes and capabilities as drivers of BM and BMI

Participant 10 described the process his company used to select and innovate their business model. In this case, the BM wasn't immediately obvious, but rather emerged over a period of time as knowledge was added through research and various options

were tested and iterated. These were recognised as internal drivers of BMI, and are discussed further in the findings for sensing dynamic capabilities (research question 1.2).

> ***Participant 10**: "So in our case we started off with the existing businesses that are operating in our space; so we only have a number of limited examples in the vanadium space, but one is in Brazil, two are in SA. So all of those three provided us with an example if you like of how they currently do things."*
>
> *"So we looked at what could we vary in that business, what opportunities did our location and our ore body provide, to vary that – and if we did it the same way they did, [….] what was the likelihood of us succeeding or failing on that basis?"*

Participant 2 described the core components of his company's BM as being a combination of a number of internal managerial capabilities focused around a highly communicative, decentralised, agile organisation that is able to move fast with empowered people making the critical business decisions. These were recognised as internal drivers of BMI and the findings are described further in the findings for transforming dynamic capabilities (research question 1.4), and also as capabilities that are essential during periods of deep uncertainty (research question 2).

> ***Participant 2**: "So when we look at unique dynamic capabilities, I am not sure we have any that are unique, but I think possibly ultimately the combination of the capabilities we have may be unique. So ultimately it is putting together a combination of capabilities that differentiate oneself from the others."*
>
> *"And I would put our capabilities in I would say four buckets. So the first one is culture, the second one is operational excellence. The third one is – and this is something fairly particular to us – is project execution capability. And then the fourth bucket I would say is ESG and permitting capability and that to me is a must, to sort of succeed in mining today, both to build mines and to successfully operate them."*

5.5.1.4. The value chain and downstream markets as a driver of BM and BMI

A very strong BMI theme identified by participants was the complex separation process of the critical metals supply chain (specifically, battery metals from lithium and vanadium,

and permanent magnets from rare earths), and the opportunities for mining companies to align their business models with existing and new end customers. These were recognised as external drivers of BMI, and are described further in the findings for market uncertainty under research question 2.

Participant 5 elaborated on the importance of understanding the entire value chain, and its impact on product selection as a driver of the BM and BMI.

> ***Participant 5****: "I think business model innovation to me is two pronged: there is the more internal focus, in running your company and producing products as efficiently as possible, but I think innovation for us starts with understanding the whole downstream market and downstream market developments."*
>
> *"So it's quite a complex market and the whole value chain is also complex. Not a lot of people – at least miners – understand that value chain, and it has a direct bearing on what product you produce."*

Participants 9 and 5 identified the need for collaboration between mining companies and end users to bridge the gap in the supply chain. These were recognised as internal drivers of BMI, and are described further in the findings for seizing dynamic capabilities (research question 1.3).

> ***Participant 5****: "So mining companies need to explore downstream, and end users need to explore upstream, and they need to find the solutions both in terms of technology but also supply chain constraints to bridge that gap."*

> ***Participant 9:*** *"So the business model I would suggest is that you are making strategic decisions here to be placed for those magnet producers within Europe, which don't exist today, but they will. They will absolutely exist in the future. So taking your time to move further downstream."*

In some instances, the downstream processes and end use cases outside of China were not well developed. Participants 7 and 9 provided insight into how they have adjusted their BMs to bridge the gap between upstream suppliers (mining companies) and downstream customers (downstream manufacturers) through the creation and building

of new markets for their specific metals. The ability to identify new opportunities were recognised as internal dynamic capabilities, and are described further in the findings for sensing, seizing and transforming (research questions 1.2, 1.3 and 1.4).

> ***Participant 7****: "And we are talking about creating a new market here for rare earths that is going to impact the next five to ten years of the rare earth space as being something that nobody else has managed to do, with a caveat of the funding being sorted out in what is a particularly volatile market at the moment but we will get there!"*

> ***Participant 9****: "So we will be revolutionary in this space. So there is only one other company that is doing the separation of rare earths and we will move downstream very quickly. So the difference here is that there is an obvious desire to diversify supply chains within the market space; so offering something alternative is fundamentally the business model."*
>
> *"I am not saying China isn't important in the supply chain moving forward, but we are offering something different and that is the business model which is different."*

5.5.1.5. Choice of technology, ESG compliance and financing limitations as a driver of BM and BMI

Participants 7 and 8 noted the impact of using familiar technology on the selection of the BM, and as a driver of BMI. These are described further in the findings for environmental uncertainty (research question 2).

> ***Participant 7****: "But I would say the key drivers have been innovation around utilising de-risked processing methodologies within the rare earths sector that are recognisable outside of the rare earth sector, in order to be familiar enough for financiers and others to understand that the process risk etc, is de-risked."*

> ***Participant 8****: "I think having technology that you can show people, you have the pilot work that is done and you can show the results of that and you can basically show that similar plants have been started and functioning."*

ESG was recognised by a few participants as having a significant impact on the ability of critical metal companies to raise project finance, with ESG requirements carrying a similar weighting to the need for derisked or proven mining / processing technology. Participant 7 provided insight into the way in which pressure from funders and investors has influenced their approach to ESG issues.

> ***Participant 7****: "It has been a multifaceted thing. It is not just on the technical capacity side of things; it has been alongside a strong drive on ESG, recognising that you are only as good next year as your sustainability policy is this year, in terms of making sure that you are aligned to preserving your business, and bettering the communities within which you operate."*

Participant 1 recognised the importance of finance and investing in the critical metals value chain, describing both as the '*fabric within which the value chain rests'*, and recognised the uncertainty created by the *push-pull* factors between funding, technological innovation and ESG.

> ***Participant 1****: "And at the bottom of the pile [….], you have got the producers. Then there is the next level, very, very broadly, which are the users of the metals. And then the third layer, which isn't even a layer, it is more kind of a fabric in which it all sits if you want, is the capital and financing of all of that. So those are the three very broad kind of stakeholders in this. And if you are talking about the concept of uncertainty, the question is whose role is it within that mixture to deal with the uncertainty?"*

5.5.1.6. Summary of findings of research question 1.1

It was noted by participants that BMs aren't immediately obvious, but rather emerged and developed over a period of time as knowledge was added through research and market intelligence, and various options were tested and iterated.

The geopolitical landscape and unique features of the political economy (context / business environment) of the country in which the organisation is located was identified as having a significant influence on BMs and BMI, and could potentially be both a mediating or a moderating variable.

The unique resources of the company, largely related to the geological and metallurgical features of the mineral resource, were recognised as influencing factors in the selection and innovation of the BM.

Combinations of managerial capabilities and processes were described as drivers of BMI, allowing companies to compare resources with their competitors to define what works and what doesn't in their unique context, and to iterate options.

A deep understanding of the critical metals value chain, how the company's products are positioned and the value that they offer was acknowledged as key considerations for BM selection and BMI.

Finally, financing, technological innovation and ESG were identified as being interlinked and potentially acting as limitations (moderating variables) on BMI through their influence on the ability of critical metal mining companies to raise finance.

The next 3 sub-sections focus in on the internal drivers of BMI in the context of the dynamic capabilities theory framework.

5.5.2. Research question 1.2: Sensing dynamic capability

Participants were asked to describe how they identify new opportunities using the sensing dynamic capabilities, and the role these play in business model innovation.

A number of microfoundations of sensing were identified from the thematic analysis and summarised in Figure 14, namely, a) the importance of an entrepreneurial mind set, b) monitoring of the market and changes in technology, c) knowledge creation and generation of new ideas, and d) the importance of experience and learning.

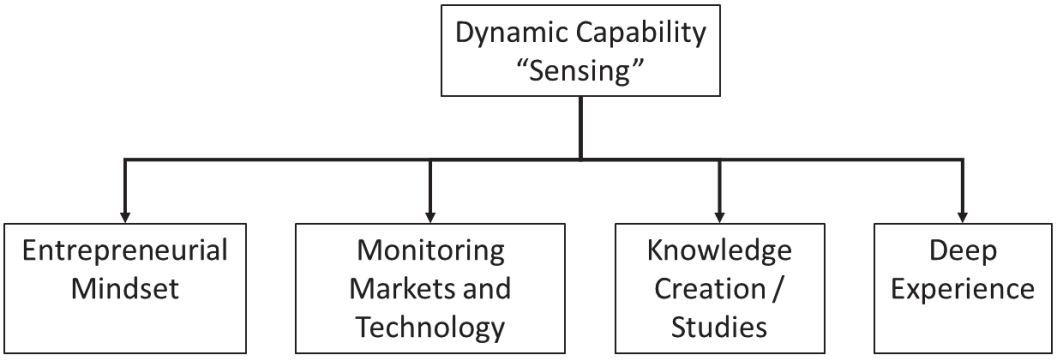

Figure 14. Key sensing dynamic capabilities identified in this study (Author's creation).

5.5.2.1. Sensing requires an entrepreneurial mind set

Participants highlighted that in larger organisations, the seeking out of new opportunities (sensing) is often assigned to a business development department or division with global responsibilities for mineral exploration, identification and follow-up of prospective target resources or companies. In smaller organisations and specifically in the junior mining company environment, however, sensing and seizing activities are often combined in an agile, rapid decision making process involving senior executives and board members.

> ***Participant 10****: "Well it is something that I do, and my chairman does. So my chairman will bring things to my attention, and I will do the same. It is not only me, but I think I am the one who follows them up in the organisation at present."*
>
> *"So when we see an opportunity, we reality check it, whether it is an M&A opportunity, an opportunity within the vanadium flow battery space, a collaboration, we get on the ground and we just go for it. And I then from my point of view, reality check it, get a bit of a feel about how the board is feeling about it, if it is a 'no - back off and stick to your knitting', or if it is something we think we should go for then we just take it to the next level."*

Participant 7 identified how sensing requires foresight and entrepreneurial vision of the founders of exploration / mining start-up companies to recognise opportunities based on a long term view of demand for specific metals, and the emergence and growth of new technological applications.

> ***Participant 7****: "Mining by nature generally follows commodity cycles, as opposed to creating them. However, in the junior mining company space the innovation occurs in the likes of exploration and early stage development entities that take a view that in five or seven years' time there is going to be an opportunity that is going to be worth something beyond what people see in the market at the moment."*

Participant 4, 5 and 9 described how this entrepreneurial activity requires the right mind set in core individuals within the organisation. Sensing was viewed by participants as an entrepreneurial capability, constantly looking for new opportunities and ways to capture new value. In the early stages of a company's development, entrepreneurship is a core

character trait of specific individuals that progressively becomes embedded in the DNA of the organisations.

> ***Participant 4**: "So it starts with backing guys that think at a high level, right? And if you don't have people in your organisation that can think at a high level then it is just not going to happen, there is not going to be any entrepreneurial thinking. And that is where it starts and ends. So we put a lot of effort into backing guys that can think out of the box, guys that are curious, guys that consistently and always look for something to improve on this or that."*

> ***Participant 5**: "So you have to start off with people that have that entrepreneurial capability, and then build a team around it. As we now develop, we realise we are quite strong on the entrepreneurial side, but we may lack the skills to run a stable sort of operations – so now we are running that part as well, but that is easier to effect because you have got people coming from big organisations, they are looking for new opportunities."*

> ***Participant 9**: "So it is about selecting people that have a hunger to develop things very quickly. You can't join a business at this stage of the kind of product or business life cycle, without being entrepreneurial yourself. So very much in interview stage you need to be looking for people that are willing to take that risk and willing to look at the ability for a company to change direction quickly – and that leads into your entrepreneurial development, I think."*

5.5.2.2. Sensing requires monitoring of the market, opportunities and changes in technology

Participants identified that the sensing capability requires an understanding of customers' requirements, the supply and demand dynamics of specific metals and the opportunities that exist based on societal trends, growth of specific technologies and metal usage associated with these technologies.

Participant 4 identified the collection and analysis of market intelligence as an internal dynamic capability, allowing senior executives to develop a robust appreciation of specific metal markets.

Participant 4: *"So we look at it fundamentally in terms of who produces the particular metal, what is the landscape looking like in terms of supply, has there been investment, has there been exploration and will demand go up or down going forward."*

"So we as the executive do it amongst ourselves you know. We read these reports and we get data and the like. We do our own research, we think about things, we think about things a lot, [….] we debate it, we look at it, we pull it apart, get an opinion around it and then back it or not."

"So we keep it simple and apply fundamental basics to forming an opinion as to whether we should invest into something and add to the global supply or not."

Networking and interacting with a wide global ecosystem was recognised as a valuable information source on trends and technology developments. Participants 9, 11 and 4 indicated how this can be carried out by talking directly with potential customers.

Participant 9*: "The things that we have that are massively advantageous for us is that not only have we distributed across the globe and gathered multiple inputs and information, but we are able to interact on things very, very quickly, it doesn't take any time at all."*

"[….] and then bringing my view of what the customers' requirements are – because essentially, we are going to be a customer led organisation, we will still be looking towards the automotive sector or wind energy sector or robotics sector to show where we need to be."

Participant 11*: "So we have picked up experience on who can be trusted and who are good offtake partners etc [in the lithium markets], so we have built up by the hard yards, and again as I have made clear to our guys, we haven't got that expertise yet of the other [metals]."*

Participant 4: *"[….] but it is also through your networking and talking to people and hearing things you know, and then sort of joining the dots as to whether there is an opportunity or not."*

Participant 5 described the process his company used to follow up on new opportunities as a structured process with specific checks, while other participants described a more organic process, subject to the specific knowledge and bias of one or two individuals in the organisation.

> ***Participant 5:*** *"I would use the analogy of a funnel, so you have to look far and wide and you have to have a pipeline of opportunities or potential opportunities that you are constantly evaluating, and need to get nuance on as soon as you progress or discard opportunities."*
>
> *"There is a degree of opportunism that you also have to allow. So in other words you can design your whole company or business development and you have to do that, but you know you get opportunities that arise at fairly short notice and you also have to have the ability to execute or to react to those."*

5.5.2.3. Sensing requires knowledge creation and generation of new ideas

Participants were aligned that gathering of knowledge on the mineral resource was a key sensing capability. Participant 10 described the value of detailed information gathered through feasibility studies and early pilot studies and the influence this knowledge has on business model innovation. In this instance, the BM was modified after new knowledge had been added.

> ***Participant 10****: "So we did a PFS around building a similar operation to those guys [competitors], single plant, everything on site, and the whole shooting match – leaving half the product behind, just taking the vanadium out."*
>
> *"So that is the first part that we changed. So we did some option studies during the first PFS, and what we saw there was an opportunity in our situation to separate the [….] processing of the ore to final product – and what that meant for us was separating those two plants from each other."*

Participant 7 provided insight into how detailed knowledge is also required on the environmental and sustainability aspects associated with critical metals projects,

providing a baseline for continuous measuring and monitoring of the ESG drivers, and a means to differentiate the business model.

> ***Participant 7***: *"From the outset we ran the ESIA [environmental and social impact assessment] alongside the exploration programme; so we did baseline studies for all of the mine areas [….] to make sure that we had the baseline available to be completely IFC compliant, no matter what aspect you looked at from a financing point of view, we wouldn't be found wanting on that ESG – and it is not just the environment, it is the social interactions that we set up with the local communities and then the governance side of things that we had to establish."*

Participant 4 described how an idea was sensed from knowledge of likely changes in international legislation that would impact on supply of a specific product, leading ultimately to the creation of a new business model and operating company.

> ***Participant 4:*** *"So what the guys did really well before I joined was they saw an opportunity of getting [the company] going on the back of international legislation that was looking to enforce conflict free minerals, and enforce end users to prove where they source material from. And the guys sensed that that is going to cause demand for illegal tin to dry up, because it is not like gold or diamonds that you can stick in your pocket and smuggle, right?"*

5.5.2.4. Sensing requires experience and learning

Ten participants spoke of the complexity of the critical metals sector and the general scarcity of technical skills. Acquiring of these skills is often only possible through work place experience, which Participant 8 likened to '*drinking from a firehose'*.

> ***Participant 8:*** *"So I'm thinking to myself … I have done all of this stuff, I have got a 30 year plus career in mining and processing, this should be pretty easy for me. Well what I found was the first year I was there, it was kind of like 'drinking from a fire hose'; it is just really different!"*

"And luckily at [my previous company] there were a lot of people there that had a great technical background. So they spoon fed me a lot of information about how the [rare earth] process worked and why it didn't work and things of that nature. I was there to lead them on the business side, but they were there to lead me on the technical side."

***Participant 4**: "So we have like five or six key guys in the organisation with the appropriate experience over many, many years. You know 20 years' experience is not a lot right, when you get to 30 and 40 years then you sort of know what you're doing. So it is people-based, and yes, we do have rotation within our team but that knowledge base sits with the core of the team and it gets passed down and it gets shared and it then becomes part of the fabric of the new guy that comes in."*

Participant 6 spoke of the value of deep experience as being equivalent to passing your information through '*an algorithm of years and years of experience*'.

***Participant 6**: "[In terms of] internal capabilities, I think one of them is really firstly the experience people bring to the table, you know you cannot discount the experience of people in this space."*

"So you have a team of engineers, some of them are already past retirement age, right? They're in their 70s or 80s but you can't discount the value of knowledge that these guys sit with because they look at something and they are not trying to be cowboys… you know it is like processing it through an algorithm of years and years of experience so that you actually come up with the best solution without making the mistakes of the past, and then what you do is you have a very junior team, or at least a young team compared to your peer group, that is driving the leadership."

***Participant 10:** "So you have to get people on board that know the commodity and have worked in it. And that was something I have been lucky enough to do, and if I did it again I would do it again, I would go hunting for vanadium people that have worked in this space, so that they can form the core of that science*

project, that technical capability moving forward. So you are never [fooling] yourself about what can or can't be done. That is really the core thing."

5.5.2.5. Summary of the findings of research question 1.2

Participants identified sensing as a dynamic capability used in the critical metals mining sector to collect and analyse data that can be used in the creation and innovation of a company's BM.

A key finding in this section was that BMs can originate through a process of idea generation based on new information that has been sensed (collected or interpolated) from other data.

Sensing was identified as an entrepreneurial capability, constantly looking for new opportunities and ways to capture new value.

The sensing capability requires an understanding of customers' requirements, the supply and demand dynamics of specific metals and the opportunities that exist based on trends, growth of specific technologies and metal usage associated with these technologies.

Discovery and increase of new knowledge through studies, R&D and pilot tests on the mineral resource was identified as a key sensing capability.

Accumulated experience and experiential learning was seen as a crucial sensing capability in the critical metals sector mainly due to the complexity of the metallurgical processes, and the hard skills required to run them.

5.5.3. Research question 1.3: Seizing dynamic capability

Participants were asked to describe how they take advantage of new business opportunities in the context of dynamic capabilities of the organisation.

Three microfoundations of seizing were identified from the thematic analysis and presented in Figure 15, namely, a) architecture and design of business models, b) establishing a strategy and planning of strategic investments, and c) collaboration with strategic partners.

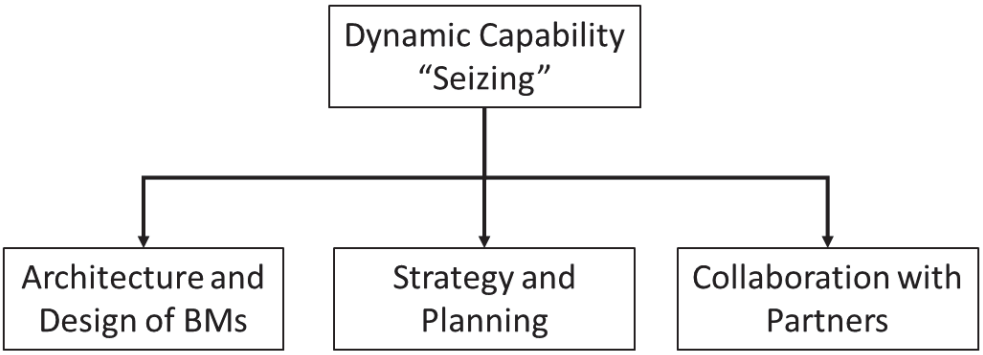

Figure 15. Key seizing dynamic capabilities identified in this study (Author's creation).

5.5.3.1. Seizing requires a dynamic BM architecture and design

BM architecture for many of the participants was influenced by their understanding of the critical metal value chain, and where demand was going to be concentrated.

> ***Participant 5****: "It is very complex, and I think [business model] innovation starts with understanding that value chain, understanding the different markets, and then [….] understanding the whole geopolitical forces [China vs the West] in the market and the impact on the market."*

Participants noted that BM design required a clear view of where they needed to position themselves along this value chain and what type of business they were, with many overlaps of points already covered in RQ 1.1. (section 5.5.1.1, summarised here by Participant 3.

> ***Participant 3: "****But what is the core business that we are in and that we want to be in in the future, and how much room do we have to make changes there, potentially adapting to where we see opportunities?"*

Participant 9 described the business model as dynamic and constantly evolving as new markets emerge or were created, and risks were identified. Six participants recognised the potential for critical metals mining companies to get involved in the mid-stream and downstream value chain. This was a recurring theme in understanding their BMs, and where deep pockets of value occur.

> ***Participant 9****: "Risk, risk is always there, but then once you start moving downstream then it is definitely an opportunity to work in a space where you can review technologies."*

Participant:7 highlighted the integrative nature of the BM and the need to incorporate flow in the business model, so that '*rather than trying to paddle upstream, it is necessary to do something that has a downstream flow to it'*.

> ***Participant 7:*** *"So it [the business model] is synchronised into what I would call background local, regional and national needs and fits and dovetails into that, and again, I think that is part of the thematic that [we have] plugged into; rather than trying to paddle upstream we have done something that has a downstream flow to it, although as with anything there are ponds and eddies associated with it but generally we are assisted by the flow, rather than battling against it."*

Similarly, Participant 3 used a Canadian ice hockey expression of '*skating to where the puck is going, not to where it's been*' meaning to position yourself towards a forecast outcome or trend.

> ***Participant 3:*** *"In Canada there is this expression, 'Don't follow the puck' in hockey – I am not expressing it perfectly, but it is not where the puck is today, but where has it got to be. The puck today I think is in the copper space and it is going to be in the copper space tomorrow."*

5.5.3.2. Seizing requires strategic planning and budgeting

Strategic planning, capital estimation and budgeting was a common process amongst participants. This process was deeply embedded in the various stage gate studies from early PEA to BFS level, and was a necessary first step in the planning phase to establish economic viability. The formulation of strategy was seen by Participants 7 and 5 as an important part of the seizing dynamic capability, providing a roadmap to realise the potential of the business model.

***Participant 7**: "All of that has been focused on, as we have gone through this process of deciding what to do, where to do it and when in maturing a project to the point where it is developable and financeable and tolerable in terms of its environs."*

***Participant 5**: "So the question now is not 'should we do lithium' – it was always on the table – but what is the quickest route to producing lithium – firstly what is the route, and then what is the quickest way of achieving that, with getting maximum 'bang for our bucks' so to speak with the capital."*

"[….] and that is where much of what we are talking about comes into play, is in how do we do that effectively and create value for our shareholders, maximum value in the shortest time possible."

Participant 10 identified that strategic planning also provides an anchor for culture and values of the organisation, right down to performance management systems.

***Participant 10:** "So having an underlying strategy, the good old five-year plan and the underlying strategy of who you are, culture, values and so on, those become really critical to painting a picture for people but then living it as well, and then having these incentives in place relatively quickly even for new arrivals, to know what they have got to do and what they are part of."*

Participants 6 used strategic planning and scenario analysis to guide them in human capital requirements including organisational design, defining what skills were required and whether those skills should be external (in the form of consultants) or in-house.

***Participant 6:** "You look at the gap analysis that you sit with and say so what are the skills that we need for this, do we have them in-house or do we actually have to get them in – and that is all part of your [strategic] process, is to identify those, come up with the time lines on the back of that, can I actually do this?'*

5.5.3.3. Seizing requires collaboration with strategic partners, governments and shareholders

Four participants noted that seizing required establishing strong collaborative relationships to acquire new resources and knowledge, and exploit opportunities.

Due to the extractive and non-renewable nature of mining and its impact on communities, there was unanimous agreement that relationship building with government departments regulating the industry was a core dynamic capability that strengthened the BM. Acknowledgment of win-win solutions in terms of revenue generation, reputational impacts and seizing of incentives offered by governments helped to strengthen these relationships.

> ***Participant 7****: "So we have experienced cooperation at a regional and national level of the government in Angola that I would say is difficult to find anywhere else in Sub-Saharan Africa quite frankly, in terms of they realise this is the way forward."*

> ***Participant 2:*** *"… people talk about Chile being a complicated place these days to get permits; it took us 11 months to get the full permit, which I think was probably a record in Chile for an EIA, and you know it is not luck, it is a planned process of building that credibility, building those relationships and working sort of genuinely with those communities and authorities all the way through."*

> ***Participant 6****: "The sort of differentiating factor that I have seen objectively when I came in here, was that all of this is done in collaboration with the community and the various stakeholders within Namibia."*

> ***Participant 10****: "… we have utilized the R&D framework that the [Australian] government provides for that, which is around defining an R&D tax credit in particular, and that is right from the exploration phase right through to the development of the process plan and beyond into production."*

Participants 7 and 6 also consulted regularly with key institutional investors to ensure progression of development projects through the various stage gates and on to production.

> ***Participant 7****: "The other aspect has been a long term cultivation of relationships with key institutional investors and shareholders that buy into the process and are prepared to support it [….] these type of underpinning financial relationships have been key in having the confidence to put in additional top up that is inevitably required for a junior company such as ours."*

> ***Participant 6:*** *"So when I look at [our CEO] he is always, always speaking to people that are going to assist this business, either now or in future."*
>
> *"So by the time we go to an investor meeting to raise some capital, it is already a done deal, but it is just because you are taking people along with you to your story of success, from onset and throughout, because people just want to be informed, whether it is good or bad."*

Participant 9 noted the strength of having strong collaborative relationships with research institutions and universities, while Participant 6 saw a need for more extensive collaboration with agencies that could facilitate cooperation across the value chain.

> ***Participant 9****: "….] the ability particularly having a separation facility in the UK next to some research institutions across the UK, which is a definite highlight for me, is that we have access to that, five or six universities that are interested in talking to us and seeking funding – so both European and UK funding is available for projects in this critical mineral space."*

> ***Participant 6****: "I think ….] that there should be much closer cooperation and we are looking for agencies that can actually facilitate this cooperation across the value chain. So there is a number of institutions that have been established in the recent year or two or three, particular on lithium, but I would even urge more should be done in this regard, and that bringing governments, end users and raw*

material suppliers together, and navigating this very complex and sort of chaotic world that we live in."

5.5.3.4. Summary of findings of research question 1.3

Participants recognised seizing as a design and planning process, and the point at which an opportunity or idea that has been sensed is formulated into a BM.

Seizing dynamic capabilities are evident in the critical metals sector, and play a significant role in the architecture, design and innovation of participant company's BMs, and are closely aligned with the preparation of a strategic roadmap and plan.

BM architecture for many of the participants was influenced by their understanding of the critical metal value chain, and where demand was going to be concentrated. Participants noted that BM design and BMI required a clear view of where they needed to position themselves along this value chain and what type of business they were.

Participants used strategic planning and scenario analysis as a seizing capability to guide the organisations' human capital needs, namely, organisational design, defining what skills were required and whether those skills should be external (in the form of consultants) or in-house.

Strong collaborative relationships with governments, research institutions, universities and industry agencies that could facilitate cooperation across the value chain were all noted as part of the seizing dynamic capability.

5.5.4. Research question 1.4: Transforming dynamic capability

Participants were asked to describe how they transform their businesses after having identified (sensed), and planned for (seized) a unique opportunity.

Transforming is an action oriented activity with four microfoundations of transforming identified from the thematic analysis and presented in Figure 16, including a) organisational restructuring b) project implementation, c), knowledge integration and transfer, and d) adoption and adaptation of best practice.

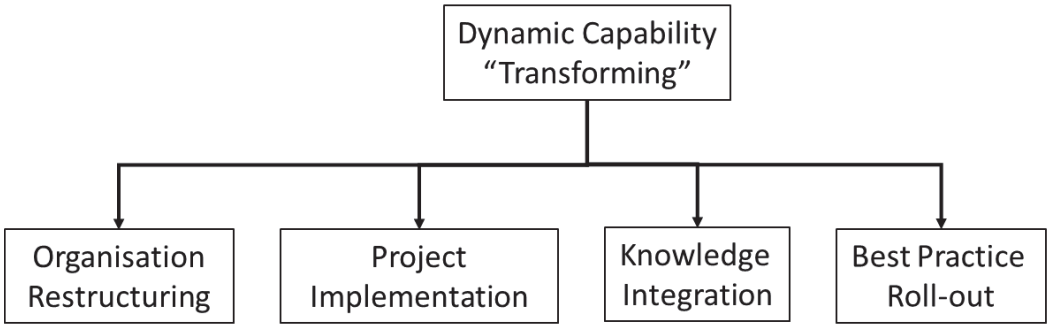

Figure 16. Key transforming dynamic capabilities identified in this study (Author's creation).

5.5.4.1. Transforming requires organisation restructuring

Participant 2 recognised that organisation restructuring requires dynamic capabilities to establish and embed a new company culture, whether in the start-up phase, operations or post-merger. The embedded culture, whether it is a focus on intrepreneurial thinking or a focus on project development, was identified as creating the unique capabilities, or '*the way things are done around here'* of the organisation going forward.

> ***Participant 2****: "I would say the first one is simply around culture – and it is all those things we were talking about – entrepreneurial culture, communicative, agile, lean. And that people see that as part of the way the business works. And so whenever they are thinking about a new process or whatever needs to be done, they do it within that context."*

> ***Participant 7:*** *"In the initial few years of the organisation, it [the company culture] definitely existed within the executives supported by the board, and has been steadily promulgated downwards into being part of the DNA of the company – whether it is the technical strategy or the ESG strategy."*

Participants 2 and 5 identified intrepreneurship as a critical differentiator of their companies, and encouraged an owner-manager mentality / culture, through a combination of share incentive schemes and other reward systems.

> ***Participant 2****: "But I would say the other key element was actually making each of them think like owners rather than managers. And I think that was actually quite*

a key part of it as well, in terms of shifting the thinking from everything was about what you are doing with the company's dollars, to one where every dollar you spend you feel it is coming out of your own pocket, and every dollar you gain you feel some part of it is going back into your own pocket."

"So every decision you make, think of it as an owner, don't think of it as a manager, and I think that has been quite powerful."

***Participant 5**: "So I think that is absolutely key for success because there is such a complex environment you haven't got templates to work from, and you effectively need to think as almost a sole proprietor in developing this business. You are working for your shareholders, but it requires let's say a very nimble and innovative thinking."*

Participants 7 and 10 highlighted that curiosity and an environment that encourages the willingness to ask questions are crucial to instilling an innovation culture as a dynamic capability.

***Participant 7**: "If you are never afraid to ask the question 'why', whether it is why do we do that the way we have done it in the past as a justification for including it in a design going forward in the future, is a particularly useful exercise to go around several times when you are at the early design stage, because it is one of the few opportunities that you actually have before setting yourself on an expensive predetermined path."*

"People like to tick boxes in terms of job done, let's move on, and now you have got to decide every now and again, was that the right box to tick – and go back and relook at it."

***Participant 10**: "I think our willingness to question ourselves and argue if you like with ourselves and ask those key questions of what is the best way to do this and not the old fashioned way of doing it – and in our case the outline of the process plant location and then following up on that with an actual plan."*

Participant 2 had recently concluded a significant merger and was still in the process of realising the synergies that had been identified prior to the merger.

> ***Participant 2:*** "*We have just obviously combined [the two companies] – so that in itself has been also a major transaction, a major integration, with work required, and one of the things it has done is given us as a combined organisation a huge amount of optionality in terms of organic growth."*
>
> *"This has actually got very, very real synergies, so the [SD and MV projects] are virtually alongside one another, able to share a lot of infrastructure, able to for example process oxides which weren't going to be processed; both sites have got cobalt, we can potentially [….] make Chile into the fourth biggest producer of cobalt in the world."*

5.5.4.2. Transforming requires project implementation and execution capabilities

Four participants highlighted the need for strong implementation and project management skills in the transforming stage.

A key observation from these participants was the importance of building capable '*in-house'* teams that understand the culture of the company and are matched to the phase (or '*season'*) of the company.

> ***Participant 4****: "So the key there is that the business goes through different phases, right, and seasons, and you need to allocate different people and teams to the different phases. And particularly in the case of [our company], you know a team needed to be backed that is not scared of the environment, that can go in there, run a straight line through the jungle, get this thing built."*

> ***Participant 2:*** *"So I think what we are trying to do is just have this really deep and permanent experience in the sort of design, engineering and construction of projects and that I think gives us a big competitive advantage compared to anyone else, in that our confidence levels in terms of being able to deliver those projects on time, on budget and that work as expected, is a lot higher than the guy down the road."*

> ***Participant 3**: "We talk up our technical capabilities which we have [….] put together through this merger, but at the same time we are quite purposefully building out our technical services team in terms of creating even a broader centre of excellence in the core competencies around mining – be it processing, mining, tailings, water, etc."*

> ***Participant 5**: "If you understand the options, it is then having the engineering and commercial ability to execute those options. It is very difficult to find those capabilities outside in consultancies and EPCM companies; we have tended to build up quite a comprehensive engineering [ability], and we are working on our in-house commercial ability, to be able to execute those options."*

Participants 4 and 7 identified the right team dynamic as being a crucial capability for transforming.

> ***Participant 4**: "So it is a small team dynamic, everyone is part of the bigger picture as well, you are not just in a box looking at your little thing independently. So what enables it is again, and I know this sounds too simple, but what enables it is backing the right people and getting the right culture going."*

> ***Participant 7**: "During the process where it has not been evident on certain aspects, it has been quite clear that without that type of positive interaction between disciplines, it becomes a problem. So that teamwork, we are on the same side of the fence irrespective of which organisation we work for, has been a driving factor in terms of particularly efficiency, and dealing with fundamental differences and finding a solution that is acceptable to go forward, bearing in mind our issues of capital and operational constraints."*

Participant 2 spoke of the importance of continuity of project implementation experience, and that they had strategically ranked their internal development projects to run consecutively, rather than concurrently to ensure they were able to leverage off the experience gained from previous projects.

Participant 2: *"And you know if you try to run these projects in parallel you would land up having to recruit a lot more people and probably filling your team up with a lot of B team players – B or C team players – and then when you stop they all leave and then you have a project in five years' time and you have to go through the whole learning process again, whereas what we are trying to do is to sort of just sequence them one after another, so that we actually gain the experience and then that same team just moves on, and we can sort of have A team players in it, and move on to the next one."*

5.5.4.3. Transforming requires recruiting the right people and ensuring knowledge transfer

Six participants identified the need to recruit the right people from the outset; understanding their strengths and weaknesses and then building them into a coherent team.

Participant 2*: "but you know when I set up the company from acquiring two [major company] assets, what I did was my entire executive team were recruited from [major mining companies] – and one of the reasons for that was I knew what I was getting and so it was an environment where I knew what those people's approach to doing business was, what their skill sets were – but I also had a fairly good idea as to what their limitations were, of what the big corporates also did."*

Participant 7*: "In terms of the engineering team I would say that the collection of individuals who have a long history associated with each other and therefore trust to be able to tackle the hard questions on a 'hardnosed, factual, how do we solve this' basis, without upsetting anybody's egos has been a key factor in this."*

Participant 8*: "What I am just trying to do is help with putting a plant together from a design perspective and a testing perspective, and then help build a team – one team in Africa and one in the UK – and beyond that I don't see myself as having much of a role. But while I am here, the company get the advantage of whatever I know, and whatever people I know in the industry."*

***Participant 10**: "And the most important thing at that point is to resource it properly, get the right people on."*

5.5.4.4. Transforming requires a combination of ordinary and dynamic capabilities, by establishing operational processes and routines

Participant 3 identified the need for operational routines and processes to codify the transforming capability, to ensure it became embedded within the organisation.

***Participant 3**: "I mean we have sort of doubled the size of the company overnight with the deal. I think all the more we are a bigger company and you sort of want I think that base of quality processes and systems and thinking that comes more with big companies; and yet we still do benefit from some of the more entrepreneurial [….] I think it is a combination frankly, some of that risk taking and aggressiveness and entrepreneurialism that I think also was a big contributor to the big merger happening."*

Participant 2 spoke of a combination of ordinary (or operationally focused) capabilities rather than unique dynamic capabilities, but that they worked in tandem and were complimentary.

***Participant 2**: "So when we look at unique [dynamic] capabilities, I am not sure we have any that are unique, but I think possibly ultimately the combination of the capabilities we have may be unique."*

5.5.4.4. Summary of findings of research question 1.4

Participants recognised that organisation restructuring requires dynamic capabilities to establish and embed a unique company culture, matched to the 'season' of the business. The embedded culture, creates the unique capabilities of the organisation going forward and is integral in the BM design and BMI.

A key observation in the transforming dynamic capability was the importance of building capable internal teams to oversee project implementation and execution capabilities, that understand the culture of the company and are matched to the phase of the company.

Transforming relied strongly on the need to recruit the right people from the outset; understanding their strengths and weaknesses and then building them into a coherent team.

The need for routines and processes was identified as crucial to codify the transforming capability and embed it within the organisation. Combinations of ordinary (or operationally focused) capabilities were able to deliver unique dynamic capabilities and facilitate BMI.

5.6. Research question 2

The findings for research question 2 are given in this section.

"How is business model innovation affected by environmental uncertainty?"

Participants were asked to comment on how their organisations perceive and deal with environmental uncertainty as an external antecedent of BMI.

Participants identified five factors uncertainty related to a) Black swan events, b) market uncertainty, c) technology uncertainty, d) financing uncertainty, and e) risk identification and mitigation strategies, and presented in Figure 17.

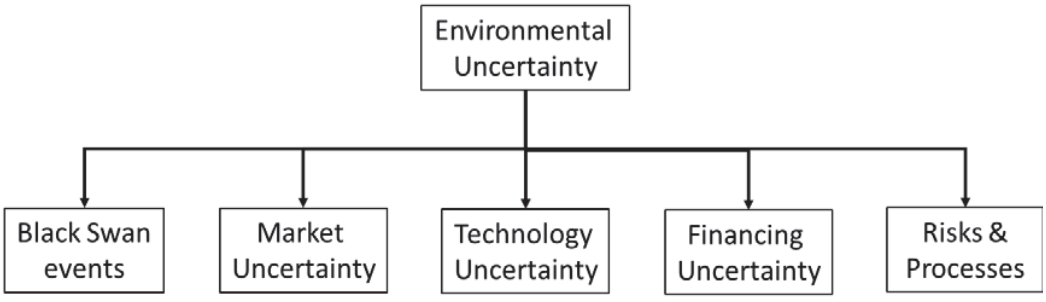

Figure 17. Key environmental uncertainty themes identified in this study (Author's creation).

5.6.1. Black Swan events (unknown-unknowns)

Black Swan or *Unknown- unknown* events are perceived as events that have such a low probability of occurrence that businesses could not have foreseen them and have not prepared for them.

Participant 2 identified having the right people, in the right roles, with strong organisational capabilities such as agility, decentralised decision making and strong communication as being fundamental to managing the high impact caused by such events. This was reinforced by Participant 3 who also identified diversification, quality and scale of resources, and investor relationships as critical capabilities.

> ***Participant 2****: "I think the true black swan events, which you don't know what they are going to be, they sort of come out of left field at you, I think that is where one needs to have that agile and decentralised and communicative model."*
>
> *"I think it is about one's operating model and how quickly can you adapt to a new situation [….] so it is about having that organisational agility and flexibility and adaptability and to me that comes back to the point about having the right people in the right role; if you can depend on the people you have got in each of the key roles, it is far more likely that when some unexpected event comes, you are going to be able to deal with it at all levels, without having to significantly rejig the organisation."*
>
> *"And if you are set up as a decentralised organisation, there is a lot more capacity to adapt quickly than if you are trying to do it through a very centralised organisation – as long as you have got good communications that allow shared learnings to be moved across pretty quickly."*

> ***Participant 3:*** *"In terms of managing those risks and really I think strengthening the longevity of the company and also not just tackling downside but positioning for upside, it does come down to team, I think it does come down to diversification, to quality of assets, scale helps, good relationship with the investor community helps, and obviously a strong balance sheet is absolutely fundamental as well."*

5.6.2. Market uncertainty

Participant 2 flagged the high rate of change as being the only constant in today's dynamic markets, and the need to develop business models and strategies to deal with environmental uncertainty.

> ***Participant 2**: "I do think that what we are faced with today compared to probably when I started out in my career in the sort of late 80s and early 90s, is a far greater rate of change; more uncertainties, more challenges, and that creates a more dynamic and fast-changing environment."*
>
> *"We know prices are volatile, we know sometimes they are going to be super high and sometimes super low – how do you set yourself up for that situation?"*

Participant 3 commented on the industry's ability to learn from previous downturns to prepare for future financial crises, identifying a strong balance sheet as fundamental to managing cyclical downturns.

> ***Participant 3**: "[….] the global financial crisis in 2007 / 2008 obviously lots of companies went into that not nearly as well prepared as they would have liked to have been in hindsight."*
>
> *"But as a result I think that is still recent enough in people's memories that even though we have now entered a little bit of a downturn, when you think of economic growth and increasing interest rates and so on, the commodity space is so much better prepared – including intermediates such as ourselves [….] and like I said before, the balance sheet is absolutely fundamental."*

Participant 6 provided insight into price uncertainty and the need to base long term investment decisions on multiple scenarios, trusting the research to ride out short term uncertainty in price.

> ***Participant 6:** "And for me the question is, we didn't build this business on short term decisions. Before we actually executed certain things we did research, we looked at the long term fundamentals, right?"*

"And if we are not using five or six kind of lenses of research to come up with this decision making then we are doing something wrong. And that is the way we have been trying to deal with the unknowns out there, is that I don't know what the price is going to do tomorrow, I don't know [….] what the exchange rate is going to do tomorrow and what my price of commodity is going to do tomorrow."

Geopolitical risk is a significant risk going forward. Tension between Chinese refineries and western producers of electric vehicles and wind turbines was flagged by two participants as likely to increase over security of supply of batteries and permanent magnets. Many western countries are now encouraging the delinking of supply from China through the development of their own critical metals supply chains. Participant 8 noted the impact of China on the future availability of certain critical metals end products.

***Participant 8**: "So one of the big problems people that are making rare earth oxides have, is that they are basically going to end up selling it to China because they don't have a lot of options to do anything different to that. So that all seems okay because there is a value number there that you can get for what you are doing …. but the problem for the people that use magnets is not this far away."*

"The Chinese are actually going to consume all the magnets that they make, and you won't be getting magnets to make cars with or wind turbines; if you want a car or a wind turbine you are going to have to go to China to get it."

5.6.3. Technology uncertainty and the risk of substitution

Participant 1 provided an investors perspective on dealing with uncertainty in the downstream renewable energy technology, noting the impact this uncertainty in the energy storage technology has on the investment decision-making process in the critical metals mining sector.

Participant 1: *"So there is this price-based uncertainty and then there is this technology-based uncertainty. So what will be the winner? Is there something better than lithium, or is lithium great? And nobody really knows; everyone who has got a technology punts it."*

"[….] and if you are talking about the concept of uncertainty, the question is whose role is it within that mixture [producers, users and financiers / investors] to deal with the uncertainty, and in critical minerals the uncertainty comes [….] because we don't quite know how the world is going to look once it has transitioned."

Participant 6 commented on the selection of downstream battery technology by the automotive industry, and the risk of metal substitution of the lithium ion battery technology.

Participant 6: *"We then go back to fundamentals and say well actually, car manufacturers have spent billions and billions of dollars and euros researching the commodity you want to produce. So tomorrow if there is a change in the commodity, they are not going to waste the millions they have spent on developing this."*

"So lithium is going to be there for a longer term, even if there are alternatives coming into the market. At the same time technologies these days, everybody is talking about energy storage in terms of through batteries, I mean vanadium redox flow batteries was what I was doing four months ago, I was trying to get that off the ground."

5.6.4. Financing uncertainty related to untested technology and ESG issues

Participants recognised the uncertainty associated with the restrictions placed by capital providers on the selection of new, untested technology in the critical metals sector. Participant 7 identified the need to creatively envision a business model that minimises the upfront financial risk associated with mining and mineral processing flowsheets.

Participant 7*: "But I would say the key drivers have been innovation around utilising de-risked processing methodologies within the rare earths sector that are recognisable outside of the rare earth sector, in order to be familiar enough for financiers and others to understand that the process risk etc, is de-risked."*

Participant 1 recognised the uncertainty created by the *push-pull* factors between financing and technological innovation, and intimated that there may be a third way to solve what on the surface appears to be an intractable problem.

> ***Participant 1****: "And at the bottom of the pile [….], you have got the producers. Then there is the next level, very, very broadly, which are the users of the metals. And then the third layer, which isn't even a layer, it is more kind of a fabric in which it all sits if you want, is the capital and financing of all of that. So those are the three very broad kind of stakeholders in this. And if you are talking about the concept of uncertainty, the question is whose role is it within that mixture to deal with the uncertainty?"*

Sustainability is increasingly acknowledged as a fundamental component of business model design, embedding ESG in the DNA of the company to attract funding. Participant 5 noted that investors are increasingly looking for opportunities that will generate a return, but at the same time also address moral and societal needs.

> ***Participant 5:*** *"Shareholders are desperate for companies [to invest in] or investing opportunities that firstly obviously create the value – because they see the opportunity that exists – but then also this whole ESG environmental incentive as well, to invest in companies that will actually facilitate this energy transition and technological transition."*

Participant 7 alluded to uncertainty and dynamic capabilities that are required to integrate complex technical, provenance, marketing, financing and ESG components into a coherent and robust business model that is also competitive on operating costs.

> ***Participant 7****: "There is no point in having a great idea even if you have got provenance and the lowest carbon footprint, if you are unable to compete cost effectively – and that is where the real engine room drive train started in terms of innovation within the project team."*

5.6.5. Risk management strategies and processes (known-unknowns)

Participants identified a number of high level strategies to address the *known-unknowns,* or identifiable / forecastable risk:

Portfolio Diversification

Participant 1 identified diversification and portfolio management as a strategy to reduce the impact of failure

> **Participant 1:** *"So [our company] has got 8 major assets and they go and do a valuation and each one is by definition quite a positive, rosy view on the asset, because everything in this space looks rosy and the tide is coming in. But then you say to them actually if you think about it, you have got 8 assets, what is the probability of every single one of these being successful? And there is a concession like 'okay, that would be too good to be true."*
>
> *"That is why you have got to have the diversity. You have got to have 8 or 10 or 12 or 15 investments and you have got to make sure you are maintaining your diversity and you are not focusing too much on any one thing, one technology, one geographic location."*

Collaboration within eco-system networks

Participant 7 mitigated demand uncertainty by proactively ensuring that their product was as closely tailored to their customers' needs as possible, thus ensuring continuity of demand through downturns in the business cycle, and limiting the need for intervention in markets by third parties.

> ***Participant 7****: "Dealing with unknown unknowns, it is one of the things where we have actually taken the bull by the horns a little bit in terms of having a good look at the opaqueness of the industry as it currently lands, understanding the need for these critical metals in the future [….] and as a consequence of that we have actually gone in and interacted with end users in particular to drive the thinking and the processes of the art of the possible in the direction that we envisage it can go."*

Risk management analysis / Risk registers

Participant 3 identified risk management analysis as a process to be used to address the known-unknowns, or risks that we can see coming. Water insecurity, decarbonisation, regulatory uncertainty around taxes and royalties were some risks identified that can be proactively managed through this process.

> ***Participant 3:*** *"[….] very closely tied to that strong sort of risk management system, you know, that starts out obviously at the site level and trickles all the way up and you try and capture everything sort of known – and obviously more difficult to go beyond that, but I think you need to have as robust strategic and risk management systems in place."*

Financial stress test and liquidity analysis

Participant 4 made use of a formalised process consisting of financial stress tests, risk management and liquidity tests and the need to keep risk registers up to date. He emphasised the ongoing and deeply embedded thinking that is however required to identify risk and uncertainty.

> ***Participant 4****: "We do stress tests, that is what we do. We consistently and often consider where the breaking points are and what is the likelihood of getting there, and for a sustained period of time. Because time is a very relevant variable you know? You could have a major issue but if you could resolve it within a short space of time you are fine. But if you have a major issue for an extended period of time you have a major problem."*

Contingencies and buffers

The establishing of financial contingency and technical buffers as described by Participant 4, was a common theme from the sample group and builds on the need for a strong balance sheet to negotiate unplanned for downturns in markets.

> ***Participant 4****: "There will be an event, you just don't know which one – it goes to uncertainty, which goes to risk, and to be able to handle those events you need buffers."*

"And it goes to not just capital reserves on your balance sheet, not too much debt, but also buffers in terms of how you design your mine, buffers in terms of your cost of production – are you going to go negative when the price collapses 50%? And actually it goes back to backing the right ore body on day one. So those are the things you need - head room, otherwise you are not going to make it in this game."

Hedging and use of financial derivatives

Participant 5 described the process of establishing pre-offtake contracts with customers and the use of financial derivative instruments to reduce financial risk by locking in a forward price.

Participant 6: *"Firstly I know for a fact that the commodities I am actually going into are things that I can hedge or come up with proper offtake agreements, right? So tin for example is coming up with a profitable hedge strategy, that says well okay, in an event where tin prices are at 30000 or 40000 dollars, the company stands to make a lot of money out of it.*

Developing a playbook

In one instance, a capital allocation approach was described by Participant 5, developing a playbook on how to deal with price volatility in the future.

Participant 5*: "I think in a black swan event you need to be able to cut the bleeding as quickly as possible, and I think both in terms of our thinking and our operating [model], we are constantly thinking 'okay if the worst case happens, what can we do? So at this point we can stop all our development capital and the only negative effect of that would be our route to market or our pathway to production would be slightly delayed, when it comes to lithium. So we have the ability to switch on and off the taps, okay?"*

5.6.6. Summary of findings of research question 2

Black Swan events are perceived as events that have such a low probability of occurrence that businesses could not have foreseen them and have not prepared for them.

Agility, decentralised decision making and strong communication, quality and scale of resources, and investor relationships were recognised by participants as critical organisational capabilities to manage under conditions of environmental uncertainty.

Participants recognised the uncertainty associated with the restrictions placed by capital providers on the selection of new, untested technology.

A number of risk mitigation strategies to manage ‘known-unknowns’ were identified.

Participants also identified specific analytical processes (financial stress tests, liquidity analysis, risk analysis and risk registers) and financial instruments (hedging, financial derivatives) that can be used to create playbooks on how to manage their businesses during periods of high uncertainty.

5.7. Chapter Conclusion

The findings from the participant interviews addressing the research questions defined in Chapter 3 have been presented in this chapter. The constructs and participants’ views have covered a broad range of topics, and generated a large number of insights pertinent to SMEs in the critical metals mining sector.

Research question 1 was divided into four sub-sections, focusing on BMI and the three dynamic capabilities of sensing, seizing and transforming.

Research question 1.1 recognised five broad themes consisting of external and internal factors that influence BMI. These included, understanding context of the company and how it interacts within the business environment, the nature of the mineral resources available, the internal capabilities and processes of the organisation, understanding the value chain and bridging the gap with downstream manufacturers, and as a final point, understanding the limiting factors associated with technology and financing uncertainty. As a high level comment, access to finance was a key external factor highlighted by most participants, which has placed a constraint on the level of technology and innovative thinking that can be implemented in new mining projects by SME companies. This is of

particularly relevance to the critical metals ecosystem, where production companies require complicated processes to recover the valuable constituents.

Research question 1.2 identified four microfoundations of sensing and these were explored in terms of their role as internal drivers of BMI within the critical metals sector. These included the importance of an entrepreneurial mind set, monitoring of the market and changes in technology, knowledge creation and generation of new ideas, and finally, the importance of experience and learning. The entrepreneurial capability was identified as a sensing DC, constantly looking for new opportunities and ways to capture new value.

Research question 1.3 noted three microfoundations of the role of seizing as an internal driver of BMI. These were defined as architecture and design of business models, establishing a strategy and planning of strategic investments, and collaboration with strategic partners. The seizing DC was recognised as the point at which business models are impacted the most, and where the logic and value creation elements of junior and mid-tier mining companies are crafted into a functional business model through an innovative design process.

Research question 1.4 identified four microfoundations of transforming as an internal dynamic capability impacting BMI. These were organisational restructuring, project implementation, knowledge integration and transfer, and adoption and adaptation of best practice. A key observation in the transforming DC was the importance of building capable internal teams to oversee project implementation and execution capabilities, and to employ the right people matched to the season or phase that the company is in.

Research question 2 noted a varied response from participants in considering the impact of environmental uncertainty on BMI. The agility and flexibility of the management team was identified as a key mitigating factor to manage during uncertain times. Interestingly, few companies used strategic foresight and scenario analysis, or deep learning methods, to identify or model out Black Swan / ‘Unknown-unknown’ type events.

The next chapter will integrate these findings with the literature study in Chapter 2.

CHAPTER 6. DISCUSSION

6.1. Introduction

This chapter discusses the findings presented in Chapter 5. The discussion is based on the research questions presented in Chapter 3 with reference to the aim of this study, which was to explore the role of dynamic capabilities as internal drivers of BMI within the critical metals mining sector. Findings from the interviews are compared with the literature reviewed in Chapter 2, looking for similarities and differences in order to articulate refinements or extensions to the BMI and DC literature.

6.2. Discussion of the findings for the framing question

> "How innovative is the mining industry, and do you feel your company is a leader or a follower in the creation and adoption of new technology?"

This question was framed to establish a baseline for impressions and attitudes towards technological innovation within the mining industry, and to compare this with innovation at an organisational level and how this impacts on BMI.

6.2.1. Innovation in the mining industry

The findings for this theme identified a divide in levels of innovation between the large mining companies (multi-national companies or MNCs), and the mid-tier and junior mining companies (collectively referred to in this section as mining SMEs). There is an apparent link between the level of technological innovativeness in the mining industry and company size, and this appears to influence the BMs adopted by companies.

The findings suggested that the mining MNCs have the R&D budgets to innovate, and the balance sheet from windfall profits over the last few years to fund new projects incorporating innovative new technology. Most of the large MNCs are however not involved in the critical metals mining sector, and as a result, a large proportion of critical metal supply (copper and PGMs excluded) has been left to entrepreneurial mining SMEs to develop.

6.2.2. Innovation in the critical metals mining sector

Findings for this theme indicated that the often complex nature of critical metals deposits means that mining SMEs need to use innovative processes to produce a product to the correct specifications for downstream customers. This supports the literature (Dymitrowski & Mielcarek, 2021), who noted that where possible, SMEs should adopt BMI using novel technologies, combining organisational and technological innovation to improve profitability and performance.

Findings showed however that critical metals mining SMEs are having to balance the level of novel technological innovativeness that they can apply in their processes with the availability of capital, which is in short supply due to conservative credit risk processes applied by traditional lenders and investors.

The reluctance of capital providers to fund novel and untested technology within the critical metals mining sector was a common thread in the data, creating uncertainty and placing a limitation on the BM and level of innovation that can be applied. A scan of the innovation literature indicates however, that lack of access to capital is a universal obstacle within the technology based SME environment. "Institution-based barriers" are recognised as limiting factors on the innovation potential of SMEs, with an established relationship between "opportunity, cost and risk of innovation" (Zhu, Wittmann, & Peng, 2012).

This has created a *wicked problem* for the critical metals producers and end-users alike, requiring higher order thinking and dynamic capabilities to solve. Wicked problems are "ill-defined and incomplete, not solvable and highly complex with a tangled causation / effect logic that can have unintended consequences" (Skaburskis, 2008, p. 278). While technically unsolvable, wicked problems can be solved using logic that is not inherent in the problem (Pasisi, Gibb, & Matthews, 2014).

6.2.3. Disconnect between upstream and downstream innovation

The findings for this theme recognised that BMI starts with the mining companies understanding the whole downstream market and end-user developments.

A search of the media outside of this study indicates that BMI in the critical metals sector has increasingly incorporated collaboration between MNCs mining companies and large downstream customers to bridge the supply gap. Recent examples include Glencore's deal with General Motors to enter into a long term cobalt supply agreement (Glencore,

2022), and the lithium supply deal between the BMW Group and Livent Corporation in 2021 (Wehring, 2021).

6.2.4. Summary of the discussion for the framing question

The research findings for this question indicated that the availability of finance is an acute external driver of BMI within the critical metals sector, subtly directing BMI and technological innovation towards incremental changes, rather than '*great leaps forward'*. This supports literature findings that funding for new technology in SMEs can be limited by "institution based barriers" (Zhu, Wittmann, & Peng, 2012).

Without business model innovation in both the mining and the financing sectors, the long lead times between discovery of a critical metal resource and production will continue to place restrictions on the supply of these metals to downstream end users in the automotive and renewable energy markets.

Innovation in the critical metals mining sector may need to contend with this problem for some time longer, and BMI may need to remain a compromise between the apparent three levers of innovation in the critical metals mining sector, namely, level of novel technology, level of ESG compliance and availability of finance.

In this regard, mining SMEs should focus on refinement of their BMs, pursuing a well thought out business model using an ordinary technology to address the financing risk, rather than developing a great technology but using an average business model (Chesbrough, 2010).

6.3. Discussion of the findings for research question 1.1: Drivers of BMI

"What is the role of dynamic capabilities as internal drivers of business model innovation?" (Foss & Saebi, 2018).

Research Question 1 was structured as four shorter questions using BMI and dynamic capabilities (sensing, seizing and transforming) as the core constructs.

These questions sought to understand business model innovation in the context of the organisation, and to identify how companies use the sensing, seizing and transforming dynamic capabilities to implement BMI. This research question also sought to

understand how entrepreneurial vision and organisational culture are instrumental in the creation of new BMs.

6.3.1. Discussion of the findings for research question 1.1: Drivers of BMI

The findings for this theme identified five drivers and high level factors that influenced selection of the business model and business model innovation within the sample group. These were; the business environment, the resources available, the capabilities and processes of the organisation, partnerships and collaboration within the value chain, and the limiting factors associated with advanced technology and financing uncertainty.

A simple framework is proposed in Figure 18 to understand these influencing factors in the form of a standard input:output production process with inputs (dependent on resources), production / operational processes (dependent on capabilities and processes), and outputs (dependent on customers' needs and requirements). This process appears to be both moderated and mediated by the business environment on the input side, while uncertainty and other limitations such as availability of capital, appear to have a mediating effect.

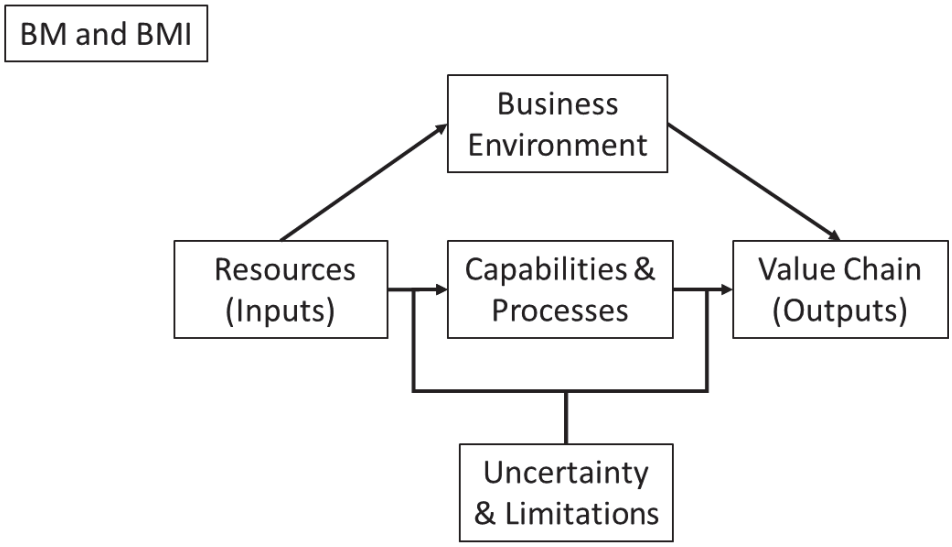

Figure 18. Hypothetical drivers (internal and external) of BMI identified in this study, simplified from Figure 8 (Author's creation).

6.3.1.1. Business environment

The findings for this theme indicate that the political economy and the business environment of the country within which an organisation is located provide context for the business model and for further innovation. This was identified in the data as an important external factor driving the selection of a business model, and to define what would work and what wouldn't.

The geopolitical landscape and unique features of the political economy of the country in which the organisation is located, including legislation and operating environment, were identified as key considerations. One participant provided an example where knowledge of changes in international legislation that would enforce conflict free minerals, led ultimately to the creation of a new business model and operating company to take advantage of the opportunity. The ability to operate in a challenging country was also flagged as providing a unique competitive advantage, where other organisations had failed.

This supports the literature which identifies how BMI occurs as a result of changes in the external business environment. Business models exhibit different degrees of change depending on the nature and duration of the external influences, and change can be either positive (proactive) or negative (reactive) with varying financial consequences (Saebi, 2015). In this environment, TMTs evolve, adapt or innovate the BM when faced with extreme uncertainty.

6.3.1.2. The nature of the resources

The findings for this theme recognised that the mineral resource of the company, with its unique mineralogy and metallurgical characteristics, were key internal drivers in the selection and innovation of the BM for a mining SME.

In the RBV theory, a company's competitive advantage comes from its internal resources and competencies that are "valuable, rare, inimitable and non-substitutable" (VRIN) allowing an organisation to grow and generate profit (Barney, 1991). While dynamic capabilities theory was developed from the resource based view (RBV), a major criticism of the RBV was that it was unable to describe how organisations react to environmental uncertainty using VRIN resources as production inputs and drivers of competitive advantage (Helfat & Peteraf , 2009). RBV is however unable to explain how an organisation would grow future resources and competencies, and how VRIN resources could be adjusted to respond to changes and uncertainty in the environment (Mousavi,

Bossink, & van Vliet, 2019). Teece (2007), reasoned that tangible assets, such as the mineral resources of a mining SME, should be viewed as a dynamic capability.

In the case of mining SMEs it can be argued from the findings data, that the mineral resource is the most fundamental driver of value and has the most significant influence on the choice of BM and the level of BMI applied and possible. This influence exceeds the value of any technology innovations or managerial capabilities.

6.3.1.3. The capabilities and processes of the organisation

The findings for this theme recognised that combinations of ordinary capabilities and processes can constitute dynamic capabilities as "signature processes" (Gratton & Ghoshal, 2005), and are viewed as critical building blocks of BMI and the BM.

This theme is discussed further in the next section on dynamic capabilities.

6.3.1.4. Partnerships and collaboration within the value chain

The findings for this theme noted that collaboration within the value chain to bridge the supply gap between upstream and downstream customers, is a key internal driver of BMI.

Willingness to explore technological and supply chain synergies either in partnerships or as separate operating companies within an ecosystem network are identified as internal dynamic capabilities, and are discussed further in the next section.

6.3.1.5. Choice of technology and financing limitations

The findings for this theme noted the interlinked relationship between availability of financing, level of technological innovation and level of ESG compliance, and how these are seen as limitations (potentially moderating variables) or enablers (potentially mediating variables) on BMI. These limitations will impact on the ability of critical metals mining companies to supply sufficient metals to downstream customers and end-users.

The unique interrelation between these three elements is not a new phenomenon (Bocken & Geradts, 2020), and further BMI work centered within the critical metals sector would expand this understanding. Zhu, Wittmann and Peng (2012) provide evidence for "institution-based barriers" as being a limiting factor on innovation, and a universal problem for technology based SMEs.

6.3.1.6. Summary of the discussion for research question 1.1

The findings for question 1.1 identified combinations of internal and external factors as drivers of BM and BMI. The findings support the notion expressed by Filsar, et al., (2021) that BMs are at the core of value creation, and can be improved by combinations of common BM elements such as “resources, processes, capabilities and revenue” to improve the value proposition (Filsar, et al., 2021).

External factors included 1) the political economy and geopolitical landscape, and 2) the influence of uncertainty regarding selection of technology, ESG requirements and their combined impact on availability of capital. The findings on the influence of the political economy support the work of Saebi (2015), that these influences can be both proactive or reactive, and can potentially be both a mediating or a moderating variable depending on context.

Internal factors include both tangible and intangible assets, of which the mineral resource is the most significant. It can be argued that the mineral resource is the most fundamental driver of value for mining SMEs, and exceeds the value of any technology innovations or managerial capabilities. The mineral resource remains central to the BM, and in the case of mining SMEs, many of the BMI activities are focused on delivering value to the customer based on the quality of the mineral resource, the level of contaminants and the quality of the recovered product.

Intangible assets also include processes, routines and activities forming the ordinary capabilities of the organisation.

The literature is replete with references to combinations of ordinary capabilities as being dynamic capabilities (Teece, 2007; Teece, 2018). These intangible assets form the basis of the dynamic capability theory, and are dealt with in more detail in the next three sections.

The research findings indicated agreement by the sample group of the need for more collaboration within the critical metals ecosystem network.

The interlinked relationship between availability of financing, level of technological innovation and level of ESG compliance are seen as limitations (potentially moderating variables) or enablers (potentially mediating variables) on BMI, and ultimately on the ability of critical metals mining companies to supply sufficient metals to downstream customers and end-users. Further work is recommended to test this within the critical metals mining sector.

6.3.2. Discussion of the findings for research question 1.2: Sensing DC

The second sub-question is the first of three sections dealing with internal drivers of BMI. This question sought to understand how organisations identify new opportunities using the sensing dynamic capability, and the role it plays in BMI.

Four microfoundations of sensing were identified from the findings describing how new opportunities were identified. These were; the importance of an entrepreneurial mind set, monitoring of the market and changes in technology, knowledge creation and generation of new ideas, and the importance of experience and knowledge transfer.

6.3.2.1. Entrepreneurial mind set

The findings of this theme identified entrepreneurship and a drive to identify new opportunities as a key internal dynamic capability. Entrepreneurship was seen as initially associated with specific individuals within the organisation, but which was progressively adopted by, and become part of the fabric or DNA of the organisation.

The findings recognised how sensing requires foresight and entrepreneurial vision of the founders of exploration / mining start-up companies to recognise opportunities based on a long term view of demand for specific metals, and the emergence and growth of new technological applications. Schwarz, Rohrbeck, and Wach (2019) elaborate on how entrepreneurs sense new opportunities through amplification of weak signals within the market using foresight and scenario analysis, and then generate and refine business models to seize these opportunities. The literature recognises how entrepreneurs exhibit dynamic capabilities and are able to reimagine their surroundings by recognising changes brought about by new trends (Vu, 2020).

The findings showed how sensing was viewed as an entrepreneurial capability, constantly looking for new opportunities and ways to capture new value. Entrepreneurship has a strong influence on business model design, and at its most fundamental level, is a driver of BM design and a primary contributor to value creation (Filser, Kraus, Breier, Nenova, & Puumalainen, 2021).

The findings indicated how this entrepreneurial activity requires the right mind set in core individuals within the organisation, and requires backing the right people that have a natural curiosity, are able to think at a high level and who one can build a team around. This supports Teece (2007) who flagged the cognitive and creative differences between

individuals in senior management as a differentiator in the ability of organisations to create and discover new opportunities.

6.3.2.2. Monitoring of markets and changes in technology

Findings from this theme highlighted that the sensing capability requires an understanding of customers' requirements, the supply and demand dynamics of specific metals and the opportunities that exist based on trends, growth of specific technologies and metal usage associated with these technologies.

Market monitoring and scanning of opportunities by internal individuals or teams, together with sourcing of external data and analytical reports was recognised by the sample group as a key sensing dynamic capability. Schwarz, Rohrbeck, & Wach (2019) state that the sensing capability is reliant on the ability of a manager or team to process large volumes of external information to isolate and articulate opportunities before they are evident to competitor organisations operating in the same sector or industry.

Networking, interacting and establishing trust with a wide global ecosystem was identified in the findings as a valuable information source on trends and technology developments, which assist in defining the BM. This supports the literature finding that the process of building an organisations sensing ability is enhanced through leveraging networks and relationships with customers, suppliers, technology partners and research organisations who contribute new knowledge and data (Foss, Lyngsie, & Zahra, 2013). Customer engagement is seen as an essential process in the sensing capability, as often customers are the first to recognise the potential of new technology (Ibarra, Bigdeli, Igartua, & Ganzarain, 2020).

The data indicated a preference by participants to carry out the market monitoring and scanning of opportunities internally, but with sourcing of external data and analytical reports. This supports the literature that organisations that demonstrate dynamic capabilities through their top management team's innate ability to identify weak signals in their environment ahead of their competition, have an edge on their competitors and are able to innovate their business model to create processes to capture the identified future value gap (Teece, 2014).

In a few cases within the sample group, there was a robust routine funnelling opportunities through a due diligence process involving multiple team members. In other instances, it fell to a senior person within the organisation, acting independently but with recommendations to a board. The findings from the participant's data identified how

smaller mining SMEs often combined sensing and seizing activities in an agile, rapid decision making process involving senior executives and board members.

For Teece (2007) the organisation is however at risk if the sensing capabilities of an organisation are dependent on the perceptions and cognitive abilities of a few individuals, and routines and processes are necessary at an organisational level to capture and synthesis information. The literature further notes that this process should include the establishing of a hypothesis that maps the development of technology, consumer requirements and market feedback and how the organisation can benefit from these changes (Teece, 2007).

6.3.2.3. Knowledge creation and generation of new ideas

Findings from this theme identified discovery and increase of new knowledge through studies, R&D, pilot tests and ESIAs (environmental and social impact assessment) on the mineral resource as a key sensing capability. The findings recognised the importance of a detailed understanding and knowledge of the organisations' mineral resource, and the ability to recover an economically viable and saleable product. The findings noted how this occurs through internal knowledge creation procedures, routines and activities.

The data provided evidence for the importance of these activities to identify, shape and direct the BM in the early stages of development through feasibility studies and pilot test work. This supports the literature (Ibarra, et al., 2020), who note that identification of opportunities is influenced by an organisations knowledge creation processes such as R&D activities, its capacity to interact with current and potential customers regarding their needs, and to classify this information.

Knowledge creation by external and internal teams was identified in the findings as a crucial component in the sensing dynamic capability. The sample group provided evidence of how detailed knowledge was also required for the environmental and community aspects associated with critical metals projects. This knowledge was used to provide a baseline for continuous measuring and monitoring of the ESG drivers, and as a means to differentiate the BM from its competitors through provenance and sustainability metrics (for example, level of scope 1, 2 or 3 emissions).

6.3.2.4. Utilising deep experience and historical knowledge

The findings for this theme indicated how accumulated experience and experiential learning was seen as a crucial sensing capability in the critical metals sector, mainly due to the complexity of the metallurgical processes and the hard skills required to run them. The data indicated how these hard skills were viewed as a necessary early input to ensure the correct information is collected, before a succinct and workable BM can be created. The value of deep experience (amounting to decades of historical knowledge and previous experience) to an organisation was equated to passing information through "*an algorithm of years and years of experience"* (Participant 6). Acquiring of these skills was often only possible through extensive work place experience, which was likened to "*drinking from a firehose"* (Participant 8). The findings noted the importance of transfer of these skills within the organisation to ensure continuity and retention of the dynamic capability. Dynamic capabilities within an organisation are led by individuals initially until it is embedded in the company culture (Teece, 2007).

This supports the literature findings that human capital and knowledge is fundamental to the sensing dynamic capability and the ability of organisations to learn, both of which are primary drivers of BMI (Loon, Otaye-Ebede, & Stewart, 2020).

6.3.2.5. Summary of the discussion for research question 1.2

The research findings for question 1.2 provided evidence that sensing is a dynamic capability used in the critical metals mining sector. This capability was used to collect and analyse data that was used in the creation and innovation of an organisations' BM.

The findings for the question showed that sensing was an entrepreneurial capability, constantly looking for new opportunities and ways to capture new value. The findings also indicated how, in the early stages of a company's development, entrepreneurship is a core character trait of specific individuals that progressively becomes embedded in the DNA of the organisation.

The findings lent support to how smaller organisations' sensing activities are often combined in an agile, rapid decision making process involving senior executives and board members. This supports the literature assessment that entrepreneurship has a strong influence on business model design, and at its most fundamental level, is a driver of BM design and a primary contributor to value creation (Filser, Kraus, Breier, Nenova, & Puumalainen, 2021).

The sensing capability requires an understanding of customers' requirements, the supply and demand dynamics of specific metals and the opportunities that exist based on trends, growth of specific technologies and metal usage associated with these technologies.

The findings from this section were unanimous with respect to the value of deep experience spanning decades, and how these skills were essential in the early sensing stages to ensure that the correct data is collected, and interpreted. This supports the literature findings on the importance of human capital and knowledge as a dynamic capability, and its role as a driver of BMI (Loon, Otaye-Ebede, & Stewart, 2020).

A key finding in this section was that BMs can originate through a process of idea generation based on new information that has been collected or interpolated from other data. Discovery and increase of new knowledge through studies, R&D and pilot tests on the mineral resource was identified as a key sensing capability that help to shape and mould the BM. Networking with a wide global ecosystem was identified in the findings as a valuable information source on trends and technology developments.

Combined these unique dynamic capabilities all contribute to the BM, and are drivers of BMI.

6.3.3. Discussion of the findings for research question 1.3: Seizing DC

The third sub-question to research question 1 sought to understand how organisations take advantage of new business opportunities in the context of the seizing dynamic capabilities and the role it plays in BMI of the organisation.

Three microfoundations of seizing were identified from the findings describing how new opportunities are acted upon. These were; architecture and design of business models, establishing a strategy and planning of strategic investments, and collaboration with strategic partners.

6.3.3.1. Architecture and design of business models

The findings for this theme recognised seizing as a design and planning process, and the point at which an opportunity or idea that has been sensed is formulated into a BM.

Findings from the data provided evidence of the role that seizing dynamic capabilities play in the critical metals sector, and the role of DCs in the architecture, design and

innovation of participant company's BMs. Successful companies in the sample group were able to translate this into a multi-layered BM through the seizing dynamic capability, articulating the logic of the company, what it does, how it works and how it creates long term value and revenue streams (Teece, 2018). This supports the literature findings that the microfoundations of the seizing dynamic capability are strongly influenced by strategic planning, business model innovation and changes to corporate governance structures and collaboration (Khan, Daddi, & Iraldo, 2020).

Participants' data indicated that BM architecture was influenced by the understanding of the critical metal value chain, and where demand was going to be concentrated. This supports the literature view that the business model design process provides detail on technologies to use, the specifications of products and services, marketing requirements and a cost / revenue model (Teece, 2018).

The findings provided evidence for BM conceptualisation and BMI as a complex process requiring constant review based on an ever deepening understanding of the value chain. The sample group recognised the need for flow in the business model, and that in BMI, "*rather than trying to paddle upstream, it is necessary to do something that has a downstream flow to it*" (Participant 7).

Positioning the company towards a predicted outcome or trend was also seen as a crucial role of the seizing dynamic capability, with a need to "*skate to where the puck is going, not to where it's been*" (Participant 3). This supports the literature that the process of BM design is complex and is as much an art as a science, requiring creativity, insight and judgement on how best to combine information from competitors, customers and suppliers (Teece, Peteraf, & Leih, 2016).

The findings indicated the dynamic nature of participant's BMs which were seen as dynamic and constantly evolving as risks were identified, and new markets emerged or were created. The potential to enhance value through involvement in the mid-stream and downstream ecosystem network was a recurring theme in the data. This supports the literature, which indicates that value for the organisation is created by changing existing market offerings; through innovative combinations or iterations of value creating activities external to the organisation; or by addition of innovative of new products, processes or services (Mousavi, Bossink, & van Vliet, 2019).

6.3.3.2. Establishing a strategy and planning of strategic investments

The findings for this theme showed a close alignment between BM design and the preparation of a strategic roadmap and implementation plan. Strategic planning, capital

estimation and budgeting was a universal process and a necessary dynamic capability amongst participants.

The findings indicate that this process was deeply embedded in the various stage gate studies from early PEA to BFS level amongst mining SMEs, and was a necessary first step in the planning phase to establish economic viability. This supports the dynamic capabilities literature that one of the mediating factors for successful business model design is scenario analysis looking at multiple alternatives (Teece, 2018).

The sample group also used strategic planning to guide them in human capital requirements including organisational design, defining what skills were required and whether those skills should be external (consultants) or in-house. This supports the literature, and the identification of organisation design as a key microfoundation of DCs required for successful BM design (Loon, Otaye-Ebede, & Stewart, 2020).

6.3.3.3. Collaboration with strategic partners, governments and shareholders

The findings for this theme recognised that seizing required establishing strong collaborative relationships to acquire resources and knowledge, and to establish a platform to exploit opportunities. This supports the literature where collaboration has been identified as an important seizing microfoundation of dynamic capability in the circular economy (Khan, Daddi, & Iraldo, 2020; Madsen, 2010).

The sample group highlighted how BMs are progressively being modified and adapted to bridge the gap between upstream suppliers (mining companies) and downstream customers (downstream manufacturers) through the creation, and building of new markets. Bocken & Geradts (2020) recognise collaborative innovation as a dynamic capability and a driver of sustainable BMI. Evidence was provided on how organisations' products were positioned, and how value that they offer influenced considerations for BM selection and BMI. Collaboration as a driver of BMI is well supported in the literature (Bocken & Geradts, 2020), and was identified as a microfoundation of dynamic capability by Khan, et al., (2020).

There was overwhelming support from the data findings that relationship building with government departments regulating the mining industry was a core seizing dynamic capability that strengthened the BM, due to the extractive and non-renewable nature of mining and its impact on communities. The findings provided evidence of how win-win solutions in terms of revenue generation, reputational impacts and seizing of incentives offered by governments helped to strengthen these relationships. This supports the

literature view that collaboration and partnership is an essential seizing capability and is necessary to acquire further knowledge and resources.

The findings indicated how mining SMEs collaborated with key institutional investors to ensure progression of development projects through the various stage gates and on to construction. This is particularly relevant in technology dependent industries where organisations may not achieve this knowledge through their own R&D activities, and are able to exploit the advanced capabilities of universities, research institutes and nongovernmental organisations (Khan, Daddi, & Iraldo, 2020).

6.3.3.4. Summary of the discussion of the findings for research question 1.3

The findings for question 1.3 recognised that seizing dynamic capabilities are evident in the critical metals sector, and form the foundation of BM architecture and design. BM architecture for many of the participants was influenced by their understanding of the critical metal value chain, and where demand was going to be concentrated. For most of the sample group, the BM provided the broad structure and guiderails for the preparation of a strategic roadmap and implementation plan.

The findings provided evidence of how the seizing dynamic capabilities of some companies within the critical metals mining sector was the integrative skill to design and weave the business model architecture into the fabric of their products, ensuring that their organisations would ultimately attract a premium pricing with a high willingness to pay from customers. This process is as much an art as a science, requiring creativity, insight and judgement on how best to combine information from competitors, customers and suppliers (Teece, Peteraf, & Leih, 2016). This is closely aligned with the literature view on the BM design process and the level of detail required on technologies to use, product specifications and marketing requirements (Teece, 2018).

The findings provided evidence for strategic planning and scenario analysis as a seizing capability to guide the organisations' human capital needs through organisational design, defining what skills were required and whether those skills should be external (in the form of consultants) or in-house. Participants identified that strategic planning also provides an anchor for culture and values of the organisation. This aligns well with the microfoundations of human capital dynamic capabilities elaborated on by Loon, et al., (2020).

The findings recognised the role of strong collaborative relationships with governments to acquire new resources, knowledge and exploit opportunities as a critical component of BMI and BM design. Strong collaborative relationships with research institutions,

universities and industry agencies that could facilitate cooperation across the value chain were all noted as part of the seizing dynamic capability.

6.3.4. Discussion of the findings for research question 1.4: Transforming DC

The fourth sub-question sought to understand how organisations transform their businesses after having identified, and planned for a unique opportunity and the role it plays on the BMI of the organisation.

Four microfoundations of transforming were identified from the findings. These were; organisational restructuring, project implementation skills, knowledge integration and transfer, and adoption and adaptation of best practice.

6.3.4.1. Organisational restructuring and company culture

The findings for this theme identified that organisation restructuring required dynamic capabilities to establish and embed a new company culture through a transformation process, from start-up phase to post-merger in the case of one participant where resources had been acquired. Participants recognised that organisation restructuring requires dynamic capabilities to establish and embed a unique company culture, matched to the *season* of the business.

Data from this question highlighted the value-add of agile, decentralised, lean management structures with a communicative overlay. The findings emphasised the role of curiosity, and an environment that encourages the willingness to ask questions as being crucial to instilling an innovation culture. This willingness to question the status quo was a common theme in the data, and was identified as a key factor, encouraging BMI and continuous modifications to the BM.

The findings provided evidence of how an embedded culture created the unique capabilities of the organisation going forward, whether it was a focus on entrepreneurial thinking at the start-up phase or a focus on project development and operations as companies matured. This culture is embedded in the BM and is a driver of BMI.

Combination of assets through M&A were recognised as requiring dynamic capabilities in order to understand how a combination of assets would create real synergies for revenue growth utilising sensing dynamic capabilities, and then to restructure the combined organisation and instil a common culture and set of values using transforming capabilities. The ability to integrate assets enhances the BM and is a driver of BMI.

This supports the literature where the transforming DC has been described as an *asset orchestration* process. For Teece (2007), assets that have greater value when combined are able to deliver more highly valued competitive advantage than if considered in isolation, but require dynamic capabilities to identify, manage and transform so that the whole is more valuable than the sum of the parts.

6.3.4.2. Project implementation skills

The findings from this theme highlighted the need for strong implementation and project execution capabilities in the transforming stage. In particular, the transforming DC in the sample group relied strongly on the need to build coherent and capable in-house teams.

The findings emphasized the importance of building stable teams to oversee project implementation and execution capabilities, and how deep and permanent experience within these teams was able to create long term value, forming a key anchor to the BM and enabling BMI.

Where companies in the sample group had multiple development assets, these were sequenced one after another rather than in parallel, ensuring quality of the design and construction and adherence to budgets. The findings also noted how the retention of in-house project implementation teams allowing the organisations to benefit from the shared learning from multiple project implementations, avoiding previous mistakes and improving delivery. The ability to learn from previous mistakes was seen as strengthening the BM, and facilitating BMI.

In the more mature organisations in the sample group, the ability to deliver projects on time, on budget and that meet design specifications were fundamental building blocks of their BM, creating value and competitive advantage.

6.3.4.3. Knowledge integration and transfer

The findings of this theme identified that the transforming dynamic capability is people and skills driven, and is enabled by ensuring that the right people are recruited, matched to the right roles, at the right time. The findings noted the importance of understanding each team member's strengths and weaknesses to ensure fit with the team.

This supports the literature on the microfoundations of human capital capabilities in BMI. Loon, et al., (2020) recognised the positive influences of careful hiring, thereby ensuring that the organisation is able to gain new skills and knowledge, while also building

resilience to periods of uncertainty. Having the right people in the right roles allows agility and encourages BMI.

The sample group recognised that where deep experience and historical knowledge was available, the crucial role in the transforming dynamic capability was to ensure that this knowledge was distributed and embedded within the organisation. Where skills and deep experience were held by older members of the team, transforming required transfer of experiential knowledge to a younger team, who were then able to internalise this information into the BM of the organisation.

6.3.4.4. Adoption and adaptation of best practice (routines and procedures)

The findings from this theme identified the need for best practice routines and processes to be codified and embedded in the organisation. The findings indicated how combinations of operationally focused capabilities were able to deliver unique dynamic capabilities and facilitate BMI.

One participant described how their unique capabilities consisted of internal managerial capabilities describing an agile, decentralised, highly communicative organisation that was able to move fast, combined with a focus on culture, operational excellence, project execution and ESG permitting capabilities. As a combination of capabilities, the organisation established a unique BM, and a key enabler for successful BMI.

The literature defines ordinary capabilities as repetitive daily activities that enable companies to produce goods or services in a semi-efficient manner, and from which they derive income. Unique combinations of these ordinary capabilities can however constitute dynamic capabilities as “signature processes” (Gratton & Ghoshal, 2005) (Teece, Pisano, & Shuen, 1997).

6.3.4.5. Summary of the discussion of the findings for research question 1.4

The findings for question 1.4 identified that organisational restructuring and transforming requires higher order capabilities and skills to establish and embed a unique culture, matched to the *season* of the business. The transforming dynamic capability was identified as people and skills driven, and was enabled by ensuring that the right people are recruited, matched to the right roles, at the right time and then combined into a coherent team.

A decentralised structure with a lean and agile team, with strong inter-discipline communication was the preferred organisational structure, encouraging local independence and resilience. This was seen as having a positive effect on BMI and the ability of the organisation to respond quickly to external inputs.

The findings indicated that mining SMEs in the critical metals sector were highly reliant on establishing an innovation culture built on trust and openness between team members. A willingness to question the status quo was a common theme in the data, and was identified as a key factor encouraging BMI and continuous modifications to the BM.

Also key to the transforming dynamic capability was the importance of building stable and capable in-house teams to oversee project implementation and execution capabilities, that understand the culture of the company and are matched to the phase of the company. The findings emphasized how deep and permanent experience within these teams was able to create long term value, forming a key anchor to the BM and enabling BMI.

Transforming requires transfer of experiential knowledge to a younger team, who were then able to internalise this information into the BM of the organisation. Routines and processes were identified as crucial for operational SMEs to embed new practices and routines into the fabric of the organisation.

6.4. Discussion of the findings for research question 2

"How is the business model affected by environmental uncertainty?"

Research question 2 sought to understand how companies perceive and deal with environmental uncertainty as an external antecedent of BMI.

The diverse responses and strategies described emphasised the complexities faced by companies operating in the critical metals mining sector, and how business is dynamic, non-linear and does not follow a script. In the critical metals mining environment, companies can be at multiple stages of sensing, seizing and transforming at the same time, indicating a high level of state uncertainty and dynamic change (Milliken, 1987).

One participant equated this uncertainty to a game of '*snakes and ladders'* or a '*corporate board game of life'*. Changes in the environment mean a company can move from being

in a transforming mode and developing towards a producing mine, and in short succession, be moved back down to a sensing mode for any of a number of reasons.

Five broad categories were identified from the findings. These were; uncertainty related to Black Swan events, market uncertainty, technology uncertainty, financing uncertainty, and, risk identification and mitigation strategies.

6.4.1. BMI affected by Black Swan events (unknown-unknowns)

The findings for this theme identified *Black Swan* or *Unknown-unknowns* events as events that have such a low probability of occurrence that businesses could not have foreseen them, have not prepared for them and that they come from *left field*.

The findings identified how having the right people in the right roles was a critical enabler to deal with unexpected events, and that while the cause of the event may have originated as an external driver, the response to these events are driven by people and their unique capabilities.

The sample group identified quality and scale of the mineral resource as a key asset of mining SMEs. High cost producers, normally associated with lower quality and lower volume, are typically the most distressed in a falling commodity price environment.

BMs and BMI are equally influenced by uncertainty, and ordinary capabilities in these conditions are short lived as competitors are quick to copy and adjust their business models to outcompete against first mover organisations (Gratton & Ghoshal, 2005).

The findings identified agility, flexibility, adaptability, decentralised decision-making coupled with strong communication and investor relationships as critical organisational and managerial capabilities needed to manage conditions of extreme environmental uncertainty.

It can be argued that these capabilities, when grouped together, define higher order dynamic capabilities which strengthen the organisation and position it to be adaptable to changing environmental conditions. This approach supports the literature, with Leih, Linden, & Teece (2015) noting how organisations can compensate for environmental uncertainty internally through decentralisation of management control and adaptability of employees throughout the organisational structure, increasing the chances of survival when faced with uncertainty. Where companies have internal dynamic capabilities to deal with uncertainty, they are able to scan and analyse the business environment, and are able to adapt to the observed uncertainty and transform their BMs to play to their strengths and reduce exposure to threats (Teece, 2018).

6.4.2. BMI affected by market uncertainty

The findings for this theme recognised that the mining industry is cyclical by nature, and prone to *boom and bust* cycles based on mismatched supply and demand, and *stickiness* in investment in new capacity.

The findings identified commodity price volatility as a reality, and the need for a strong balance sheet as being fundamental to managing cyclical downturns. The findings suggested that long term investment decisions be based on multiple scenarios, testing the viability of an investment at a number of commodity price points. This has a significant impact on the BM and BMI, with certain options not likely to be viable at lower prices.

Market uncertainty in the critical metals is also highly susceptible to geopolitical risk based on tensions between China and the west. This is particularly significant in certain metals where supply of finished products, such as batteries and permanent magnets, are dominated by China. The findings recognise that BMs for many mining SMEs providing the raw material for these products are fluid and in a state of change, as many western countries have started encouraging the delinking of supply from China through the development of their own critical metals supply chains.

The impact of these changes provides an opportunity for those organisations that are able to apply dynamic capabilities to sense, seize and transform opportunities into real economic value. Findings in this theme suggest that companies within the sample group were alert to these signals, and were actively innovating their BMs to supply existing markets and create new markets where they these do not exist. This supports the literature (Teece, 2018), where opportunities to address these factors might include product differentiation and segmentation to separate them in the market and gain competitive advantage

6.4.3. BMI affected by technology uncertainty

The findings for this theme recognised the uncertainty in the downstream renewable energy technology (for example, lithium ion batteries), noting the impact this uncertainty in the energy storage technology has on the investment decision-making process in the critical metals mining sector.

Findings were inconclusive on how to deal with technology uncertainty, except to rely on the embedded technology of many of the downstream end-users, and that this is not

likely to change soon due to the large investments that have been made, for example, in lithium ion battery technology.

6.4.4. BMI affected by financing uncertainty

The findings have recognised the importance of finance and investing in the critical metals value chain, describing both as the '*fabric within which the value chain rests'*, and recognised the uncertainty created by the push-pull factors between funding, technological innovation and ESG. The interlinked relationship between availability of financing, level of technological innovation and level of ESG compliance was viewed as an external environmental uncertainty, but with internal controls for mining SMEs.

The findings recognise ESG compliance as having a significant impact on the ability of critical metal companies to raise project finance, with ESG requirements carrying a similar weighting to the need for de-risked or proven mining / processing technology.

The findings indicate that the lack of financing availability was a limitation (and a potentially moderating variable) on BMI, but that could be enabled (potentially mediated) by a lower level of technology, and a higher level of ESG compliance. The findings identified the need to minimise the upfront financial risk for financiers by creatively envisioning a business model that uses proven technology, while also ensuring that ESG issues are properly managed.

6.4.5. Strategies to manage uncertainty and risk

The findings for this theme identified risk management and comprehensive financial analysis as a process to be used to address the *known-unknowns* (observable risks).

The sample group identified specific analytical processes (stress tests, liquidity analysis, risk management and risk registers) and financial tools (hedging, financial derivatives) that can be combined to create playbooks on how to manage their businesses during periods of high uncertainty.

The findings noted the use of buffers and contingency reserves in both a technical design sense (for example, designing spare capacity on a tailings dam to address extreme weather conditions) and a financial management sense (as cash reserves or access to funding) as a way to manage risk and uncertainty.

The findings identified close communication with customers as an essential strategy to ensure long term alignment of their product with the end-users needs (and thus strengthen demand) to insulate the company from demand weakness and price volatility.

6.4.6. Summary of the discussion of the findings for research question 2

The findings of this question identified how having the right people in the right roles with unique managerial dynamic capabilities and decision-making autonomy was crucial to deal with environmental uncertainty. Agility, adaptability and flexibility are all key traits that potentially mediate this ability to manage uncertainty.

Environmental uncertainty has a significant impact on the selection of the BM and the ability of an organisation to innovate. The findings recognised the uncertainty associated with the restrictions placed by capital providers on the selection of new, untested technology, identifying lack of financing availability as a limitation (and a potentially moderating variable) on BMI, but that could be enabled (potentially mediated) by a lower level of technology, and a higher level of ESG compliance. This opens up an avenue for future research.

The findings identified the need to minimise the upfront financial risk for financiers by creatively envisioning a business model that uses proven technology, while also ensuring that ESG issues are properly managed. The ability to translate this into a competitive advantage requires dynamic capabilities to incorporate this knowledge into the design and fabric of the BM and strategy.

Mining SMEs that are able to address this wicked problem through application of managerial and organisational dynamic capabilities will be able to create value for shareholders and end-users alike, and develop resilience to environmental uncertainty and extreme event shocks.

The findings also identified a number of risk mitigation strategies to manage known-unknowns including specific analytical processes (financial stress tests, liquidity analysis, risk analysis and risk registers) and financial instruments (hedging, financial derivatives) that can be used to create playbooks on how to manage their businesses during periods of high uncertainty. The use of technical buffers and financial contingency reserves were also flagged as a way to manage environmental uncertainty.

CHAPTER 7. CONCLUSION AND RECOMMENDATIONS

7.1. Introduction

This study was established to explore the role of dynamic capabilities as internal drivers of business model innovation within the critical metal mining sector. This research was set at the level of the organisation, and was contextualised within a globally dynamic environment, looking at the impact that environmental uncertainty has on business model innovation, and some of the strategies that exist to deal with this uncertainty.

Results from this study indicate that dynamic capabilities have a significant impact on business models and business model innovation. Dynamic capabilities have been shown to be enablers of business model innovation of critical metal mining companies, and more generically mining SMEs. Furthermore, dynamic capabilities were also identified as being useful to manage in times of extreme uncertainty.

Results were presented in Chapter 5 based on 11 interviews of senior (C-suite and executive level) participants drawn from the critical metals sector. Chapter 6 pulled in the themes and categories identified in the thematic analysis carried out in Atlas.ti as findings, which were then compared to the literature review in Chapter 2.

In this chapter, findings are further condensed and summarised and compared against the research questions and objectives established in Chapter 1. Recommendations are then made to management of mining SMEs operating in the critical metals sector.

Finally, research limitations are discussed and recommendations for future research are made.

7.2. Summary of the research findings

This research has addressed the main research problem outlined in Chapter 1 regarding the role dynamic capabilities play in the creation and innovation of business models in the critical metals mining sector.

This was initially framed as a high level question to establish participants' views on innovation within the mining sector. This was then narrowed down to the critical metals mining sector, first identifying the drivers of business model innovation within the critical metals mining sector, and then looking at the data findings for each of the three dynamic capabilities, namely, sensing, seizing and transforming.

The constructs and participants' views discussed in Chapter 5 and Chapter 6 covered a wide range of topics, and generated a large volume of insights pertinent to the critical metals mining sector.

The research indicated that business model conceptualisation and innovation is a complex process requiring constant review and an ever deepening understanding of the value chain. Translation of this understanding into a multi-layered business model, expressing the logic of the company, what it does, how it works and how it will create long term value and revenue streams was seen as a dynamic process, requiring skilful iteration and weaving into a coherent story.

7.3. Proposed framework

A generalised schematic illustrating the relationships between the various themes and constructs investigated in this study is presented in Figure 19. Uncertainty is viewed as all around in many different forms, and at various levels of intensity. These define the operating environment with the positioning for this study as the global energy transition.

The critical metals sector is a subset of the global energy transition, within which there are various business models and strategies to create value. These are enabled by the dynamic capabilities of sensing, seizing as black dashed lines which have arrows facing inwards towards the business model and strategy at the centre to denote the evolving process over time. Sensing starts outside of the business model, and progressively narrows down into the critical metals sector. Seizing starts within the sector but then narrows down further to select a business model and an execution strategy. The transforming dynamic capability is drawn as arrows facing outwards from company strategy to denote execution and implementation via a strategy to outcompete within the critical metals sector.

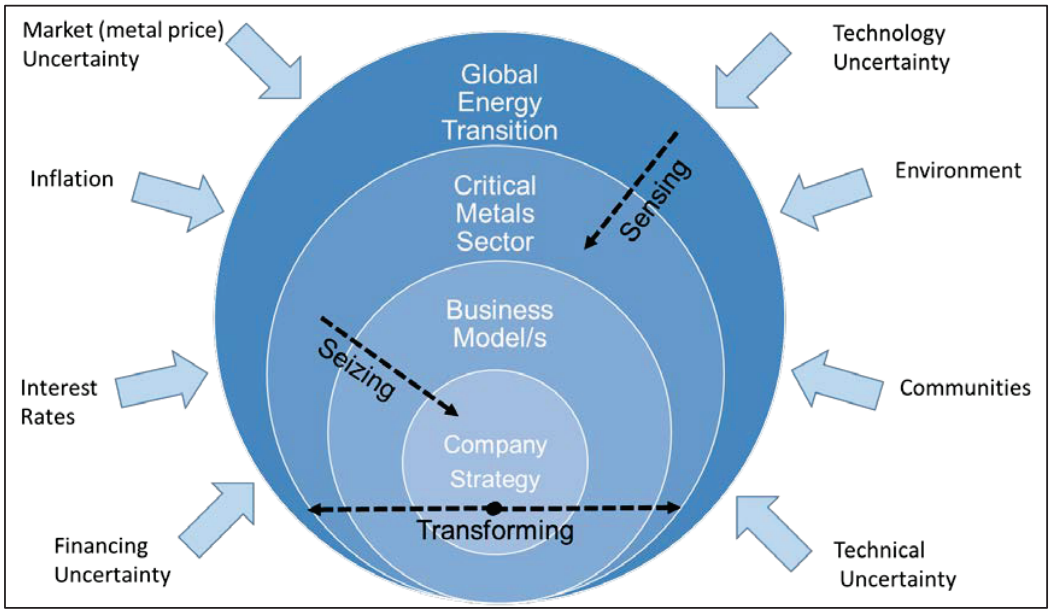

Figure 19. Schematic illustrating the role of dynamic capabilities on BM innovation as identified in this study (Author's creation).

7.4. External Drivers of BMI

This research has identified combinations of internal and external factors as drivers of BM and BMI. External factors included 1) the political economy and geopolitical landscape, and 2) the influence of uncertainty regarding selection of technology, ESG requirements and their combined impact on availability of capital.

This research has highlighted that the availability of finance is an acute external driver of BMI within the critical metals sector, subtly directing business model innovation and technological innovation towards small incremental changes rather than *great leaps forward*.

This research recognised the uncertainty associated with the restrictions placed by capital providers on the selection of new, untested technology, identifying lack of financing availability as a limitation (and a potentially moderating variable) on BMI, but that could be enabled (potentially mediated) by a lower level of technology, and a higher level of ESG compliance. Further work is recommended to test this within the critical metals mining sector.

This has created a *wicked problem* for the critical metals producers and end-users alike, requiring higher order thinking and dynamic capabilities to solve. Mining SMEs that are able to address this wicked problem through application of managerial and organisational

dynamic capabilities will be able to create value for shareholders and end-users alike, and develop resilience to environmental uncertainty and extreme event shocks.

Contrary to what many of the participants reported, mining SMEs within the critical metals sector have been innovative, but in a negative sense, having had to find ways to negotiate around the financing bottleneck.

The findings suggest that companies have responded to the negative feedback from financiers, and have adjusted their BMs by ensuring there is limited novel, untested technology, with high ESG compliance to minimise risk. Innovation in the critical metals mining sector may need to contend with this problem for some time longer, and BMI may need to remain a compromise between the apparent three levers of innovation in the critical metals mining sector, namely, level of novel technology, level of ESG compliance and availability of finance.

In this regard, mining SMEs should focus on refinement of their BMs, pursuing a well thought out business model using an ordinary technology to address the financing risk, rather than developing a great technology but using an average business model (Chesbrough, 2010).

7.5. Internal Drivers of BMI

Internal factors include both tangible and intangible assets, of which the mineral resource was identified as the most significant.

It can be argued that the mineral resource is the most fundamental driver of value for mining SMEs, and exceeds the value of any technology innovations or managerial capabilities. The mineral resource remains central to the BM, and in the case of mining SMEs, many of the BMI activities are focused on delivering value to the customer based on the quality of the mineral resource, the level of contaminants and the quality of the recovered product.

To address the internal drivers of BMI, the research identified the microfoundations of dynamic capabilities in the critical metals mining sector.

Some of the key findings are summarised below.

7.5.1. Sensing

This research identified entrepreneurial capability as a sensing DC, constantly looking for new opportunities and ways to capture new value. In the early stages of a company's

development, entrepreneurship is a core character trait of specific individuals that progressively becomes embedded in the DNA of the organisation. The research identified how in smaller organisations' sensing activities are often combined in an agile, rapid decision making process involving senior executives and board members. The sensing capability requires an understanding of customers' requirements, the supply and demand dynamics of specific metals and the opportunities that exist based on trends, growth of specific technologies and metal usage associated with these technologies.

This research found strong support for the value of deep experience spanning decades, and how these skills were essential in the early sensing stages to ensure that the correct data is collected, and interpreted. The research identified how BMs can originate through a process of idea generation based on new information that has been collected or interpolated from other data.

Discovery and increase of new knowledge through studies, R&D and pilot tests on the mineral resource was identified as a key sensing capability that help to shape and mould the BM. Networking with a wide global ecosystem was identified in the findings as a valuable information source on trends and technology developments.

Combined, these unique dynamic capabilities all contribute to the BM, and are drivers of BMI.

7.5.2. Seizing

This research identified the seizing dynamic capabilities as being the lynchpin of BM and BMI within the critical metals sector.

BM architecture and design appears to be mediated by the sensing dynamic capability, and is influenced by the depth of understanding of the critical metal value chain, and where demand was going to be concentrated. Within the seizing capability, the BM provided the broad structure and guiderails for the preparation of a strategic roadmap and implementation plan.

This research provided evidence of how the seizing dynamic capabilities of some companies within the critical metals mining sector was the integrative skill to design and weave the business model architecture into the fabric of their products, ensuring that their organisations would ultimately attract a premium pricing with a high willingness to pay from customers. This process is as much an art as a science, requiring creativity, insight and judgement on how best to combine information from competitors, customers and suppliers (Teece, Peteraf, & Leih, 2016).

This is closely aligned with the literature view on the BM design process and the level of detail required on technologies to use, product specifications and marketing requirements (Teece, 2018).

This research provided evidence for strategic planning and scenario analysis as a seizing capability that is used to guide the organisations' human capital needs through organisational design, defining what skills were required and whether those skills should be external or in-house. The research also identified BMI and strategic planning as an anchor for culture and values of the organisation. This aligns well with the microfoundations of human capital dynamic capabilities elaborated on by Loon, et al., (2020).

This research recognised the role of strong collaborative relationships with governments, research institutions, universities and industry agencies that could facilitate cooperation across the value chain as part of the seizing dynamic capability.

Where this collaboration results in new resources, knowledge or opportunities being acquired, it enables BMI and BM design.

7.5.3. Transforming

This research identified the transforming dynamic capability as people and skills driven, and was enabled by ensuring that the right people are recruited, matched to the right roles, at the right time and then combined into a coherent team. The research identified organisational restructuring as necessary to establish and embed a unique culture, matched to the *season* of the business.

A decentralised structure with a lean and agile team, with strong inter-discipline communication was the preferred organisational structure, encouraging local independence and resilience. This structure appears to have a positive (possibly mediating) effect on BMI, and the ability of the organisation to respond quickly to external inputs.

The research identified that mining SMEs in the critical metals sector were highly reliant on establishing an innovation culture built on trust and openness between team members. A willingness to question the status quo was a common theme in the data, and was identified as a key factor encouraging BMI and continuous modifications to the BM.

Also key to the transforming dynamic capability was the importance of building stable and capable in-house teams to oversee project implementation and execution

capabilities, that understand the culture of the company and are matched to the phase of the company.

Transforming requires transfer of experiential knowledge to a younger team, who were then able to internalise this information into the BM of the organisation. Routines and processes were identified as crucial for operational SMEs to embed new practices and routines into the fabric of the organisation.

The research emphasized how deep and permanent experience within these teams was able to create long term value, forming a key anchor to the BM and enabling BMI.

7.6. Environmental Uncertainty

This research identified how having the right people in the right roles with unique managerial dynamic capabilities and decision-making autonomy was crucial to deal with environmental uncertainty. Agility, adaptability and flexibility were all key traits that potentially mediate this ability to manage uncertainty.

Environmental uncertainty has a significant impact on the selection of the BM and the ability of an organisation to innovate.

The findings also identified a number of risk mitigation strategies to manage known-unknowns including specific analytical processes (financial stress tests, liquidity analysis, risk analysis and risk registers) and financial instruments (hedging, financial derivatives) that can be used to create playbooks on how to manage their businesses during periods of high uncertainty. The use of technical buffers and financial contingency reserves were also flagged as a way to manage environmental uncertainty.

Few companies applied strategic foresight and scenario analysis, or deep learning methods to identify or model out Black Swan / 'Unknown-unknown' type events.

7.7. Managerial Implications

This research highlighted a few high level findings relevant to the role of dynamic capabilities to business model innovation are summarised as follows:

- Critical metals are niche commodities, and require substantial investment in time and analysis of the supply and demand aspects of the specific metals markets, as each market is different.
- The critical metals sector is knowledge driven, and is experiencing a global technical and commercial skills shortage.

- Many of the people with these skills have three or four decades of experience. Acquisition and transfer of this knowledge is a key element of business model and strategy design.
- Junior and mid-tier mining companies in the upstream supply of critical metals have difficulty raising finance for projects where processing technology to recover the complex minerals is not 'tried and tested', or has high risk associated with high capital intensity.
- Critical metals have a complex and extended supply chain that is complicated by Chinese dominance of the renewable energy end-products, namely, batteries and permanent magnets for the electric vehicle and wind turbine markets.
- There is a need for upstream mining companies to bridge the midstream and downstream gap with end customers to ensure correctly specified products that meet customer's needs.
- There is a need for innovation in the financing of these projects to ease this bottleneck. Venture capital and private equity time horizons are too short for the development of mining projects that could take up to 10 years to develop, and many hundred millions of dollars.
- Without an increase in supply and allocation of Permanent Capital that understands these markets and the technical process risks of individual metals, the addition of new critical metals will remain constrained.

This research suggests that part of the solution lies in more effective communication between stakeholders at all points in the critical metals ecosystem network to find ways to bridge the gap between upstream suppliers and downstream markets in the value chain, and that financing needs to be included in this value chain ecosystem as an overarching enabling layer (or '*fabric*') rather than to be viewed as an outsider to the value chain.

Specialist finance providers (private equity or permanent capital) with deep research and analytical capabilities that understand the critical metal markets, would seem to be a better fit than traditional mining project finance providers.

The more successful mining SMEs in this value chain will be those that are able to create value for their shareholders by unlocking access to capital through innovative business models incorporating technological improvements, ESG compliance and financing partnerships along the value chain.

7.8. Research Implications

This research has not extended dynamic capability (DC) or the business model innovation (BMI) theory due to the small population size and inability to compare responses in an academically valid manner.

This research has however identified a number of areas relevant to the critical metals sector that would benefit from further study.

Possible hypotheses worth pursuing are:

- H1: Does lack of project financing availability act as a moderating or mediating variable on BMI within the critical metals sector?
- H2: Does the level of technology act as a mediating or a moderating variable on the availability of project financing in the critical metals sector?
- H3: Is project finance within the critical metals sector mediated or moderated by a lower level of technology?
- H4: Is project finance within the critical metals sector mediated or moderated by a higher level of ESG compliance?

7.9. Research Limitations

The qualitative and exploratory nature of this research meant that it is difficult to demonstrate academic rigour in terms of the observations and findings due to the small sample size and semi-structured nature of the data collection.

The researcher acknowledges the subjectivity of the answers provided in the interview, and that not all questions were answered in full by the participants.

While care was taken to identify and interview senior executives within the critical metals sector, critical metals are not homogenous and each metal is unique with different processes applicable. This may have influenced the answers form participants.

7.10. Conclusion

This research was positioned in the mining industry to explore the drivers of business model innovation in answer to a 2021 survey carried out by EY, recognising for the first time that supply disruptions to metals markets have compelled global mining and metals businesses to create and innovate business models to identify, optimise and capture new value. The unique supply and demand constraints of the critical metals sector identified that a more nuanced understanding of the business models and strategies applied in this sector was needed.

Business model creation and innovation is a complex process and is as much an art as a science, requiring creativity, insight and judgement on how best to combine information from competitors, customers and suppliers (Teece, Peteraf, & Leih, 2016). This has been made more complex for the junior and mid-tier mining SMEs who are developing the next wave of critical metals projects, as a result of restrictive access to capital which has placed a cap on the level of innovation that can be applied within the business model and at a project level.

This research has identified the need to minimise the upfront financial risk for financiers by creatively envisioning a business model that uses proven technology, while also ensuring that ESG issues are properly managed. In this regard, mining SMEs should focus on refinement of their BMs, pursuing a well thought out business model using an ordinary technology to address the financing risk, rather than developing a great technology but using an average business model (Chesbrough, 2010).

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APPENDICES

Appendix A: Interview Questionnaire

Introduction

The business context for this research is the energy transition from fossil fuels to renewables, and concerns raised in numerous forums regarding the mining sector's ability / capacity to deliver sufficient critical metals (specifically copper, nickel, cobalt, lithium, tin, rare earths, pgm's) for the accelerated deployment of solar panels, wind turbines, battery electric vehicles and hydrogen electrolysers to meet the net zero objectives agreed to by many countries in the next decade.

Research Topic

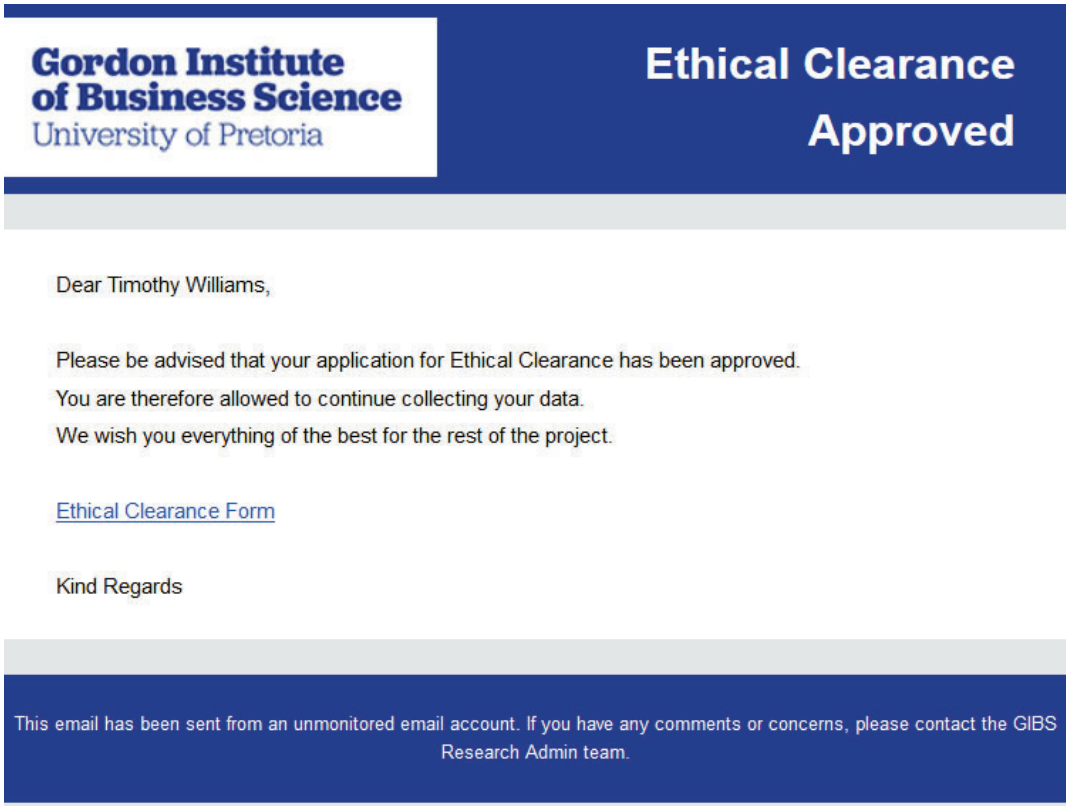
The research topic is exploratory in nature, and will use a semi-structured interview format (max 60min) to explore the unique ("dynamic") internal capabilities mining companies have developed to inform and modify their business models when faced with uncertainty ("unknown-unknowns") in both current and future business environments. The intention is to identify multiple themes from the interview, which will then be used to define high level concepts across a sampling of critical metal mining companies.

Exploratory questions covering Business Model Innovation, Dynamic Capabilities and Environment Uncertainty

1. In your opinion, how innovative is the mining industry, and do you feel your company is a leader or a follower in the creation and adoption of new technology? ["*opening / framing" question*]
2. What does business model innovation mean for your company and the commodities it produces? ["*BMI" question*].
    - ✓ How do you encourage entrepreneurial / intrapreneurial thinking within your company, and should it be incentivised?
3. Can you elaborate on some of the unique internal capabilities that set you apart from your competitors? *["dynamic capabilities" question*].
    - ✓ Where in your company is this level of thinking located, and how does your company address gaps in these unique capabilities?
4. How does your company identify and take advantage of new business opportunities? *["sensing & seizing" question"].*

5. In your experience, how adaptable has your company been to changing opportunities and new challenges, and how is this change facilitated / enabled? *[“transforming” question]*
6. What does your company do to deal with uncertainties in the business environment, and how do you prepare the company and deal with external “unknown-unknowns” or “black swan” events in the future? [“*uncertainty”, “forecasting” question*]
7. Is there anything else you’d like to add, or that we might have missed? [“*closing” question*]

Appendix B: Ethical Clearance



Gordon Institute of Business Science
University of Pretoria

Ethical Clearance Approved

Dear Timothy Williams,

Please be advised that your application for Ethical Clearance has been approved.
You are therefore allowed to continue collecting your data.
We wish you everything of the best for the rest of the project.

Ethical Clearance Form

Kind Regards

This email has been sent from an unmonitored email account. If you have any comments or concerns, please contact the GIBS Research Admin team.

Appendix C: Participant Consent Form

Dear Mr _____

I am conducting research on the *role of dynamic capabilities of an organisation as internal drivers of business model innovation within the mining industry*. I have narrowed the focus of this research to companies in the critical metal sub-sector as there is compelling evidence that both supply and demand side strategies / business models will need to be modified to deliver these metals in the volumes required for the energy transition from fossil fuel to renewable energy sources in the next 10 years.

Our interview is expected to last 45 to 60 minutes, and will help me understand the specific capabilities needed by companies to best identify and act upon opportunities, and to transform their organisations under conditions of environment uncertainty. Your participation is voluntary, and you can withdraw at any time without penalty.

By signing this letter, you are indicating that you are giving permission for:

- ✓ The interview to be recorded;
- ✓ The recording to be transcribed by a third-party transcriber, who will be subject to a non-disclosure agreement;
- ✓ Verbatim quotation from the interview will be used in the report, provided they are not identified with your name or that of your organisation;
- ✓ The data to be used as part of a report that will be publically available once the examination process has been completed; and
- ✓ All data to be reported and stored without identifiers.

If you have any concerns, please contact my supervisor or me. Our details are provided below.

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Signature of Participant: _____

Date: _____

Signature of Researcher: _____

Date: _____